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April 4, 2014

Ms. Donna Wilson
Environmental Engineer
NC DENR - Division of Waste Management
1646 Mail Service Center
Raleigh, North Carolina 27699

RE: Permit Amendment Application
Johnston County MSW Landfill (Permit No. 51-03)
Smithfield, North Carolina

Dear Ms. Wilson:

On behalf of Johnston County, Smith Gardner, Inc. (S+G) would like to submit for your review the enclosed permit amendment application for the Johnston County Municipal Solid Waste (MSW) Landfill located in Smithfield. Note that many of the documents in the application are the same as were recently submitted for the permit amendment application for the County's construction and demolition debris (C&D) landfill.

Should you have any questions or require clarification or additional information, please contact me at your earliest convenience.

Sincerely,
SMITH GARDNER, INC.

Pieter K. Scheer, P.E.
Vice President, Senior Engineer
pieter@smithgardnerinc.com

Enclosure: Permit Application

cc: Ed Mussler, P.E., DWM
Rick Proctor, Johnston County

Permit Amendment Application

Johnston County MSW Landfill - Phase 4A
Smithfield, North Carolina

Prepared for:

Johnston County Department of Solid Waste Services
Smithfield, North Carolina

March 2014

Prepared by:

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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Permit Amendment Application

Johnston County MSW Landfill - Phase 4A
Smithfield, North Carolina

Prepared For:

Johnston County Department of Solid Waste Services
Smithfield, North Carolina

S+G Project No. JOHNSTON-13-4

NORTH CAROLINA PROFESSIONAL SEAL 021666 ENGINEER PIETER K. SCHEER

4/1/14

Pieter K. Scheer, P.E.
Vice President, Senior Engineer

NORTH CAROLINA LICENSED SEAL 1389 GEOLOGIST JOAN A. SMYTH

4/1/14

Joan A. Smyth, P.G.
Senior Hydrogeologist

March 2014

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

Johnston County MSW Landfill - Phase 4A
Smithfield, North Carolina

Permit Amendment Application

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(15A NCAC 13B.1619 - .1620)

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(15A NCAC 13B.1621)

Attachment D Operations Manual
(15A NCAC 13B.1625)

Attachment E Closure and Post-Closure Plan
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Attachment G Landfill Gas Monitoring Plan
(15A NCAC 13B.1626)

Attachment H Permit Drawings
(15A NCAC 13B.1619, .1620, .1624, .1625, and .1629, and 15A NCAC 4)

EXECUTIVE SUMMARY

General

The following is a Permit Amendment Application submitted on behalf of Johnston County (County) for the continued operation of the County's Phase 4A municipal solid waste (MSW) landfill unit at the County's existing landfill facility. Phase 4A, which includes Cells 1-3 (total area of 29.4 acres), is a double-lined piggyback landfill unit located in-between and overlying the closed unlined Phase 3 and Phase 4 MSW landfills units and the Area 1 construction and demolition debris (C&D) landfill unit.

As described in the Facility and Engineering Plan (Attachment B), Phase 4A is anticipated to have approximately 6.4 to 8.6 years of remaining capacity (from June 14, 2013) assuming annual disposal rates of 120,000 and 90,000 tons, respectively.

The Phase 4A liner and leachate collection system consists of the following components (top-down):

Alternative Liner System - Phase 4A (Existing):

- a leachate collection system (LCS) consisting of natural and/or geosynthetic drainage media and collection piping;
- a 60 mil HDPE geomembrane liner;
- a geosynthetic clay liner (GCL);
- a drainage geocomposite (leak detection system);
- a 40 mil LLDPE geomembrane liner; and
- a 12 inch thick compacted soil liner with a hydraulic conductivity of no more than 1 x 10^{-5} cm/sec (base of Cell 1 only).

Leachate generated from Phase 4A is collected in a sump located at the north end of Cell 1. From the sump, the leachate is pumped using side riser pumps and a force main to the existing leachate storage lagoon located to the northwest end of the facility.

This document also provides an updated facility plan for all future MSW and C&D landfill units currently planned for development. The disposal volumes and estimated life expectancy of these future landfill units are given in the Facility and Engineering Plan (Attachment B).

Attachments

This submittal has been prepared in accordance with the requirements of the North Carolina Solid Waste Management Rules (15A NCAC 13B.1600), which are enforced by the Division of Waste Management (DWM) of the North Carolina Department of Environment and Natural Resources (DENR). Included in this submittal are the following attachments *(with applicable rule(s) in italics)*:

A. General Information

This attachment includes general information related to the facility including contacts, a description of the facility, and property information.

B. Facility and Engineering Plan *(.1619 and .1620)*

The Facility and Engineering Plan presents plans for the development of existing and future MSW and C&D landfill units and the detailed engineering design of Phase 4A. This document has been prepared to comply with the requirements of 15A NCAC 13B.1619 and .1620.

C. Construction Quality Assurance (CQA) Manual *(.1621)*

The Construction Quality Assurance (CQA) Manual has been prepared to provide the Owner, Engineer, and CQA Engineer the means to govern the construction quality and to satisfy landfill certification requirements under current North Carolina Solid Waste Management rules. This document has been prepared to comply with the requirements of 15A NCAC 13B.1621.

D. Operations Manual *(.1625)*

The Operations Manual outlines and describes protocols for facility operation and maintenance and was prepared to provide landfill personnel with a clear understanding of how the Design Engineer assumed that the completed facility would be operated. Along with the Project Drawings, this document has been prepared to comply with the requirements of 15A NCAC 13B.1625.

E. Closure and Post-Closure Plan *(.1629)*

The Closure and Post-Closure Plan was prepared to outline the requirements for closure and post-closure activities at the landfill and includes a cost analysis for each. Along with the Project Drawings, this document has been prepared to comply with the requirements of 15A NCAC 13B.1629.

F. Water Quality Monitoring Plan *(.1630, .1631, .1632, .and 1633)*

The Water Quality Monitoring Plan (WQMP) has been updated to reflect current conditions and specifies the procedures and requirements to satisfy the requirements of 15A NCAC 13B.1630, .1631, .1632, and .1633. The WQMP has been certified by a Licensed Geologist and includes information related to groundwater monitoring system, sampling and analysis protocols and requirements, and detection monitoring requirements.

G. Landfill Gas Monitoring Plan *(.1626)*

The Landfill Gas (LFG) Monitoring Plan was prepared to specifies the procedures and requirements to satisfy the requirements of 15A NCAC 13B.1626. The LFG Monitoring Plan includes information related to the LFG monitoring system including general monitoring and contingency requirements.

H. Permit Drawings *(.1619, .1620, .1624, .1625, and .1629)*

The Permit Drawings include a site plan, grading plans, phasing plans, cross sections, and details related to the Phase 4A MSW landfill unit and include phasing plans for both existing and future MSW and C&D landfill. The drawings have been prepared to comply with the requirements of 15A NCAC 13B.1619, .1620, .1624, and .1629 and 15A NCAC 4.

General Information

Johnston County Landfill Facility
Smithfield, North Carolina

Prepared for:

Johnston County Department of Solid Waste Services
Smithfield, North Carolina

December 2013

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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Johnston County Landfill Facility
Smithfield, North Carolina

General Information

1. **Facility Name:**

   Johnston County Landfill

2. **Owner Contact Information:**

   Johnston County Department of Solid Waste Services
   680 County Home Road
   P.O. Box 2263
   Smithfield, NC 27577
   Phone: (919) 938-4750
   Fax: (919) 989-7152
   Contact: Rick Proctor, Director
   rick.proctor@johnstonnc.com

3. **Consulting Engineer Contact Information:**

   Smith Gardner, Inc.
   14 N. Boylan Ave.
   Raleigh, NC 27603
   Phone: (919) 828-0577
   Fax: (919) 828-3899

   Contacts: Pieter Scheer, P.E., Vice President, Senior Engineer
   pieter@smithgardnerinc.com

   Joan A. Smyth, P.G., Senior Hydrogeologist
   joan@smithgardnerinc.com

4. **Permit/Annual Fee Invoices:**

   Direct to Rick Proctor, Solid Waste Services Director
   (See Contact Information in #2 above)

5. Facility Description:

Johnston County, North Carolina (County) currently owns and operates a landfill facility on Old County Home Road near Smithfield. The landfill is permitted under NC Permit 51-03 for the disposal of municipal solid waste (MSW) and construction and demolition debris (C&D) waste in separate disposal areas. The County also conducts several other solid waste management activities at the facility. A site development history is as follows:

MSW Landfill Units

The Johnston County Landfill facility has three (3) existing unlined municipal solid waste (MSW) landfill units (Phases 1 & 2, 3, and 4). Operations in Phase 1 were initiated in 1973. The subsequent Phase 2 expansion was permitted in September 1974. Operations in subsequent Phases 3 and 4 began in approximately 1979 and 1984, respectively. NC Solid Waste Permit 51-01 was issued for the site in March 1984. The County ceased disposal in Phases 1 & 2 as well as a majority of Phase 4 prior to October 9, 1993 and these units were closed in accordance with the then current rules. The Phase 3 landfill unit and southern portion of the Phase 4 landfill unit were operated until the end of 1997.

Closure of Phases 3 and 4 as well as an enhancement of the closure of the top portion of Phases 1 & 2 was completed in 1999.

Phase 5 was the initial lined Subtitle D landfill unit developed at the site and was permitted under NC Permit 51-02. Construction of Phase 5 was completed in 1997 and operations began in October 1997.

The currently active Phase 4A landfill unit was permitted in 2001 and is a double lined piggyback landfill unit between the Phase 3 and Phase 4 landfill units. At the time of permitting the Phase 4A landfill unit, the previous site solid waste permits (51-01 and 51-02) were combined as one permit (51-03). Construction of Cell 1 was completed in late 2002 and operations began in early 2003. Cells 2 and 3 were constructed and in 2004 and 2008, respectively.

Construction and Demolition Debris (C&D) Landfill Units

The Johnston County Landfill facility has two (2) existing construction and demolition debris (C&D) landfill units (Areas 1 and 2). Prior to 1999, construction and demolition debris (C&D) waste was co-disposed with MSW. The unlined Area 1 landfill unit was permitted in 1999 and is a vertical expansion over the closed Phase 4 MSW landfill unit. Modifications of Area 1 were permitted in 2002 and 2006 which expanded the original footprint. Closure of the Area 1 C&D landfill unit was completed in 2011.

The lined Area 2 landfill unit was permitted in 2006 and the construction of Cell 1 was completed in 2007. Cell 1 is currently active.

Refer to **Figure 1** which shows existing and proposed landfill units and solid waste management activities.

6. Property Information:

The current landfill facility boundary includes the following properties owned by Johnston County. The identified parcels are also shown on **Figure 1**.

Parcel	County Reference (See Notes 1 & 2)	Acreage
1	Deed Book 775, Page 410 (Permit); Tract 6 Land Book E, Page 305	420.44
2	Deed Book 952, Page 374 (Permit); Tract 6 Land Book E, Page 305	
3	Deed Book 763, Page 525; Deed Book 952, Page 375 (Permit)	
4	Deed Book 1228, Page 652 Second Tract; Land Book E, Page 305	
5	Deed Book 1228, Page 652 First Tract; Land Book E, Page 305	
6	Deed Book 1215, Page 747 Tax #15I09002C	64.00
7	No Deed Reference Tax #15I08032C	8.22
8	No Deed Reference Tax #15I08032B	13.01
9	Deed Book E-3, Page 1 Tax #15I08028C	9.71
10	Deed Book 2190, Page 599 Plat Book 58, Page 449-450 Tax #15I09033	14.02
	Total Acreage:	**529.4**

Notes:

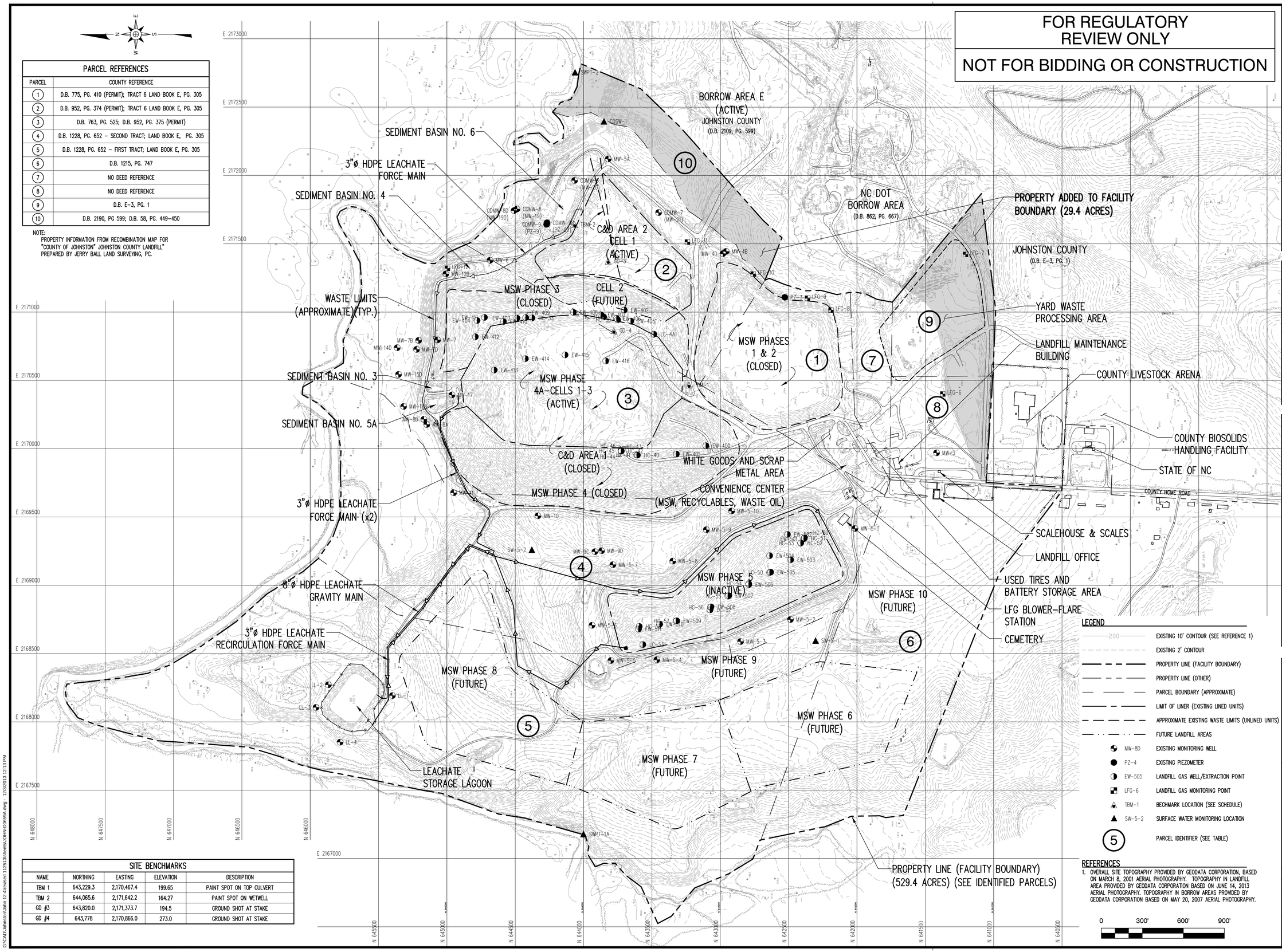
1. Reference: Johnston County Register of Deeds (http://www.johnstonnc.com/rod2) and Geographic Information Systems websites (http://www.johnstonnc.com/gis2).
2. Parcels 1-5 fall under Tax #15I08028.

FOR REGULATORY REVIEW ONLY

NOT FOR BIDDING OR CONSTRUCTION

PARCEL REFERENCES	
PARCEL	COUNTY REFERENCE
1	D.B. 775, PG. 410 (PERMIT); TRACT 6 LAND BOOK E, PG. 305
2	D.B. 952, PG. 374 (PERMIT); TRACT 6 LAND BOOK E, PG. 305
3	D.B. 763, PG. 525; D.B. 952, PG. 375 (PERMIT)
4	D.B. 1228, PG. 652 – SECOND TRACT; LAND BOOK E, PG. 305
5	D.B. 1228, PG. 652 – FIRST TRACT; LAND BOOK E, PG. 305
6	D.B. 1215, PG. 747
7	NO DEED REFERENCE
8	NO DEED REFERENCE
9	D.B. E-3, PG. 1
10	D.B. 2190, PG 599; D.B. 58, PG. 449-450

NOTE:
PROPERTY INFORMATION FROM RECOMBINATION MAP FOR "COUNTY OF JOHNSTON" JOHNSTON COUNTY LANDFILL" PREPARED BY JERRY BALL LAND SURVEYING, PC.



SITE BENCHMARKS				
NAME	NORTHING	EASTING	ELEVATION	DESCRIPTION
TBM 1	643,229.3	2,170,467.4	199.65	PAINT SPOT ON TOP CULVERT
TBM 2	644,065.6	2,171,642.2	164.27	PAINT SPOT ON WETWELL
GD #3	643,820.0	2,171,373.7	194.5	GROUND SHOT AT STAKE
GD #4	643,778	2,170,866.0	273.0	GROUND SHOT AT STAKE

PREPARED FOR:

JOHNSTON COUNTY NORTH CAROLINA DEPARTMENT OF PUBLIC UTILITIES

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+ GARDNER ENGINEERS

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

SEAL

SEAL

REV.	DATE	DESCRIPTION
1	12/4/13	NEW PROPERTY SURVEY

PROJECT TITLE:

JOHNSTON COUNTY LANDFILL

DRAWING TITLE:

EXISTING AND PROPOSED LANDFILL UNITS AND SOLID WASTE MANAGEMENT ACTIVITIES

DESIGNED: P.K.S.	PROJECT NO: JOHN 12-4
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED:	DATE: AUG. 2012
FILENAME: JOHN-D0659A	
SHEET NUMBER:	DRAWING NUMBER: FIG.1

G:\CADD\Johnston\John 12-4\revised 12\513\sheets\JOHN-D0659A.dwg 12/2/2013 12:13 PM

Facility and Engineering Plan

Johnston County MSW Landfill - Phase 4A
Smithfield, North Carolina

Prepared for:

Johnston County Department of Solid Waste Services
Smithfield, North Carolina

March 2014

NC LIC. NO. C-0828 (ENGINEERING)

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Johnston County MSW Landfill - Phase 4A
Smithfield, North Carolina

Facility and Engineering Plan

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APPENDIX

Appendix A Landfill Design Calculations

1.0 INTRODUCTION

The Johnston County Landfill facility is located on County Home Road off NC Highway 210 near Smithfield, North Carolina and is owned and operated by Johnston County (County) under NC Solid Waste Permit 51-03. The landfill facility includes an active 29.4 acre Subtitle D municipal solid waste (MSW) landfill (Phase 4A - Cells 1 - 3) and an active construction and demolition debris (C&D) landfill (Area 2 - Cell 1). The facility includes a scale and scale house facility, an office building, a maintenance building, a citizen's convenience center, and a yard waste processing area. The facility also has one (1) inactive MSW landfill unit (Phase 5 (lined)), three (3) closed MSW landfill units (Phases 1 and 2, Phase 3, and Phase 4 (each is unlined)), and one (1) closed C&D landfill unit (Area 1 (vertical expansion of Phase 4 MSW landfill unit)) which are maintained by the County.

Based on current projections, the active MSW landfill unit (Phase 4A - Cells 1 - 3) is expected to remain in operation until at least 2020. Likewise, the active C&D landfill unit (Area 2 - Cell 1) is expected to remain in operation until at least early 2015. As these units approach their capacity, the County will need to develop the subsequent disposal units.

The purpose of this Facility and Engineering Plan is to present the plans for the development of the landfill facility and the detailed design of the Phase 4A landfill unit. The Facility Report (Section 2) and the design information for Phase 4A updates the information contained in the following previously approved document:

> Facility and Engineering Plan
> Johnston County MSW Landfill - Phase 4A - Cell 3
> Prepared by Richardson Smith Gardner & Associates, Inc.
> As Revised Through December 2008.

This section gives a brief overview of this report and a description of the site. Section 2 gives a description of the development of the Johnston County Landfill facility including the planned future MSW and C&D landfill units. Sections 3 through 5 of this report focus on the detailed design of geosynthetics, the leachate management system, and the final cover system of the Phase 4A MSW unit, respectively.

1.1 Site Description

Existing and proposed landfill units are located within the previously approved facility boundary, which consisted of approximately 500 acres. An expansion of the facility boundary was proposed as part of the recent permit application for the C&D landfill (currently pending approval) to include additional County-owned property. The expanded facility boundary consists of approximately 529 acres. The landfill facility is generally bounded to the north and west by Middle Creek and on the east and west by unnamed tributaries of Middle Creek. Adjacent properties include property owned by the County (including the site's active borrow area (Borrow Area E) located to the east of the facility boundary and a borrow area owned by the NC Department of Transportation

(NC DOT) located to the southeast of the facility boundary. The topographic relief of the site is approximately 160 feet, ranging from elevation 120 feet along Middle Creek to elevation 280 feet on top of the closed Area 1 C&D landfill unit. Existing conditions are shown on **Figure 1** of **Attachment A** of this Permit Application. Access to the facility is from County Home Road.

The existing Phase 4A landfill unit was constructed in three cells and occupies 29.4 acres (lined). As described in **Section 2**, Phase 4A - Cell 3 (Fill Sequence 1) is anticipated to have approximately 3.0 to 4.0 years of remaining capacity (from June 14, 2013) assuming annual disposal rates of 120,000 tons and 90,000 tons, respectively. Another fill sequence (Fill Sequence 2) will provide approximately an additional 3.4 to 4.6 years of disposal capacity based on the same annual disposal rates. Life expectancies may be reduced should the County elect to accept any out-of-County waste from their approved service area of the State of North Carolina.

Additionally, Phase 4A has been designed to meet current DWM setback and horizontal buffer requirements: 300 feet from property lines, 500 feet from residences or active water wells.

1.2 Site Development History

MSW Landfill Units

The Johnston County Landfill facility has three (3) existing unlined municipal solid waste (MSW) landfill units (Phases 1 & 2, 3, and 4). Operations in Phase 1 were initiated in 1973. The subsequent Phase 2 expansion was permitted in September 1974. Operations in subsequent Phases 3 and 4 began in approximately 1979 and 1984, respectively. NC Solid Waste Permit 51-01 was issued for the site in March 1984. The County ceased disposal in Phases 1 & 2 as well as a majority of Phase 4 prior to October 9, 1993 and these units were covered with 2 feet of soil cover in accordance with the then current regulations. The Phase 3 landfill unit and southern portion of the Phase 4 landfill unit were operated until the end of 1997.

Closure of Phases 3 and 4 as well as an enhancement of the closure of the top portion of Phases 1 & 2 was completed in 1999. The Phase 3 closure included a 24-inch thick soil cover over side slopes and a geosynthetic clay liner (GCL) and drainage composite overlain by 18-inches of soil cover on the top ridge of the unit. The south end of Phase 4 and the top of Phases 1 and 2 were closed with a 12-mil scrim reinforced geomembrane overlain by 18-inches of soil cover.

Phase 5 was the initial lined Subtitle D landfill unit developed at the site and was permitted under NC Permit 51-02. Construction of Phase 5 was completed in 1997 and operations began in October 1997. The liner system for Phase 5 includes the following components (listed top-down):

- a leachate collection system (LCS);
- a 60 mil HDPE geomembrane liner (textured on side slopes; smooth on base slopes); and
- a 24-inch thick soil liner ($k \leq 1 \times 10^{-7}$ cm/sec).

The currently active Phase 4A landfill unit was permitted in 2001 and is a double lined piggyback landfill unit between the Phase 3 and Phase 4 landfill units. At the time of permitting the Phase 4A landfill unit, the previous site solid waste permits (51-01 and 51-02) were combined as one permit (51-03). Construction of Cell 1 was completed in late 2002 and operations began in early 2003. Cells 2 and 3 were constructed in 2004 and 2008, respectively. The liner system for Phase 4A includes the following components (listed top-down):

- a leachate collection system (LCS);
- a 60-mil textured HDPE geomembrane liner;
- a geosynthetic clay liner (GCL);
- a leak detection system (LDS) (drainage geocomposite); and
- a 40-mil thick textured LLDPE geomembrane liner.

Additionally, on the base slopes of Cell 1, the above listed components were placed over a 12-inch thick soil liner ($k \leq 1 \times 10^{-5}$ cm/sec).

Construction and Demolition Debris (C&D) Landfill Units

The Johnston County Landfill facility has two (2) existing construction and demolition debris (C&D) landfill units (Areas 1 and 2). Prior to 1999, construction and demolition debris (C&D) waste was co-disposed with MSW. The unlined Area 1 landfill unit was permitted in 1999 and is a vertical expansion over the closed Phase 4 MSW landfill unit. Modifications of Area 1 were permitted in 2002 and 2006 which expanded the original footprint. Closure of the Area 1 C&D landfill unit was completed in 2011 and the final cover consists of the following components (listed top-down):

- a 24-inch thick vegetative soil layer;
- a drainage geocomposite;
- a 30-mil textured LLDPE geomembrane; and
- intermediate (soil) cover.

The lined Area 2 landfill unit was permitted in 2006 and the construction of Cell 1 was completed in 2007. Cell 1 is currently active. The liner system for Area 1 - Cell 1 includes the following components (listed top-down):

- a leachate collection system (LCS);
- a 40-mil textured LLDPE geomembrane liner; and
- a 12-inch thick soil liner ($k \leq 1 \times 10^{-5}$ cm/sec).

2.0 FACILITY REPORT

This section presents an updated plan for the development of the Johnston County Landfill facility. This report has been prepared in accordance with the requirements of Rule .1619 of the North Carolina Solid Waste Management Rules. Whereas some information is provided for C&D landfill units, emphasis is on the Phase 4A MSW landfill unit.

2.1 Facility Services and Waste Stream

2.1.1 Facility Services

Currently, the following activities or services are provided at the Johnston County Landfill facility (as shown on **Figure 1** of **Attachment A**):

- Scales and scale house
- Administrative offices
- Maintenance building
- Subtitle D MSW landfill
- C&D landfill
- White goods, scrap metal, and tire handling area
- Convenience center
- Yard waste processing area.

2.1.2 Types of Waste

The Johnston County Landfill facility accepts municipal solid waste (MSW) originating from residential, commercial, and industrial sources, construction and demolition debris (C&D) waste, and other wastes (i.e. white goods, tires, and yard waste). These wastes are segregated and directed to on-site facilities for disposal or processing/handling area as described below. Refer to the Operations Manual (**Attachment D**) for more information on wastes and materials accepted at the facility for processing and/or disposal.

2.1.3 Disposal Rates and Estimated Variances

Based on the FY 2012-2013 Solid Waste Management Annual Report information provided by the County, 92,085 tons of MSW and 20,142 tons of C&D waste were disposed of from 7/1/12 to 6/30/13 (average 7,674 tons per month and 307 tons per day of MSW and 1,679 tons per month and 67 tons per day of C&D waste based on 300 operating days per year). These are very similar figures from FY 2011-2012. However, disposal tonnages have been down in recent years due to the economy and changes in market conditions. As documented during the prior

local government approval process[1], the County has set the following maximum disposal rates for the facility of which a maximum of 156,000 tons/year will be from outside the County:

2013-2015	350,000 tons/year
2016-2025	401,000 tons/year
2026-2035	452,000 tons/year
2036-2045	505,000 tons/year
2046-2055	568,000 tons/year.

For purposes of current facility life expectancy calculations, ranges of annual disposal rates were assumed as follows:

MSWLF:

Phase 4A & 6:	90,000 tons/year (Low); 120,000 tons/year (High)
Phases 7-10:	110,000 tons/year (Low): 160,000 tons/year (High)*

C&DLF:

Area 2:	20,000 tons/year (Low); 40,000 tons/year (High)

*The disposal rates for Phases 7-10 assume co-disposal of C&D waste.

2.1.4 Service Area

The landfill facility currently serves the State of North Carolina.

2.1.5 Procedures for Waste Segregation

A brief description of procedures for waste segregation at the landfill is as follows.

Wastes are segregated at the scale house. Operators at the scale house are trained to classify and segregate the waste stream. MSW and C&D wastes will directed to the active MSW or C&D landfill unit. Yard wastes will be directed toward the yard waste processing area. Tires and white goods will be directed to the appropriate processing/handling area where they will be temporarily stockpiled for collection by recycling contractors. Small loads and recyclables will be directed toward the citizen's convenience center.

[1] G.N. Richardson & Associates, Inc. (2006), "Permit to Construct Application, Johnston County C&D Landfill – Area 2, Johnston County, North Carolina", October 2005 (as revised through May 2006) (Local Government Approval Dated January 3, 2006).

Employees at the landfill are trained in the safety procedures for the handling and detection of illegal waste. The screening of unacceptable waste will be done through the random checking of incoming loads by a County employee at the scale house and at the tipping area. When unacceptable waste is detected at the scale house, the load will be rejected and not permitted into the facility. If hazardous waste is found at the tipping area, identification of the truck or persons will be made (if possible) and documented, then the hazardous waste will be identified and placed in a hazardous waste container by appropriately trained personnel and taken to a designated hazardous waste staging area for proper disposal. If this occurs, the event will be reported to the appropriate authorities.

Refer also to the facility Operations Manual (**Attachment D**) for more information.

2.1.6 Equipment Requirements

The County will maintain on-site equipment required to perform the necessary landfill activities. Periodic maintenance of all landfilling equipment and minor and major repair work will be performed at designated maintenance zones.

2.2 Landfill Capacity

2.2.1 Total Operating Capacity and Life Expectancy

Drawings P1 - P3 (MSW Landfill Phasing Plan) and **Drawing P4** (C&D Landfill Phasing Plan), show conceptual base and final cover grades, respectively, for the development of MSW Phases 4A and 6 through 10 and C&D Area 2. The final cover side slopes will be at a 4H to 1V slope, then transition at flatter slopes (5 to 8%) to the peak elevations.

The estimated gross and net operating capacities, life expectancies, and areas of existing and planned MSW and C&D landfill units are shown in **Table 2.1**. Note that the approximate total capacities and waste footprint areas for closed MSW and C&D landfill units are also shown in **Table 2.1**. The net capacity for waste and corresponding life expectancy of each landfill unit accounts for daily and intermediate cover and/or final cover. Life expectancies were calculated based on the disposal rates listed in **Section 2.1.3**.

2.2.2 In-Place Ratio of Waste to Soil and Waste Densities

2.2.2.1 MSW Landfill Units

The capacities obtained above were based on a 15 percent periodic cover ratio and a waste density ranging from 1,200 to 1,400 pounds per cubic

yard (pcy). The assumed periodic cover ratio is indicative of the County's current practices of using a tarp as an alternative to placing 6 inches of daily cover soil. The assumed waste density of 1,200 pcy is conservative for areas with lesser waste thicknesses (i.e. Phases 6, 7, and 8). The assumed waste density of 1,400 pcy is based on a recent analysis of waste density in Phase 4A and is assumed for areas with the greatest waste thicknesses (i.e. Phase 4A - Cell 3, Phase 9, and Phase 10).

2.2.2.2 C&D Landfill Unit

The capacities obtained above were based on a 10 percent periodic cover ratio and a waste density of 1,000 pounds per cubic yard (pcy). The assumed periodic cover ratio is indicative of the County's current practices. The assumed waste density of 1,000 pcy is based on a recent analysis of waste density in Area 2 and is conservative as waste thicknesses increase.

Note that changes in landfill operations (i.e. changes in the use of alternative daily cover and/or compaction equipment/methods) may affect the values assumed above and, thus, alter the life of the various landfill units.

2.3 Available Soil Resources and Required Soil Quantities

2.3.1 Earthwork Quantities

The soils required to construct and operate the existing and planned MSW and C&D landfill units will be removed from on-site borrow sources or will be imported from off-site. The soils removed during excavation of landfill units may be used for structural fill, soil liner, periodic cover, final cover, and general fill. These excavation (cut) and structural fill (fill) volumes are shown in **Table 2.2**.

2.3.2 Soil Liner

The soil required for the soil liner will be on-site or imported soils (A supply of 1 x 10^{-5} centimeters per second (cm/sec) or less soil is anticipated within Borrow Area E). The in-place volume required for each landfill unit is shown in **Table 2.3**.

2.3.3 Leachate Collection System (LCS) and Protective Cover

Overlying the liner system is the leachate collection system and protective cover. This layer is 24 inches thick on both the landfill base and side slopes. The required in-place volume of protective cover for each landfill unit is shown in **Table 2.4**. A portion of this volume will consist of aggregate, which will come from off-site sources.

2.3.4 Daily and Intermediate Cover

Assuming the previously mentioned periodic cover ratios, the required in-place volume for use as daily and intermediate cover during operations of each landfill unit is shown in **Table 2.5**.

2.3.5 Vegetative Soil Layer

On the basis of the 2 foot thick vegetative soil layer required for the landfill final cover, the in-place volume required for each landfill unit is shown in **Table 2.6**.

2.3.6 Soil Summary

The above on-site and off-site soil quantities are summarized in **Table 2.7**. Note that, based on the proposed base grades, long-term there is a soil deficit, which will be made up from the current and future borrow areas (adjacent County-owned properties).

2.4 Facility Design Criteria

Existing and proposed MSW landfill units were and will be constructed in accordance with Section .1624 of the North Carolina Administrative Code, Title 15A, Chapter 13, Subchapter 13B including the following requirements:

2.4.1 Horizontal Separation Requirements

The horizontal separation requirement between the disposal boundary (edge of waste) and the property lines is a minimum of 300 feet; the minimum buffer between private residences and wells and the disposal boundary is 500 feet; and the minimum buffer between any surface water (stream, river, creek) and the disposal boundary is 50 feet. The proposed design satisfies all buffer requirements.

2.4.2 Vertical Separation Requirements

The post-settlement bottom elevation of the liner system will meet the minimum requirement of four (4) feet above the seasonal high groundwater table and bedrock.

2.5 Containment and Environmental Control Systems

The following systems and elements are the basic containment and environmental controls for the MSW landfill units. Technical specifications were provided in the following approved document:

Technical Specifications
Johnston County Landfill
Prepared by Richardson Smith Gardner & Associates, Inc.
Dated December 2008.

Construction quality assurance requirements can be found in **Attachment C**.

2.5.1 Landfill Subgrade and Perimeter Berms

The landfill subgrade elevations are designed for minimum post-settlement slopes of two (2) percent. The subgrade elevations will be achieved by excavation or placement of compacted structural fill (embankment). During excavation, a determination of unsuitable soils (i.e. soils which are too soft, wet, or organic) will be made. Where unsuitable soils are found, the soils will be undercut and backfilled with structural fill.

In addition to providing the liner foundation in fill areas, structural fill will be used for berm and roadway construction. Structural fill will consist of on-site soils removed during excavation of the landfill units or imported borrow soils, except that no CH, OL, or OH soils will be allowed.

2.5.2 Liner and Leachate Collection Systems

The base liner areas for Phase 4A - Cell 3, and Phases 6-10 are shown on **Drawing S2** (Site Development Plan - Base Grades). The base liner will consist of either a standard composite liner system or an alternative liner system as allowed under North Carolina regulations. The components of this liner system will consist of the following components (top-down):

Standard Liner System - Phase 5 (Existing) and Phases 6-10 (Future):

- a leachate collection system (LCS) consisting of natural and/or geosynthetic drainage media and collection piping;
- a 60 mil HDPE geomembrane liner; and
- a 24 inch thick compacted soil liner with a hydraulic conductivity of no more than 1×10^{-7} cm/sec.

OR

Alternative Liner System - Phase 4A (Existing):

- a LCS (components as listed above for the standard liner system);
- a 60 mil HDPE geomembrane liner;
- a geosynthetic clay liner (GCL);
- a drainage geocomposite (leak detection system);
- a 40 mil LLDPE geomembrane liner; and
- a 12 inch thick compacted soil liner with a hydraulic conductivity of no more than 1 x 10^{-5} cm/sec (base of Cell 1 only).

Alternative Liner System - Phases 6-10 (Future):

- a LCS (components as listed above for the standard liner system);
- a 60 mil HDPE geomembrane liner;
- a geosynthetic clay liner (GCL); and
- an 18 inch thick compacted soil liner with a hydraulic conductivity of no more than 1 x 10^{-5} cm/sec.

2.5.3 Stormwater/Leachate Separation System

In order to increase facility operating efficiency by reducing the leachate treatment quantities, stormwater/leachate separation is planned for each landfill unit. Leachate is considered to be any precipitation or fluid that comes in direct contact with the waste. This liquid will be collected by the LCS and pumped to the leachate storage tanks. Precipitation that falls in areas where it does not contact waste, such as within inactive areas, does not have to be treated as leachate. This fraction of the precipitation is treated as stormwater, which is treated for removal of sediment only.

For landfill units that have waste placed in them, precipitation infiltrates or runs-off into the LCS. For areas that have no waste, run-off is captured in one or more low points where a pump conducts the water to a perimeter drainage structure. This run-off does not contact waste or leachate. At their discretion, the County may also employ the use of geosynthetic rain cover (GRC) to further segregate leachate and stormwater. The GRC, if used, is removed and discarded as each portion of an area is placed into active operation. For additional discussion of the leachate-stormwater separation system, see the Operations Manual (**Attachment D**).

2.5.4 Final Cover System

The final cover system for Phase 4A and future MSW landfill units will consist of the following components (top-down):

- a 24-inch thick vegetative soil layer (including 6 inches of topsoil);

- a drainage geocomposite (with drainage breaks);
- a 30-mil textured LLDPE geomembrane; and
- a 12-inch thick intermediate cover layer.

A detailed discussion of the design of the final cover system can be found in **Section 5.0** (Final Cover System Design).

2.5.5 Erosion and Sedimentation Control

Erosion and sedimentation control devices/measures will be designed and maintained to manage the run-off generated by the 25-year 24-hour storm event and conform to the requirements of the North Carolina Sedimentation Pollution Control Law (15A, NCAC, 4).

Reference is made to the following documents which have been approved by the NC Division of Energy, Mineral, and Land Resources:

Erosion and Sedimentation Control Plan
Johnston County MSW Landfill - Phase 4A
Prepared by G.N. Richardson & Associates, Inc.
Dated June 2001.

Erosion and Sedimentation Control Plan
Johnston County C&D Landfill Vertical Expansion
Prepared by G.N. Richardson & Associates, Inc.
Dated December 2003.

2.5.6 Landfill Gas Control

The landfill gas (LFG) control system for Phase 4A and future MSW landfill units will consist of collection wells and/or collector trenches placed within the waste to capture the gas. It is anticipated that the majority of future wells and/or collector trenches will be connected to the existing LFG collection and control and electrical generation system. The LFG collection and control and electrical generation system consists of the following components:

- Extraction wells with wellheads;
- Collection piping (header and laterals);
- Isolation valves;
- Condensate sumps and pumps (CS-H2, CS-3A, and CS-4B);
- Air and condensate force main piping for condensate sumps and pumps;
- Blower/flare station (1,250 scfm flare); and
- Electrical generation facility.

LFG is collected from extraction wells by applying a vacuum pressure produced by the blowers. Adjustments are made at each wellhead to maintain adequate quality and quantity of LFG and to minimize air intrusion into the system. Collected LFG is routed to either the electrical generation facility for combustion in a reciprocating engine generator set (genset) or to the flare (when the genset is not operating).

The collection and control and electrical generation system is routinely monitored and maintained by Carbon Infrastructure Investment Methane Management IV, LLC. under agreement with the County.

Also refer to the facility Operations Manual (**Attachment D**) for a discussion of LFG monitoring and record keeping requirements.

2.5.7 Access and Roadways

The facility is accessed from County Home Road. A scale and a scale house are located near this entrance. All-weather access to active areas as well as areas under intermediate cover will be provided. Access ramps into the landfill units will be provided where necessary.

2.6 Slope Stability, Settlement, and Bearing Capacity

An evaluation of the slope stability of the overall waste mass and perimeter berms, the LCS/protective cover veneer, and the final cover veneer, as well as evaluations of foundation settlement and bearing capacity were addressed in the following document which was part of the previously approved Phase 4A - Cell 3 Permit Amendment Application:

Slope Stability, Settlement, and Bearing Capacity Evaluation
Johnston County MSW Landfill - Phase 4A
Prepared by Richardson Smith Gardner & Associates, Inc.
Dated December 2008.

Analyses contained therein indicated that the completed Phase 4A landfill configuration will satisfy applicable regulatory criteria.

2.7 Leachate Management

The general leachate management system includes the collection, storage, treatment (if required), and disposal of the leachate generated. The collection and transmission of leachate to the on-site storage lagoon is as described in **Section 4.0** (Leachate Management System Design). From the storage lagoon, which also serves as a wastewater equalization basin, the leachate is pumped via force main to a local

wastewater treatment plant (WWTP) for disposal. Pretreatment, if required, will be employed on-site to meet the standards for disposal into the WWTP.

A detailed discussion of the leachate management system, including anticipated leachate volumes, can be found in **Section 4.0** (Leachate Management System Design).

2.8 Special Engineering Features

Special engineering features proposed for existing and proposed MSW landfill units include alternative liner systems.

2.8.1 Alternative Liner Systems

Alternative liner systems, as described above, are proposed for use at the facility due to the limited supply of 1 x 10^{-7} cm/sec soil on-site.

Table 2.1 Total Operating Capacity and Life Expectancy - MSWLF Units

Landfill Unit	Area (Acres)	Gross Capacity (CY)	Net (Waste) Capacity (CY/Tons)	Life Expectancy (Years)[1]
Unlined Landfill Units				
Phase 1/2	22.1	732,363	459,790 CY 279,474 Tons	Closed
Phase 3	25.4	1,174,139	819,136 CY 491,482 Tons	Closed
Phase 4	37.3	1,631,731	1,133,533 CY 680,120 Tons	Closed
Total (Unlined):	84.8	3,538,233	2,448,459 CY 1,469,076 Tons	Closed
Lined (Subtitle D) Landfill Units				
Phase 5	19.2	1,087,199	884,625 CY 514,181 Tons	Inactive
Phase 4A - Used	29.4	1,932,768	1,642,853 CY 1,072,776 Tons	-----
Phase 4A - Remaining				
Fill Sequence 1		599,180	509,303 CY 356,512 Tons	3.0 to 4.0
Fill Sequence 2		785,112	586,711 CY 410,698 Tons	3.4 to 4.6
Phase 6	21.1	1,402,016	1,167,578 CY 700,547 Tons	5.8 to 7.8
Phase 7	19.8	1,758,991	1,462,230 CY 877,338 Tons	5.5 to 8.0
Phase 8	25.2	1,844,867	1,495,182 CY 897,109 Tons	5.6 to 8.2
Phase 9	22.5	6,684,914	5,611,690 CY 3,928,183 Tons	24.6 to 35.7
Phase 10	17.5	3,137,920	2,524,065 CY 1,766,846 Tons	11.0 to 16.1
Total (Lined):	154.7	19,232,967	15,884,237 CY 10,524,190 Tons	58.9 to 84.4
Total (Overall):	239.5	22,771,200	18,332,696 CY 11,993,266 Tons	58.9 to 84.4

Notes:

1. Life expectancy for the active Phase 4A unit shown above is from 6/14/13. Life expectancies are based on disposal rates of 120,000 tons/year and 90,000 tons/year (Phases 4A and 6) and 160,000 tons/year and 110,000 tons/year (Phases 6-10).

Table 2.2 Total Operating Capacity and Life Expectancy - C&DLF Units

Landfill Unit	Area (Acres)	Gross Capacity (CY)	Net (Waste) Capacity (CY/Tons)	Life Expectancy (Years)[1]
Area 1	16.2	614,472	515,563 CY 304,780 Tons	Closed
Area 2 Cell 1 Used	11.9	323,132	290,819 CY 151,988 Tons	-----
Cell 1 Remaining		87,544	62,237 CY 31,118 Tons	0.8 to 1.6
Cell 2 (See Note 2)	3.9	462,658	387,062 CY 232,237 Tons	5.8 to 11.6
Total:	32.0	1,487,806	1,255,681 CY 720,123 Tons	6.6 to 13.2

Notes:

1. Life expectancy for the active Area 2 unit shown above is from 6/14/13. Life expectancies are based on disposal rates of 40,000 tons/year and 20,000 tons/year.
2. A portion of the Cell 2 capacity is available within the footprint of Cell 1 (i.e. without need to construct Cell 2).

Table 2.3 General Earthwork Quantities

Landfill Unit	Cut (CY)	Fill (CY)
MSW Landfill Units		
Phase 6	279,493	55,613
Phase 7	222,037	85,202
Phase 8	242,630	105,976
Phase 9	68,999	178,758
Phase 10	151,736	21,326
C&D Landfill Units		
Area 2 - Cell 2	0	3,436

Table 2.4 Soil Liner Quantities

Landfill Unit	Required Volume (CY)
MSW Landfill Units	
Phase 6	51,062
Phase 7	47,916
Phase 8	60,984
Phase 9	54,450
Phase 10	42,350
C&D Landfill Units	
Area 2 - Cell 2[1]	6,292

Note:

1. Or structural fill layer.

Table 2.5 Leachate Collection System/Protective Cover Quantities

Landfill Unit	Required Volume (CY)
MSW Landfill Units	
Phase 6	68,083
Phase 7	63,888
Phase 8	81,312
Phase 9	72,600
Phase 10	56,467
C&D Landfill Units	
Area 2 - Cell 2	12,584

Note:

1. The quantity shown above is for a thickness of 24 inches.

Table 2.6 Daily and Intermediate Cover Quantities

Landfill Unit	Required Volume (CY)
MSW Landfill Units	
Phase 4A - Fill Seq. 1 Phase 4A - Fill Seq. 2	89,817 103,537
Phase 6	206,043
Phase 7	258,041
Phase 8	263,856
Phase 9	990,298
Phase 10	445,423
C&D Landfill Units	
Area 2 - Cell 1	6,915
Area 2 - Cell 2	43,007

Note:

1. Volumes shown above for Phase 4A and Area 2 are from 6/14/13.

Table 2.7 Vegetative Soil Layer Quantities

Landfill Unit	Required Volume (CY)
MSW Landfill Units	
Phase 4A	94,864
Phase 5	61,952
Phase 6	68,083
Phase 7	63,888
Phase 8	81,312
Phase 9	72,600
Phase 10	56,467
C&D Landfill Units	
Area 2	50,981

Note:

1. The quantity shown above is for a thickness of 24 inches.

Table 2.8 Soil Summary

Material	Quantity (CY)
Excavation	964,895
Structural Fill	(450,311)
Soil Liner	(263,054)
LCS/Protective Cover[1]	(354,933)
Daily/Intermediate Cover	(2,406,997)
Vegetative Soil Layer	(550,147)
Total[1]:	(3,060,547)

Notes:

1. A portion of the LCS/Protective Cover will be from off-site sources.
2. Soil deficit shown will be made up from existing and future borrow sources located on County-owned property adjacent to the site.

3.0 LINER SYSTEM DESIGN

This section addresses the design of the Phase 4A liner system. Technical specifications for liner system components were provided in the following approved document:

Technical Specifications
Johnston County Landfill
Prepared by Richardson Smith Gardner & Associates, Inc.
Dated December 2008.

Construction quality assurance requirements for liner system components can be found in **Attachment C**. Also refer to the Permit Drawings (**Attachment H**) for liner system details.

3.1 Liner System Components

As described in **Section 2.5.2**, the Phase 4A liner system consists of the following components (top-down):

- a leachate collection system (LCS) (see **Section 4.1**);
- a 60 mil HDPE geomembrane liner;
- a geosynthetic clay liner (GCL);
- a leak detection system (LDS) (see **Section 4.2**);
- a 40 mil LLDPE geomembrane liner; and
- a 12 inch thick compacted soil liner with a hydraulic conductivity of no more than 1×10^{-5} cm/sec (base of Cell 1 only).

The liner system was placed on structurally sound, compacted, or adequately prepared native soil subgrades at a maximum slope of 3H:1V.

3.1.1 Geomembranes

The geomembrane components of the liner system function as the primary barrier layers. The upper (primary) geomembrane is a textured 60-mil thick High Density Polyethylene (HDPE) synthetic liner. The lower (secondary) geomembrane is a textured 40-mil thick Linear Low Density Polyethylene (LLDPE) synthetic liner. The geomembranes were installed by a qualified contractor.

3.1.2 Geosynthetic Clay Liner (GCL)

The GCL functions as a secondary barrier layer beneath the primary geomembrane. The selected material for the GCL consists of a layer of sodium bentonite bonded between two (2) geotextiles. The selected GCL provides a maximum hydraulic conductivity of 5×10^{-9} cm/sec when hydrated and is reinforced to prevent potential shearing in the bentonite layer.

3.1.3 Soil Liner (Cell 1 Base Only)

The soil liner functions as a secondary barrier layer beneath the secondary geomembrane in the base of Cell 1 only. The soil liner consists of compacted on-site borrow soils. The soil liner was compacted in 6 inch lifts to achieve the required hydraulic conductivity and strength requirements.

3.2 Liner System Design

3.2.1 Slope Stability

An evaluation of the slope stability of the Phase 4A landfill unit was provided in the following approved document:

Slope Stability, Settlement, and Bearing Capacity Evaluation
Johnston County MSW Landfill - Phase 4A
Prepared by Richardson Smith Gardner & Associates, Inc.
Dated December 2008.

Even though the project site lies outside of a seismic impact zone, both static and seismic slope stability analyses were performed. The evaluation indicated that the liner system will be able to satisfy design criteria (FS_{static} = 1.5; $FS_{seismic}$ = 1.0) under both short-term (protective cover veneer stability) and long-term (waste mass) conditions if the minimum peak interface shear strength for the weakest interface is defined by the following values:

Normal Loads </= 1,000 psf (Based on Veneer Stability)*:

Cohesion = 0 psf
Phi = 26.5 degrees

* Also applies to internal shear strength of the protective cover.

Normal Loads > 1,000 psf (Based on Global Stability):

Cohesion = 0 psf
Phi = 20 degrees*

* Note that, although 20.0 degrees was used in the evaluation, a value of 11.0 degrees is required to achieve the minimum required factors of safety.

Based on the slope stability analyses performed, textured geomembranes and reinforced GCL were deemed to be required on both the base and side slopes of the landfill. Interface shear strength testing of the materials representative of

those to be used in construction was conducted prior to installation to verify that the above minimum criteria were met.

3.2.2 Settlement

3.2.2.1 Virgin Ground

An evaluation of the settlement of the Phase 4A landfill foundation under the central portion of Cell 1 (over virgin ground) was provided in the following approved document:

> Slope Stability, Settlement, and Bearing Capacity Evaluation
> Johnston County MSW Landfill - Phase 4A
> Prepared by Richardson Smith Gardner & Associates, Inc.
> Dated December 2008.

Based on a worst case cross section, the evaluation indicates that the maximum total foundation settlement will be approximately 1.6 feet under maximum loads. Strains resulting from differential settlements are expected to be negligible meaning that no adverse impacts on the function of the liner or leachate collection systems are anticipated.

3.2.2.2 Piggyback Areas

See **Section 3.4**.

3.2.3 Bearing Capacity

An evaluation of the bearing capacity of the Phase 4A landfill unit was provided in the following approved document:

> Slope Stability, Settlement, and Bearing Capacity Evaluation
> Johnston County MSW Landfill - Phase 4A
> Prepared by Richardson Smith Gardner & Associates, Inc.
> Dated December 2008.

Both the bearing capacity of the landfill subgrade and the bearing capacity of the leachate collection system under anticipated construction and operations equipment loads were evaluated. Based on the anticipated conditions, the landfill subgrade and the leachate collection system have adequate bearing capacity. The evaluation of the equipment loads also determined the required vertical separation between equipment and the underlying geomembrane (see **Sections 3.3.1 and 3.3.2**).

3.2.4 Anchor Trench Design

An anchor trench size of 2.0 feet wide by 2.0 feet deep (1.0 feet deep for primary geomembrane) with a 3 foot setback from the crest of the slope was evaluated to allow pullout of the primary geomembrane before the yield stress in the primary geomembrane is achieved (see **Appendix A**). In this configuration, the anchor trench provides sufficient resistance to prevent pullout during anticipated loading conditions. Large scale yielding or tearing of the primary geomembrane is, however, prevented under extreme loading conditions since the primary geomembrane is designed to pull out of the anchor trench rather than yield. It should be noted that the anchor trench calculations are very conservative, since the use of geosynthetics with the above listed minimum interface shear strength values (see **Section 3.2.1**) provide for an inherently stable system (see **Section 3.3.1**).

3.2.5 Protection of Geomembrane

Appendix A contains a cushion geotextile analysis which shows the minimum weight of nonwoven geotextile required to perform adequately as a cushion under long-term loads. Based on the analysis, the drainage geocomposite should have a minimum of 10.5 ounces per square yard (oz./SY) of nonwoven geotextile (conservatively not including any cushioning from the geonet drainage core) in order to protect the geomembrane from the gravel columns surrounding the leachate pipes. A 6 oz./SY nonwoven geotextile bonded to each side of the geonet drainage core will satisfy this requirement.

In that the analysis was based on a maximum load for Cells 1-3, the existing 12 oz./SY nonwoven cushion geotextile in Cell 1 and the double-bonded drainage geocomposite in both Cells 1 and 2 are suitable as a cushion under the proposed Cell 3 loads.

3.3 Anticipated Stresses

3.3.1 Installation Stresses

The most critical time for potential damage to the liner system occurs following installation of the geomembrane liner when the overlying components are placed. Installation stresses imposed on the geomembrane due to deployment are negligible under normal procedures. Due to the selection of textured HDPE and LLDPE geomembranes on facility side slopes, interface friction angles for geosynthetics are expected to be greater than the maximum 3H:1V side slope angle (see **Section 3.2.1**). Thus, negligible stresses will be placed on geosynthetics and the system will be inherently stable.

Installation of the drainage geocomposite and aggregate/protective cover over the geomembrane (and other geosynthetics) will need to be performed with extreme care so as to minimize the potential for damage to these geosynthetics. The aggregate/protective cover will be placed on landfill side slopes by pushing from the bottom up using low ground pressure (LGP) (< 6 pounds per square inch (psi)) dozers. This operation will be carefully observed such that the development of wrinkles and tension in the underlying geosynthetics is minimized. With the exception of properly operated ATVs used in deployment of the geosynthetics, no construction equipment should be allowed to drive down the landfill side slopes. Based on the bearing capacity analysis, it is recommended that non-LGP dozers (up to 12 psi contact stress), if used on the landfill base slopes, operate on at least 1 foot of aggregate/protective cover; also it is recommended that trucks used to haul material into the landfill have at least 3 feet of separation between the truck tires and the geomembrane.

3.3.2 Operational Stresses

Operational stresses are greatest during placement of the initial lift of waste. The facility Operations Manual (**Attachment D**) discusses the placement of an initial 4 to 5 foot (min.) lift of select waste (free of larger items) to minimize the potential for damage to the liner system. Based on the bearing capacity analysis, it is recommended that waste compactors have at least 3 feet of vertical separation to the liner system (when compacting the initial lift).

3.3.3 Long-Term Stresses

Settlement analyses performed for Phase 4A demonstrate that the anticipated tensile stresses in the liner system due to settlement of underlying subgrade will be negligible. Also, refer to **Section 3.4.1** for a discussion of anticipated stresses in the piggyback liner system from the settlement of underlying waste.

3.4 Piggyback Liner Considerations

3.4.1 Settlement and Liner System Stresses

The original analysis performed as part of the Permit to Construct application for Phase 4A Cells 1 & 2 was revisited to evaluate the effect of increasing the height of Cell 3. The original analysis considered a worst case cross section running east-west through Phase 4A under the maximum waste thicknesses (Cross Section B). This section was compared with an updated section (see **Figure 3-1**) to evaluate the changes in waste thickness and the corresponding changes in liner system stresses along critical sections. The evaluation, which is provided in **Appendix A**, shows that long-term stresses in the liner system are expected to be less than 1 percent. This maximum amount of strain is well below the 5% level, which is considered to be the tolerable limit.

Additionally, an evaluation of settlement along the alignment of the Cell 3 leachate collection header pipe (running north-south) was provided in the following approved document:

> Slope Stability, Settlement, and Bearing Capacity Evaluation
> Johnston County MSW Landfill - Phase 4A
> Prepared by Richardson Smith Gardner & Associates, Inc.
> Dated December 2008.

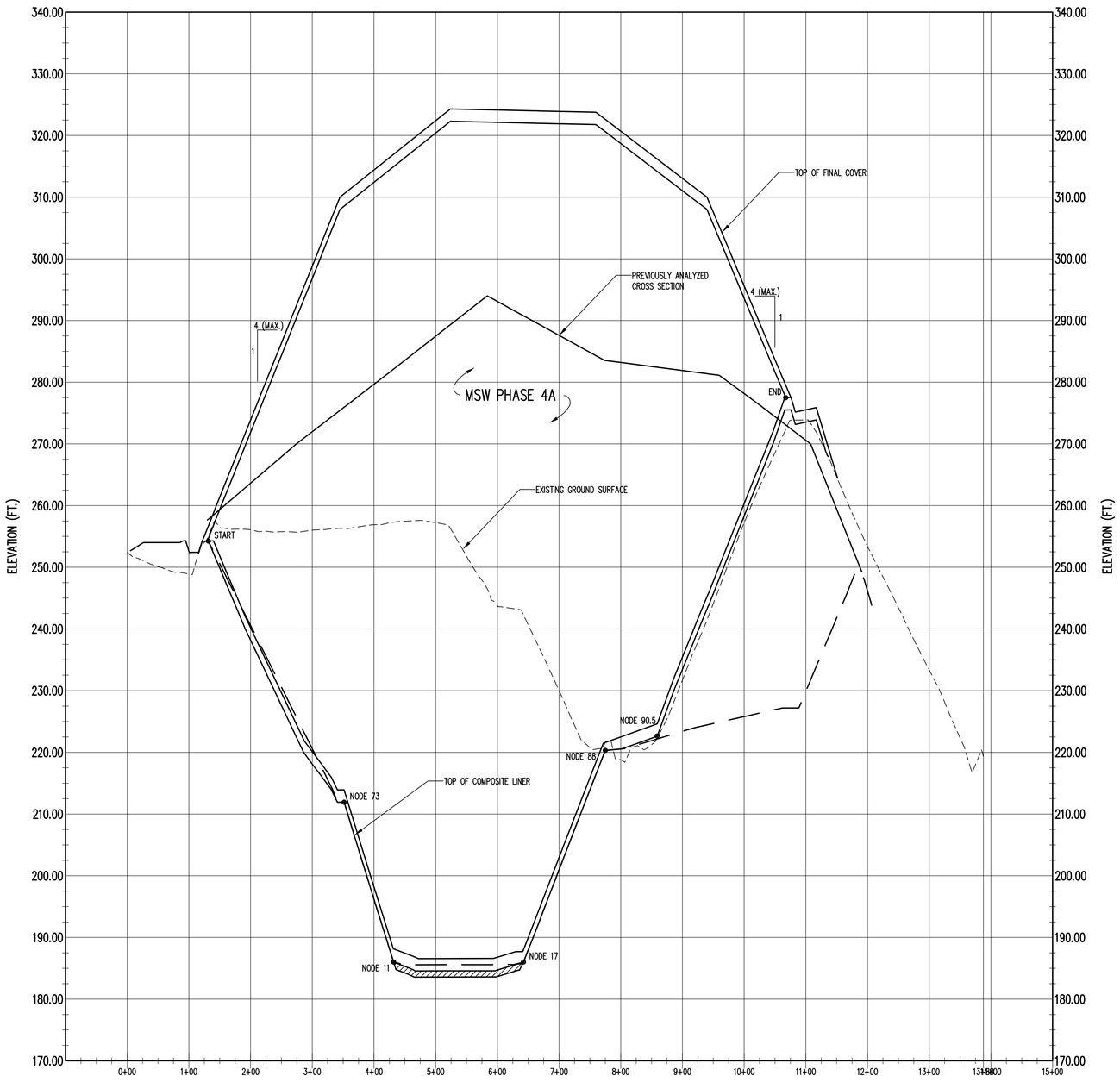
This evaluation showed that maximum anticipated strains in the Cell 3 liner system will be well below the 5% level. The evaluation also demonstrated that positive slope will be maintained along this header pipe after settlement.

3.4.2 Localized Subsidence

The original analysis performed as part of the Permit to Construct application for Phase 4A Cells 1 & 2 evaluated the effect of localized subsidence (i.e. "rusted refrigerator" evaluation) on the piggyback liner system. The best method for ensuring that localized subsidence is not a concern is to use geophysical methods to check the near surface for potentially large metal objects and physically removing them (or verifying that they are not present within about 5 feet of the surface).

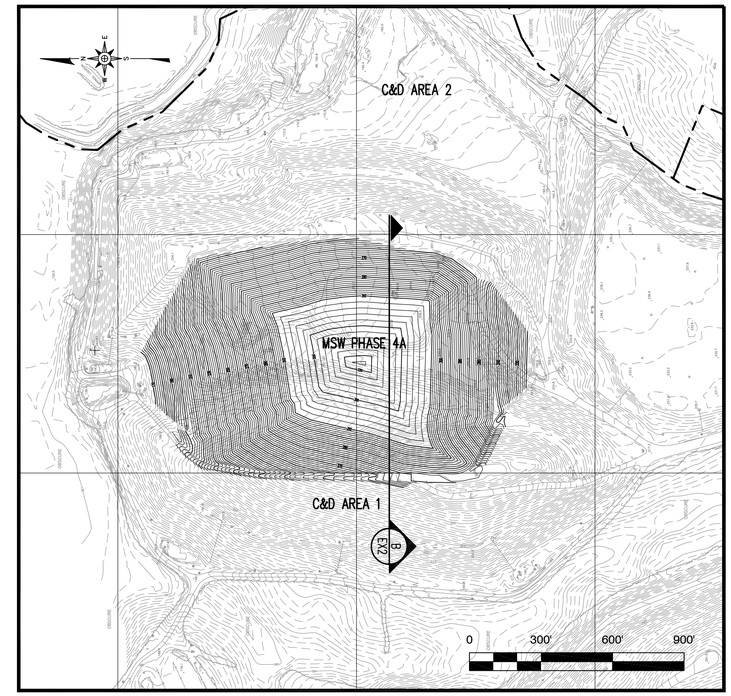
A geophysical survey which utilized frequency-domain electromagnetic (EM) imaging techniques was performed across the Cells 1-3 area by The Hutchinson Group, Ltd. prior to the construction of Cell 1. The survey indicated no potential near-surface metal anomalies in the Cell 1 or Cell 2 area but did identify five potential anomalies; four of which were within the Cell 3 limits (see **Figure 3-2**). The anomalies within the Cell 3 limits were marked and evaluated as part of the construction of Cell 3. As documented in the construction quality assurance (CQA) report for Cell 3[2], only small near-surface metal objects were found.

[2] Richardson Smith Gardner & Associates, Inc. (2009), "Construction Quality Assurance Report, Johnston County MSW Landfill - Phase 4A - Cell 3", Smithfield, NC, July 2009.



SECTION B

SECTION B EX2
NOT TO SCALE



30'
20'
10'
0

0 100' 200' 300'

LEGEND

- 200 — EXISTING 10' CONTOUR
- EXISTING 2' CONTOUR
- 150 — PROPOSED 10' CONTOUR
- PROPOSED 2' CONTOUR
- PROPERTY LINE

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY GEODATA CORP., BASED ON JUNE 6, 2008 AERIAL PHOTOGRAPHY.

NO.	DATE	REVISION
1	11/08	RESPONSE TO NCDENR COMMENTS AND ADDITIONAL CHANGES

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Ave.
Raleigh, N.C. 27603
www.rsgengineers.com
ph: 919-828-0577
fax: 919-828-3899

SEAL

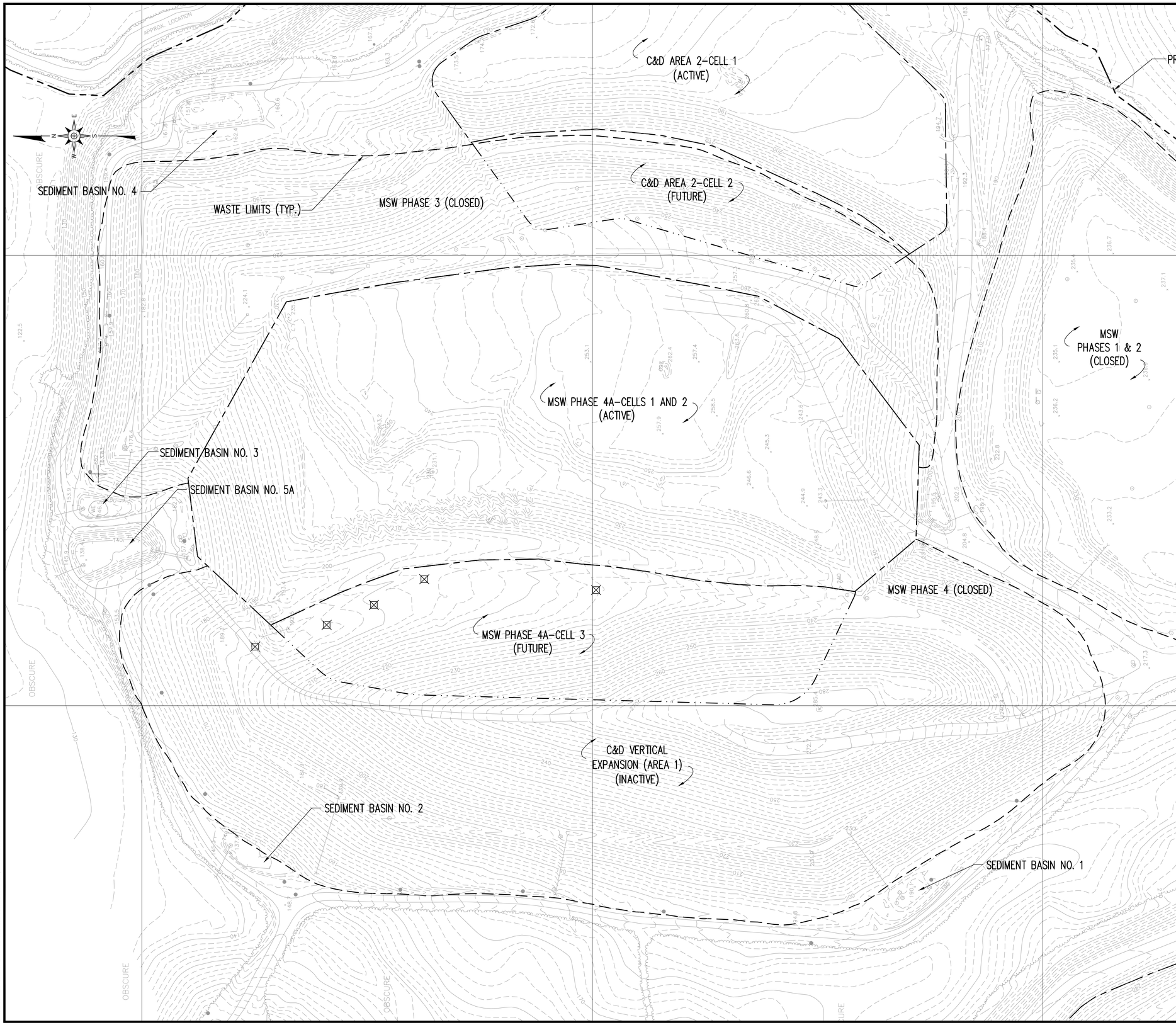
SEAL

PROJECT TITLE:
JOHNSTON COUNTY MSW LANDFILL
PHASE 4A - CELL 3
PERMIT AMENDMENT DRAWINGS

DRAWING TITLE:
PIGGYBACK LINER ANALYSIS
COMPARISON OF CRITICAL
CROSS SECTION

DESIGNED BY: P.K.S.	DRAWN BY: J.A.L.
CHECKED BY:	PROJECT NO.: JOHN 07-2
SCALE: AS SHOWN	DATE: MAY 2007
FILE NAME: JOHN-D0509A	
SHEET NO.: FIG. 3-1	DRAWING NO.:

G:\CAD\Johnston\John 07-2\rev 102108\sheets\JOHN-D0509A.dwg - 12/2/2008 10:26 AM



LEGEND

- EXISTING 10' CONTOUR (SEE REFERENCE 1)
- EXISTING 2' CONTOUR
- PROPERTY LINE
- LIMIT OF LINER (LINED LANDFILL UNITS)
- APPROXIMATE EXISTING WASTE LIMITS (UNLINED UNITS)
- FUTURE LANDFILL AREAS
- NEAR SURFACE METAL ANOMALY (IDENTIFIED BY HUTCHINSON GROUP SURVEY 2002)

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY GEODATA CORPORATION, BASED ON JUNE 6, 2008 AERIAL PHOTOGRAPHY.

0 100' 200' 300'

DATE	NO.	REVISION
11/08	1	RESPONSE TO NCDENR COMMENTS AND ADDITIONAL CHANGES

RICHARDSON SMITH GARDNER & ASSOCIATES
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fax: 919-828-3899

SEAL

SEAL

PROJECT TITLE:
JOHNSTON COUNTY MSW LANDFILL
PHASE 4A - CELL 3
PERMIT AMENDMENT DRAWINGS

DRAWING TITLE:
APPROXIMATE LOCATION
OF NEAR-SURFACE
METAL ANOMALIES

DESIGNED BY: P.K.S.	DRAWN BY: C.T.J.
CHECKED BY:	PROJECT NO.: JOHN 07-2
SCALE: AS SHOWN	DATE: JUNE 2007
FILE NAME: JOHN-D0511A	
SHEET NO.: FIG. 3-2	DRAWING NO.

G:\CAD\Johnston\John 07-2\rev 102108\sheets\JOHN-D0511A.dwg - 11/18/2008 6:24 PM

4.0 LEACHATE MANAGEMENT SYSTEM DESIGN

This section addresses the design of the Phase 4A leachate management system. The leachate management system for the Phase 4A consists of the leachate collection system (LCS), a leak detection system (LDS), and the leachate transmission and storage system. Note that the design of the existing leachate transmission and storage system was evaluated as part of the Permit to Construct application for Phase 4A - Cells 1 and 2[3].

The LCS and LDS for Phase 4A consists of natural and/or geosynthetic drainage media on the base and side slopes of the landfill as well as a collection pipe network. Leachate collected from Phase 4A is pumped via an existing HDPE force main to the existing leachate storage lagoon. Technical specifications for leachate management system components were provided in the following approved document:

Technical Specifications
Johnston County Landfill
Prepared by Richardson Smith Gardner & Associates, Inc.
Dated December 2008.

Construction quality assurance requirements for leachate management system components can be found in **Attachment C**. Also refer to the Permit Drawings (**Attachment H**) for leachate management system details.

4.1 Leachate Collection System (LCS) Components

The LCS is constructed directly above the primary geomembrane on both the base and side slopes of the landfill. The LCS functions to collect leachate as quickly as is practical and to conduct the fluid out of the landfill via the sump located at the north end of Cell 1. The LCS also provides protection of the liner system. The goal of the LCS is to minimize the hydraulic head acting on the liner, thereby reducing the leak potential. As described in **Section 2.5.2**, the components of the LCS consist of the following (top-down):

Base Slopes (Phase 4A - Cell 1):

- a 12-inch thick layer of protective cover soil;
- a separator/filter (Type GT-S) geotextile;
- a 12-inch thick layer of leachate collection media (No. 78 stone);
- a series of perforated collection pipes placed within coarse aggregate columns; and
- a cushion (Type GT-C) geotextile.

[3] G.N. Richardson & Associates, Inc. (2001), "Permit to Construct Application, Johnston County MSW Landfill – Phase 4A, Johnston County, North Carolina", April 2000 (as revised through December 2001).

Base and Side Slopes (Phase 4A - Cell1 (Side Slopes Only), Cell 2, and Cell 3):

- a 24-inch thick layer of protective cover soil;
- a series of perforated collection pipes placed within coarse aggregate columns; and
- a drainage geocomposite.

Additionally, as noted in **Section 2.5.3**, the County elected to install geosynthetic rain cover over much of the LCS to aid stormwater/leachate separation.

4.1.1 Drainage Aggregate

Drainage aggregate used in the LCS consists of coarse aggregate (No. 57 stone or similar aggregate meeting required permeability and angularity criteria) which will provide primary leachate removal capacity is placed around collection piping. Leachate collection media consisting of No. 78 stone is also used as a blanket drain on the base slopes of Cell 1.

4.1.2 Drainage Geocomposite

The drainage geocomposite functions as a blanket drain to conduct leachate to collection piping. The drainage geocomposite consists of a polyethylene drainage net (geonet) bonded on both sides with a nonwoven, needle-punched geotextile. The minimum required transmissivity of the drainage geocomposite was determined in the LDS/LCS drainage layer analysis (see **Section 4.4.1** and **Appendix A**). The minimum required properties of the drainage geocomposite to perform as a cushion were determined in the cushion geotextile analysis (see **Section 3.2.5** and **Appendix A**).

4.1.3 Separator (Type GT-S) Geotextile

A nonwoven separator (Type GT-S) geotextile is used as a component of the drainage geocomposite. The Type GT-S geotextile is also installed over gravel columns to keep the aggregate from fouling prior to waste placement. Due to long-term bio-clogging concerns, the geotextile should be cut and laid back or removed from gravel columns just ahead of waste placement so that the waste can be placed in direct contact with the aggregate. The minimum required properties of the Type GT-S geotextile to perform as a filter were determined in the filter geotextile analysis (see **Section 4.4.5** and **Appendix A**).

4.1.4 Collection Piping

The leachate collection piping is high density polyethylene (HDPE) (DR 13.5 - Cells 1 and 2; DR 17 - Cell 3) pipe. The required pipe dimension ratio (DR) (ratio of outside pipe diameter to wall thickness) was selected based upon the

maximum static and dynamic loading conditions to be placed on the pipe (see **Section 4.4.4** and **Appendix A**).

Collection pipes have coarse aggregate placed over and around them and are referred to as "gravel columns". These gravel columns provide a significant amount of storage, provide primary leachate removal capacity, and are resistant to biological clogging. Since the gravel column aggregate extends through the protective cover and is in direct contact with the waste (the Type GT-S geotextile placed initially was removed prior to waste placement), the long-term clogging potential is significantly reduced. Cleanout ports are designed, where possible, at the end of leachate collection piping along the perimeter berm to allow periodic hydro-washing and inspection of the piping when necessary. The collection piping of the LCS conducts the leachate to the Cell 1 sump for the removal from the landfill by side riser pumps.

4.1.5 Geosynthetic Rain Cover (GRC)

The GRC consists of a thin geomembrane. The GRC was used at the option of the County to prevent stormwater infiltration through the protective cover and the gravel columns of the LCS in inactive cells. Where used, the GRC was removed by operations personnel prior to activation of an individual disposal area or portion thereof.

4.2 Leak Detection System (LDS) Components

The LDS is constructed directly above the secondary geomembrane on both the base and side slopes of the landfill. The purpose of the LDS is to provide rapid detection of a major breach in the primary geomembrane and limit the head on the secondary geomembrane, thereby reducing the leak potential. The components of the LDS consist of the following (top-down):

Base and Side Slopes:

- a drainage geocomposite; and
- leak detection trenches (No. 78 stone and collection pipe).

4.2.1 Drainage Aggregate

Drainage aggregate used in the LDS consists of coarse aggregate (No. 78 or similar aggregate meeting required permeability and angularity criteria) placed around collection piping within leak detection trenches.

4.2.2 Drainage Geocomposite

The drainage geocomposite functions as a blanket drain to conduct any leachate which leaks through the overlying primary geomembrane and GCL to collection piping. The drainage geocomposite consists of a polyethylene drainage net (geonet) bonded on both sides with a nonwoven, needle-punched geotextile. The minimum required transmissivity of the drainage geocomposite was determined in the LDS/LCS drainage layer analysis (see **Section 4.4.1** and **Appendix A**).

4.2.3 Collection Piping

As for the LCS, the collection piping of the LDS is high density polyethylene (HDPE) (DR 13.5 - Cells 1 and 2; DR 17 - Cell 3) pipe. The required pipe dimension ratio (DR) was selected based upon the maximum static and dynamic loading conditions to be placed on the pipe (see **Section 4.4.3** and **Appendix A**).

The collection piping of the LDS conducts the leachate to the existing leak detection sump in Cell 1 or directly to the existing leak detection pump station. From the leak detection sump the leachate is pumped to the leak detection pump station. From the leak detection pump station, the leachate is pumped to the leachate storage lagoon via the existing force main.

4.3 Leachate Transmission and Storage System Components

Leachate from the Phase 4A LCS is collected in the leachate sump located at the north end of Cell 1. The leachate collected in the sump is pumped to the leachate storage lagoon via the existing force main.

4.3.1 Pumps

Two side riser pumps are used in the leachate sump (Leachator or equal that are rated at a minimum flow of 75 to 100 gallons per minute (gpm)). The pumps and control system include an alarm for high level conditions. A flow meter is included to monitor leachate production. During normal operations, the pumps alternate to reduce wear on one particular pump. Under high flow conditions, both pumps operate in tandem to keep the head on the liner system to a minimum. Pump requirements were determined in the leachate pump and force main evaluation performed as part of the Permit to Construct application for Phase 4A - Cells 1 and 2.

4.3.2 Transmission Piping

The leachate transmission piping is HDPE (DR 17) pipe. The required pipe DR was selected as part of the Permit to Construct application for Phase 4A - Cells 1

and 2 based upon the maximum static and dynamic loading conditions to be placed on the pipe.

4.3.3 Storage Lagoon/Wastewater Equalization Basin

Leachate from Phase 4A is routed to the existing leachate storage lagoon (pond) which has a capacity of approximately 4,200,000 gallons (not including 2 feet of freeboard). The pond is lined with a composite liner system consisting of 24 inches of compacted clay liner ($k \leq 1 \times 10^{-7}$ cm/sec) overlain by a 60 mil HDPE geomembrane and a 6 inch thick Fabri-Form concrete liner. The lagoon drains to an existing pump station. From this pump station, the leachate is pumped via a force main to a local wastewater treatment plant (WWTP) owned and operated by Johnston County.

Due to the large size of the pond relative to typical leachate generation at the site (between 1.26M and 3.05M gallons per year based on 2004 and 2005 data), the County previously modified the storage lagoon for use as an equalization basin for raw wastewater.

The maximum water level in the modified pond will be maintained at approximately elevation 151 to 152. With a top of pond elevation of approximately 155, this will provide a volume of at least 1 foot (approximately 650,000 gallons) below the required 2 feet of freeboard under typical conditions. This capacity is much greater than the anticipated surge volume from a newly operational landfill unit. Additionally, considering the very large pumping capacity (two 1,300 GPM pumps) of the existing raw sewage pump station which is connected to the pond, the ability to handle leachate generation at the site is very high.

The operation of the leachate storage lagoon as an equalization basin will not affect the County's ability to draw-down the basin in advance of predicted heavy rainfall (tropical storm, hurricane, etc.).

4.4 Leachate Management System Design

4.4.1 LDS/LCS Drainage Layer Analysis

The spacing of the LDS/LCS collection pipes was evaluated to verify that the maximum hydraulic head on the geomembrane will be less than 1 foot (or within the thickness of the drainage geocomposite - where used) during normal operating conditions. The analysis (see **Appendix A**) was conducted using McEnroe's mounding equations and considered impingement rates corresponding to active, intermediate, and final conditions (Based on HELP Model projections - see **Section 4.5**). The analyses for intermediate and final conditions conservatively included reduction factors (intrusion, creep

deformation, chemical clogging, and biological clogging plus an overall factor of safety) to represent these longer-term cases.

Based on the analysis, a minimum transmissivity of 5.0 x 10^{-4} cubic meters per meter per second (m^3/m/sec) was selected for the drainage geocomposite in the Cell 3 LDS and LCS. Transmissivity tests for the drainage geocomposite were conducted based on anticipated field conditions (maximum normal load, boundary conditions, and gradient) as part of construction documentation.

An evaluation of the natural and geosynthetic drainage media used in the LDS and LCS for Cells 1 and 2 was performed as part of the Permit to Construct application for Phase 4A - Cells 1 and 2.

4.4.2 LDS/LCS Pipe Sizing

The capacity of LDS piping was evaluated by comparing the maximum capacity of the assumed pipe diameter with the peak daily leachate generation rate (100 gallons/acre/day assumed) (see **Appendix A**). Based on this evaluation (for Cell 3), a 4-inch diameter HDPE (DR 17) (I.D. = 4.0-inches) will handle a maximum drainage area of over 50 acres with a factor of safety of over 50. This maximum drainage area greatly exceeds the maximum drainage area to be drained by any one pipe.

The capacity of LCS piping was evaluated by comparing the maximum capacity of the assumed pipe diameter with the peak daily leachate generation rate (0.55 inches/day = 14,900 gallons/acre/day) (see **Appendix A**). Based on this evaluation (for Cell 3), a 6-inch diameter HDPE (DR 17) (I.D. = 5.8-inches) will handle a maximum drainage area of over 20 acres with a factor of safety of 2.0. This maximum drainage area greatly exceeds the maximum drainage area to be drained by any one pipe.

4.4.3 LDS/LCS Pipe Perforation Analysis

The maximum LDS/LCS pipe perforation size was evaluated based on the size of the pipe bedding. LDS/LCS pipe perforation calculations are presented in **Appendix A**. For No. 78 stone (or similarly graded) bedding, a maximum perforation size of 0.375 inches (diameter of circular holes) is acceptable. For No. 57 stone (or similarly graded) bedding, a maximum perforation size of 0.5 inches (diameter of circular holes) is acceptable.

The number of perforations required will depend on the quantity of leachate being handled by the pipe. However, for collection piping located along the center of each cell, 2 rows of 0.5-inch diameter circular holes or 0.125-inch wide by 1.0-inch long slots aligned 60 degrees from the bottom of the pipe with holes 4 to 6 inches apart will allow much greater inflow to the pipe than required to

handle the peak leachate generation rates (Optionally, a third row of perforations can be added along the top of the pipe.).

4.4.4 Leachate Pipe Mechanical Properties

All leachate piping is HDPE. For HDPE pipe, the required pipe dimension ratios (DR) for collection, side riser, and transmission piping were selected based upon anticipated static and dynamic loading conditions both during and after construction. Both the static and dynamic criteria are discussed briefly below. Pipe stress analyses for HDPE pipe are presented in **Appendix A**. All collection and side riser piping will be bedded in No. 57 (or similar) stone to ensure a safe load distribution on the piping under long-term conditions.

4.4.4.3 Static Load Requirement

The vertical stress applied by the fully constructed landfill, including (for collection and side riser piping) maximum waste and final cover loads, was used to calculate the required DR. Calculations were performed for crushing, buckling, and pipe deflection.

For HDPE collection piping (also represents a worst case for side riser and transmission piping), the analysis for static loading was performed using a normal compressive stress greater than anticipated to account for potential future vertical expansion (approximately 73 psi assuming a maximum waste/cover thickness of ±150 feet and a density of 70 pcf). The analysis indicates that the selected DR of 17 will have factors of safety of 2.6 and 4.5 for crushing and buckling, respectively.

The analysis indicates that pipe deflections for the piping will be within acceptable limits.

Note that the analysis verified that the existing DR 13.5 piping in Cells 1 and 2 will handle the additional loading of Cell 3.

4.4.4.4 Equipment Loading (Dynamic Load Requirement)

During construction of the landfill, it may be necessary for certain construction equipment to operate over the pipe. Under this worst case condition, a dynamic impact factor of 1.5 was used to account for equipment loading. Under no circumstances should tracked vehicles be allowed to turn when operating over the pipe.

For analysis, typical construction and operations equipment were selected for calculation of dynamic crushing loads.

On the basis of the selected DR, the following equipment limitations will be employed:

- Placement of the leachate collection media/protective cover and No. 57 stone:
  - Low ground pressure (LGP) (< 6 psi) tracked equipment on 6H:1V and steeper slopes (12 inch minimum cover over geosynthetics and/or piping);
  - Tracked equipment with ground pressure of 12 psi or less on slopes flatter than 6H:1V (12 inch minimum cover over geosynthetics and/or piping); and
  - Wheeled equipment (hauling vehicles) (3 foot minimum cover over geosynthetics and/or piping).

- Placement of initial lift of waste:
  - Landfill compactors and hauling vehicles (3 foot minimum cover over geosynthetics and/or piping).

4.4.5 Filter Geotextile Analysis

A filter geotextile analysis was performed to determine the apparent opening size (AOS) and permittivity required for the proper performance of 1) the Type GT-S geotextile and 2) the upper geotextile component of the drainage geocomposite as a filter. The analysis (see **Appendix A**) assumes that the protective cover will be silty and clayey sands (based on the typical grain size curves evaluated). Based on the filter geotextile analysis, recommended AOS and permittivity of the upper geotextile component are as follows:

AOS (upper geotextile) (ASTM D 4751):	70+ (U.S. Sieve)
Permittivity (upper geotextile) (ASTM D 4491):	1.0 sec-1

AOS and permittivity were determined based on typical values for a 6 oz./SY nonwoven geotextile.

4.5 Leachate Generation

The leachate management system for Phase 4A has been designed to minimize head on the liner system and to maximize effective operations. The leachate generation rate for the landfill is heavily dependent on the following:

- Design storm event(s);
- Amount of waste in the cell; and
- Method of landfill operations.

An evaluation of leachate generation rates was performed to estimate flow rates during active, interim, and closed conditions (see **Appendix A**). The Hydrologic Evaluation of Landfill Performance (HELP) Model (Version 3.07) was used to confirm the volume of leachate anticipated during these three discrete conditions. It was found that the HELP Model values were approximately equal to or somewhat lower than empirical generation rates for these conditions which are based upon actual data. Thus, the empirical rates were applied to the proposed operational conditions to yield leachate generation rates for various stages of landfill development.

In order to determine typical leachate flow rates, empirical daily leachate generation values of 1,200 gallons per acre per day (gpapd) for active, 500 gpapd for interim, and 100 gpapd for final were applied to the proposed operational scenarios. Each operational scenario is basically a "snapshot" developed to depict the typical combination of areas which are being operated under active, interim, and final cases.

In order to simulate a "surge" volume, a precipitation event of 3.2 inches for a 1-year 24-hour storm was applied over a maximum open area of the landfill corresponding to each newly opened cell and added to the leachate being produced under active, interim, and final conditions. The 1-year recurrence interval was selected since it is a conservative representation of the timeframe that an area will be open and only partially filled across the bottom. As shown in the calculations, the flow rate with the 1-year 24-hour storm event is estimated at approximately 191,000 gallons. This should be considered as a "worst case" scenario. Once covered by waste, the potential for a "surge" event in the landfill is essentially eliminated due to the ability of the waste to absorb and slowly release precipitation. The more typical flow rate for Phase 4A operations is anticipated to be less than 50,000 gallons per day (includes flow from Phase 5 and Area 2).

The ability to prevent ponding in the landfill rests on the ability to hold leachate in the storage lagoon. As noted in **Section 4.2.3**, the capacity of the existing storage lagoon is approximately 4,200,000 gallons, which is greater than the total volume of leachate that can be generated by the "surge" event. This means that little to no ponding of leachate will occur in the landfill when the lagoon can handle the entire design storm.

In order to minimize the ponding potential in the landfill, the County will remove leachate from the storage lagoon at a rate to maintain water levels in the lagoon at or below elevation 152 on a typical basis, which will allow approximately 650,000 gallons of storage while maintaining 2 feet of freeboard.

5.0 FINAL COVER SYSTEM DESIGN

This section addresses the design of the final cover system for Phase 4A. Technical specifications for final cover system components were provided in the following approved document:

Technical Specifications
Johnston County Landfill
Prepared by Richardson Smith Gardner & Associates, Inc.
Dated December 2008.

Construction quality assurance requirements for final cover system components can be found in **Attachment C**. A facility Closure and Post-Closure Plan, including cost analyses, is provided as **Attachment E**. Also refer to the Permit Drawings (**Attachment H**) for final cover system details.

5.1 Final Cover System Components

As described in **Section 2.5.4**, the final cover system for Phase 4A will consist of the following components (top-down):

- a 24-inch thick vegetative soil layer (including 6 inches of topsoil);
- a drainage geocomposite (with drainage breaks);
- a 30-mil textured LLDPE geomembrane; and
- a 12-inch thick intermediate cover layer.

The final cover system will be placed on prepared intermediate cover at a maximum slope of 4H:1V. Landfill gas (LFG) wells and surface water control devices will also be incorporated into the final cover. The final cover surface will be vegetated upon completion of the final cover installation according to the project seeding specifications.

5.1.1 Vegetative Soil Layer

The function of the vegetative soil layer will be to provide support for vegetation and protection of the underlying geosynthetics. The vegetative soil layer consists of on site or imported soil (the upper 6 inches of which will be capable of supporting the growth of vegetative cover).

5.1.2 Drainage Geocomposite

The drainage geocomposite will function as a blanket drain to conduct infiltration through the vegetative soil layer to the surface water drainage features (i.e. rain gutters, down pipes, and/or perimeter channels) and, thus, reduce the head on the underlying geomembrane.

The drainage geocomposite will consist of a polyethylene drainage net (geonet) bonded on both sides with a nonwoven, needle-punched geotextile. Alternatively, the drainage geocomposite may consist of a series of small diameter pipes bonded on both sides within two nonwoven geotextiles (Draintube or equal). The minimum required transmissivity of the drainage geocomposite was determined in the final cover drainage layer analysis (see **Section 5.2.3** and **Appendix A**).

5.1.3 Geomembrane

The geomembrane component of the final cover system will function as a barrier layer. The geomembrane will be a textured 30-mil thick Linear Low Density Polyethylene (LLDPE) synthetic liner. The geomembrane will be installed by a qualified contractor.

5.1.4 Intermediate Cover

The intermediate cover will separate the waste from and provide a foundation for the overlying geosynthetics. The intermediate cover will be placed by the landfill operator and will consist of on-site or imported soils. Additional intermediate cover may also be used for leveling or fine grading or for bridging of localized soft areas, as required.

5.1.5 Landfill Gas (LFG) Control System

The landfill gas (LFG) control system will consist of collection wells placed within the waste to capture the gas for utilization in the existing LFG to energy system. Optionally, the gas can be passively vented (using utility flares if required or desired). The collection wells should be placed before any final cover geosynthetics are placed. The selected system will be designed to limit the gas pressures on the final cover geosynthetics.

5.1.6 Surface Water Control Devices

Surface water run-off will be controlled in the final cover system by drainage breaks (rain gutters and/or diversion berms) that limit the distance the water flows and collects the water for conveyance (via down pipes and/or perimeter drainage structures) to one of the site sediment basins. The design of rain gutters and down pipes is discussed in **Section 5.2.5**.

5.2 Final Cover System Design

5.2.1 Final Cover Infiltration Analysis

The Hydrologic Evaluation of Landfill Performance (HELP) Model (Version 3.07) was used to evaluate the effectiveness of the proposed final cover at minimizing infiltration on both the flatter top slopes and the steeper side slopes. The HELP Model analyzes the fraction of precipitation that leaves the landfill cover via runoff, infiltration, evaporation, and transpiration.

In that the proposed final cover system is an alternate system to the regulatory minimum cover (RMC) (18 inches of 1 x 10^{-5} cm/s soil with overlying 30 mil geomembrane), the infiltration through the proposed system was compared to the infiltration through the regulatory system. For both the top and side slopes, the infiltration analysis demonstrates that the addition of a drainage geocomposite over the geomembrane significantly reduces the head on the barrier and, thereby, significantly reduces the calculated infiltration as compared to the RMC (see **Appendix A**). The results of the infiltration analysis are summarized as follows:

Condition	Average Annual Infiltration	
	(inches)	(gallons/acre)
Proposed Final Cover System:		
Top Slopes (8%):	0.006	157
Side Slopes (4H:1V):	0.002	46
Regulatory Minimum Final Cover System (RMC):		
Top Slopes (8%):	0.540	14,662
Side Slopes (4H:1V):	0.536	14,553

5.2.2 Slope Stability

An evaluation of the veneer stability of the Phase 4A final cover system was provided in the following approved document:

Slope Stability, Settlement, and Bearing Capacity Evaluation
Johnston County MSW Landfill - Phase 4A
Prepared by Richardson Smith Gardner & Associates, Inc.
Dated December 2008.

The evaluation indicates that the final cover system will satisfy design criteria if the minimum peak interface shear strength for the weakest interface is defined by the following values:

Normal Loads </= 1,000 psf (Based on Veneer Stability):

Cohesion = 0 psf
Phi = 24 degrees

Based on the slope stability analyses performed, a textured geomembrane is required. Interface shear strength testing of the materials representative of those to be used in construction should be conducted prior to installation to verify that the above minimum criteria are met.

5.2.3 Drainage Layer Analysis

The analysis of the final cover drainage layer (drainage geocomposite) is provided in **Appendix A**. This analysis focused on determining the required value of transmissivity to maintain peak heads within the drainage geocomposite.

The analysis was performed based on a worst case condition of 4H:1V (14.0 degrees) slopes and a maximum 140 foot flow length (horizontal projection) to drainage breaks in the drainage geocomposite (coincides with the maximum side slope length between rain gutters). This condition represents the worst case in that adequate transmissivity is required along the steeper side slopes to maintain flow within the geocomposite and, thus, minimize seepage forces in the vegetative soil layer which could affect stability. Calculations were carried out assuming the maximum permeability of the vegetative soil layer is 1×10^{-4} cm/sec (typical for on-site soils to be used). The calculations, which include an overall reduction factor of 6 (accounts for a factor of safety of 2 plus a combined reduction factor of 3 for long-term intrusion, creep, and clogging concerns), indicate that a minimum transmissivity of 1×10^{-3} m^3/m/sec is required for the drainage geocomposite. Transmissivity tests should be conducted based on anticipated field conditions (maximum normal load, boundary conditions, and gradient).

The soils proposed for use as the vegetative soil layer should be evaluated prior to construction to ensure compatibility with all the design assumptions stated herein.

5.2.4 Filter Geotextile Analysis

A filter geotextile analysis was performed to determine the apparent opening size (AOS) and permittivity required to ensure the proper performance of the upper geotextile component of the drainage geocomposite as a filter. The

analysis (see **Appendix A**) assumes that the vegetative soil layer will be silty and clayey sands (based on the typical grain size curves evaluated) and non-dispersive (that is having a double-hydrometer ratio (DHR) (ASTM D 4221) of < 0.5). Based on the filter geotextile analysis, recommended AOS and permittivity of the upper geotextile component of the drainage geocomposite are as follows:

AOS (upper geotextile) (ASTM D 4751):	70+ (U.S. Sieve)
Permittivity (upper geotextile) (ASTM D 4491):	1.0 sec-1

AOS and permittivity were determined based on typical values for a 6 oz./SY nonwoven geotextile.

The soils proposed for use as the vegetative soil layer should be evaluated prior to construction to ensure compatibility with all the design assumptions stated herein.

5.2.5 Rain Gutters and Down Pipes

Calculations for the design of rain gutters and down pipes are provided in **Appendix A**. These devices were conservatively designed based on the peak run-off from a 25-year storm.

5.3 Anticipated Stresses

The most critical time for potential damage to the final cover geomembrane occurs following installation of the geomembrane when the overlying components are placed. Installation stresses imposed on the geomembrane due to deployment are negligible under normal procedures. Due to the selection of textured LLDPE geomembrane, all interface friction angles for geosynthetics are expected to be greater than the maximum 4H:1V side slope angle (see **Section 5.2.2**). Thus, negligible stresses will be placed on geosynthetics and the system will be inherently stable.

Installation of the drainage geocomposite and the vegetative soil layer over the geomembrane (and other geosynthetics) will need to be performed with extreme care so as to minimize the potential for damage to these geosynthetics. The vegetative soil layer will be placed on landfill side slopes by pushing from the bottom up using low ground pressure (LGP) (< 6 psi) dozers. This operation will be carefully observed such that the development of wrinkles and tension in the underlying geosynthetics is minimized. With the exception of properly operated ATVs used in deployment of the geosynthetics, no construction equipment should be allowed to drive down the landfill side slopes.

In the construction of the final cover system, the hauling of materials down side slopes is not generally recommended. However, hauling down side slopes could be possible in certain situations should an analysis by a qualified engineer determine that there is an adequate factor of safety (>/= 1.5 for both static and dynamic loads) against sliding of the

final cover veneer on the weakest interface. The analysis would have to evaluate the actual equipment to be used and use project specific interface shear strength values.

Appendix A

Landfill Design Calculations

Facility and Engineering Plan
Johnston County MSW Landfill - Phase 4A
Smithfield, North Carolina

Facility and Engineering Plan
Appendix A: Landfill Design Calculations

Table of Contents

1.0 Quantity Calculations *(Updated)*
- Capacity Evaluation (Density & Life Calcs.)
- Earthwork Quantities

2.0 Liner and LCS Geosynthetics Calculations*
- Anchor Trench Sizing
- Filter Geotextile Analysis - LCS
- Cushion Geotextile Analysis

3.0 Leachate Management System Calculations*
- LDS/LCS Drainage Layer Analysis
- LDS/LCS Collection Pipe Sizing
- HDPE Pipe Stress Analysis
- Evaluation of Leachate Generation Rates
- Leak Detection Travel Time Analysis

4.0 Final Cover System Calculations*
- Final Cover Infiltration Analysis
- Final Cover Drainage Layer Analysis
- Filter Geotextile Analysis - FCS
- Rain Gutter & Down Pipe Sizing

5.0 Piggyback Liner Calculations*
- Piggyback Liner Evaluation

**Except where updated calculations are noted, the attached calculations were included with the previously approved Permit Amendment application for Phase 4A - Cell 3.*

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Anchor Trench Analysis

JOB NO. JOHNSTON-07-2
DATE 2/16/07
COMPUTED BY PKS
CHECKED BY

Objective To analyze the geomembrane anchor trench to ensure that it will anchor the membrane during normal construction and operation but will pull out before the sheet yields under excessive loads.

Reference Richardson, G.N. & Koerner, R.M. (1987), "Geosynthetic Design Guidance for Hazardous Waste Landfill Cells & Surface Impoundments", EPA Guidance Document (EPA 600/2-87/097).

Assumptions
1. Max. Anchorage (σ_{max}) = 1,300 psi
2. Min. Anchorage (σ_{min}) = 20 psi

Analysis Use the procedure outlined in EPA 600/S2-87/097.

- Trench Resisting Force (T) (lb/ft):

$$T = \frac{qL\tan\delta + (K_P + K_A)\tan\delta(0.5\gamma d^2 + qd)}{FS_{\min}\cos\beta - \sin\beta\tan\delta}$$

(EPA Eq. 3.21)

where:
β = slope angle (degrees)
L = trench set-back from crest (feet)
d = trench depth (feet)
FS_{min} = minimum factor of safety

Backfill Parameters:

ϕ = internal friction angle (degrees)
δ = friction angle between backfill & geomembrane (degrees) (for smooth HDPE/Clay 10-20° is typical) (20 -25+° for textured HDPE)
γ = backfill unit weight (pcf)
K_A = active soil pressure coef. = $\frac{1-\sin\phi}{1+\sin\phi}$
K_P = Passive Soil Pressure Coefficient (Varies from K_o (AT REST) = 1 - $\sin\phi$ to $K_P = 1/K_A$)
q = $d\gamma$

Determine T over range of δ. Compute stress in geomembrane by taking T/A, where A = Thickness of Geomembrane (ft) over unit width of 1 foot. Compare stress with allowable anchorage requirements. Also, compare stress of the geomembrane (60 mil HDPE σ_{yield} = 2,000 psi.).

ANCHOR TRENCH.WPD

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Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 2 / 2
JOB #: JOHNSTON-07-2
DATE: 3/19/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
Anchor Trench Analysis

Input Parameters:

Side Slope Angle: 18.4 degrees

Geomembrane:

Yield Stress (σ_{max}) = 2,000 psi Primary (HDPE) Geomembrane
Thickness = 0.06 in

Backfill Parameters:

Internal Friction Angle (ϕ)= 30 degrees K_A = 0.33
Unit Weight (γ) = 110 pcf K_P = 3.00

Trench Parameters:

Set-Back (L) = 3.0 feet
Depth (d) = 2.0 feet (Worst Case - Secondary GM)
$FS_{min.}$ = 1.5

Stress Calculations:

δ	tan δ	T (lb/ft)	Stress in GM (psi)	FS_{yield}
10	0.176	368.7	512.1	3.9
15	0.268	572.4	795.0	2.5
20	0.364	795.6	1,105.0	1.8
25	0.466	1,045.1	1,451.5	1.4

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Filter Geotextile Analysis - LCS

JOB NO. JOHNSTON-07-2
DATE 3/15/07
COMPUTED BY PKS
CHECKED BY

Objective To determine the maximum geotextile apparent opening size (AOS) to provide proper retention to protect drainage media from piping and clogging from adjacent soil. Additionally, to determine the minimum required geotextile permittivity to provide proper drainage from the adjacent soil. Geotextile filtration properties must be selected based on the up-gradient soil gradation and plasticity and site specific hydraulic conditions.

References

Bhatia, S.K. and Huang, Q. (1995), "Geotextile Filters for Internally Stable/Unstable Soils", *Geosynthetics International*, Vol. 2, No. 3, pp. 537-565.

Koerner, Robert M. (1999), Designing with Geosynthetics, 4th Ed., Prentice-Hall Inc., Englewood Cliffs, NJ, pp. 84-91.

Mirafi - Geotextile Filter Design, Application, and Product Selection Guide, Ten Cate Nicolon Corp. (www.mirafi.com).

Richardson, G.N., Giroud, J-P., and Zhao, A. (2000), Design of Lateral Drainage Systems for Landfills, Tenax Corp., Baltimore.

Assumption The design criteria given assume that the soil is "set" in intimate contact with the geotextile.

Background From Richardson et. al.:

For the purposes of filtration design, soils can be characterized as stable or unstable. Stable soils perform an internal filtration process that limits migration of fines within the soil. Typically, these soil types include well-graded soils. Unstable soils are those which cannot perform self-filtration (i.e. they have the potential to pipe internally). They may include gap-graded, broad-graded, and other highly erodible soils. In gap-graded soils, there exists a coarse and fine fraction, but very little medium fraction. If there is an insufficient quantity of soil particles in the medium fraction, fine soil particles pipe through the coarse fraction. In broad-graded soils, the gradation is distributed over a very wide range of particle sizes such that fine soil tends to pipe through coarser particles.

Analysis

1. **Define Application and Function of Geotextile:**

Define the application and function of the geotextile (i.e. where the geotextile is to be used and whether retention or permeability is the key function of the material) and also the confining stress (i.e. high - leachate collection system; low - final cover system) and flow conditions (i.e. steady-state - landfill drains; dynamic - shoreline protection).

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2. Evaluate Soils Information:

For representative soils, evaluate grain size and plasticity information. From the grain size curves determine the coefficients of uniformity and curvature as follows:

$$C_u = \frac{d_{60}}{d_{10}}$$

$$C_c = \frac{d_{30}^{\ 2}}{\left(d_{10} \times d_{60}\right)}$$

where: C_u = coefficient of uniformity (quantifies the distribution of particle sizes)
C_c = coefficient of curvature (identifies internal soil stability)
d_x = the diameter at which x percent of the soil is finer

For $C_u \leq 4$, the soil is uniformly-graded; for $4 < C_u \leq 20$, the soil is well-graded; and for $C_u > 20$, the soil is broad-graded. Uniformly-graded and broad-graded soils require careful analysis. Gap-graded soils which have a coarse and fine fraction, but limited medium fraction are of particular concern and should be avoided. Gap-graded soils are readily identified by the appearance of the grain size curve. For $1 \leq C_c \leq 3$, the soil should be internally stable (Bhatia and Huang state that soils having $C_c \leq 7$ are internally stable.).

Additionally, in general, particles do not move within soils having a plasticity index (PI) greater than 15% so there is no clogging potential (Richardson et. al.).

3. Selection of Soil Retention Requirements (Maximum AOS):

To determine the maximum AOS, use the method given in Koerner/Mirafi (after Luettich) and the method given in Bhatia and Huang. For the AOS determined by either method, the following shows the relationship between opening size and the corresponding U.S. sieve number (with typical non-woven geotextile information as shown).

Opening Size (mm)	U.S. Sieve
0.150	100 (most 8 to 16 oz/sy non-wovens)
0.180	80
0.212	70 (most 4 to 6 oz/sy non-wovens)
0.250	60
0.300	50
0.425	40
0.600	30

- Luettich Method:

For steady-state conditions, use the chart below.

- Bhatia and Huang Method:

Bhatia and Huang developed the following retention criteria:

For $n \geq 60\%$: $O_{95} < d_{85}(2.71 - 0.36C_c)$ $\quad C_c \leq 7$

$O_{95} < d_{85}(0.65 - 0.05C_c)$ $\quad C_c > 7$

For $n < 60\%$: $O_{95} < d_{85}$

where:
O_{95} = apparent opening size
n = geotextile porosity (%) (for non-woven geotextiles this value is typically 70 to 90%)

4. Determine Geotextile Permittivity Requirements:

Determine the geotextile permittivity requirements:

$$\Psi = \frac{k_g}{t_g} \qquad (\text{sec}^{-1})$$

where:
Ψ = minimum required geotextile permittivity (sec^{-1})
k_g = minimum allowable geotextile permeability (cm/sec)
$k_g \geq i_S k_S$
t_g = geotextile thickness under design load (cm)
i_S = hydraulic gradient (use 1.5 for landfills)
k_S = permeability of retained soil (cm/sec).

5. Other Considerations:

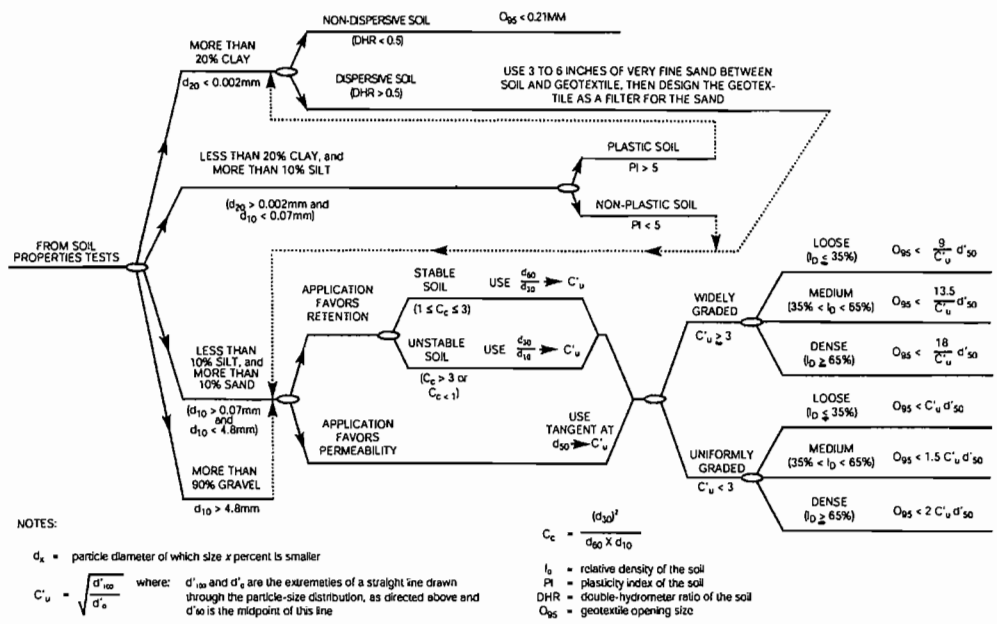
Other things to consider in the design of a filter geotextile include anti-clogging requirements and survivability/durability requirements. For anti-clogging, it is generally best to use the largest AOS that satisfies the retention criteria. For non-woven geotextiles used in landfill applications, an AOS of 0.21 mm (No. 70 sieve) is typically the largest AOS that is available. For survivability/durability concerns, generally an adequately UV stabilized geotextile made from polypropylene or polyester with an AASHTO M288 Strength Class of 2 is suitable for use in subsurface drainage applications.

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Filter Geotextile Analysis - LCS

JOB NO. JOHNSTON-07-2
DATE 3/15/07
COMPUTED BY PKS
CHECKED BY

Chart 1. Soil Retention Criteria of Steady-State Flow Conditions



Ref: Mirafi (After Luettich)

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SHEET: 5/9
JOB #: JOHNSTON-07-2
DATE: 3/19/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
Filter Geotextile Analysis (Leachate Collection System)

Application: Leachate Collection System Drainage Geocomposite
Primary Function: Retention/Permeability
Relative Confining Stress: High
Flow Conditions: Steady-State

	Soil Evaluated				
	643-01-01	643-01-03	643-04-01	643-06-01	
Soil Description:	Brown Sandy Silt	Brown Clayey Sand	Tan Clayey Sand	Reddish Tan Sand w/ Silt	
Soil Type:	ML	SC	SC	SP-SM	
Particle Size (mm) d_{85}:	0.700	0.600	1.000	0.850	
d_{60}:	0.060	0.320	0.480	0.500	
d_{50}:	0.020	0.270	0.370	0.400	
d_{30}:	0.003	0.110	0.200	0.270	
d_{20}:	0.001	0.010	0.120	0.160	
d_{10}:	0.001	0.001	0.010	0.100	
PI:	11	25	18	2	
C_u:	120.00	320.00	48.00	5.00	
	Use Caution - Soil is Broad Graded!	Use Caution - Soil is Broad Graded!	Use Caution - Soil is Broad Graded!	Soil is Well Graded.	
C_c:	0.30	37.81	8.33	1.46	
Luettich Method:*	-----	-----	-----	-----	
Soil Dispersion (When Applicable):	Is Soil Dispersive? (Y/N)	Is Soil Dispersive? (Y/N)	Is Soil Dispersive? (Y/N)	NA	
	N	N	N		
Recommended Maximum AOS (mm) (When Applicable):	**0.210**	**0.210**	**0.210**		
	No. 70 Sieve	**No. 70 Sieve**	**No. 70 Sieve**		
Internal Soil Stability (When Applicable):	NA	NA	NA	Soil is Stable	
				Draw straight line through d60 and d30 to obtain C'u.	
Particle Size (mm) for Determining C'_u d'_{100}:				1.300	
d'_{50}:				0.400	
d'_0:				0.110	
C'_u (When Applicable):				3.44	
				Soil is Widely Graded.	
Soil Relative Density (I_D) (Loose (L), Medium (M), Dense (D) (When Applicable):				D	
Recommended Maximum AOS (mm) (When Applicable):				**2.094**	
				No. 30 Sieve	
Bhatia & Huang Method:	-----	-----	-----	-----	
Internal Soil Stability:	Soil is Stable.	Soil is Unstable.	Soil is Unstable.	Soil is Stable.	
Geotextile Porosity (%):	80	80	80	80	
Recommended Max. AOS (mm):	**1.821**	**-0.744**	**0.233**	**1.857**	
	No. 30 Sieve	**Check Available Geotextiles.**	**No. 70 Sieve**	**No. 30 Sieve**	
Required Geotextile Properties:	-----	-----	-----	-----	
Hydraulic Gradient (i_a):	1.5	1.5	1.5	1.5	
Estimated Soil Permeability (k_s) (cm/sec):	1.0E-03	1.0E-03	1.0E-03	1.0E-03	
Min. Allowable Geotextile Permeability (k_g) (cm/sec):	1.5E-03	1.5E-03	1.5E-03	1.5E-03	
Geotextile Thickness (t_g) (cm):	0.25	0.25	0.25	0.25	
Min. Required Geotextile Permittivity (Ψ) (sec^{-1}):	**0.006**	**0.006**	**0.006**	**0.006**	

***Note: Spreadsheet assumes retention application in using the Luettich Method.**

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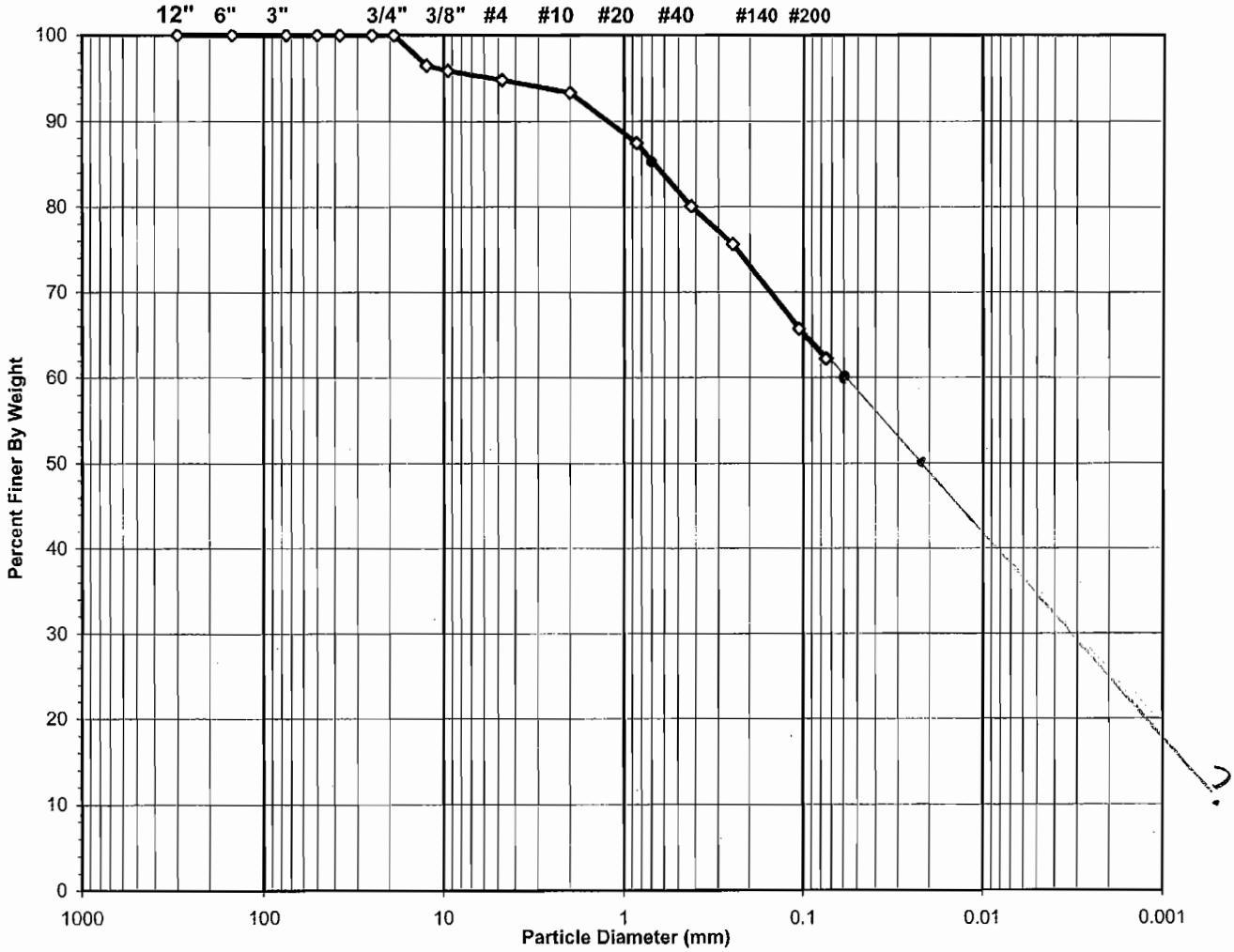
SIEVE ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	GN RICHARDSON & ASSOC.	Boring No.	TP-01
Client Reference	JOHNSTON CO. C&D LF AREA 2 CELL 1	Depth (ft)	1-5'
Project No.	2006-643-01	Sample No.	SF-01
Lab ID	2006-643-01-01	Soil Color	**BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	**gravel**	**sand**	**silt and clay**



USCS Symbol ***ML, TESTED***

USCS Classification ***SANDY SILT***

Tested By JSC Date 10/24/2006 Checked By GSM Date 10-25-06

 DCN: CT-S3C DATE 6-25-98 REVISION: 2 *\\Lab1\c\2006 PROJECTS\2006-643 GNRA JOHNSTON CO\[2006-643-01-01 SIEVE.XLS]Sheet1*

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geotechnics
INTEGRITY IN TESTING

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

Client	GN RICHARDSON & ASSOC.	Boring No.	TP-03
Client Reference	JOHNSTON CO. C&D LF AREA 2 CELL 1	Depth (ft)	0.5-3'
Project No.	2006-643-01	Sample No.	SF-03
Lab ID	2006-643-01-03	Soil Color	**BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	**gravel**	**sand**	**silt and clay**

USCS Symbol ***SC, TESTED***

USCS Classification ***CLAYEY SAND***

Tested By JSC Date 10/24/2006 Checked By Gem Date 10-25-06

 DCN: CT-S3C DATE 6-25-98 REVISION: 2 *\\Lab1\c\2006 PROJECTS\2006-643 GNRA JOHNSTON CO\[2006-643-01-03 SIEVE.XLS]Sheet1*

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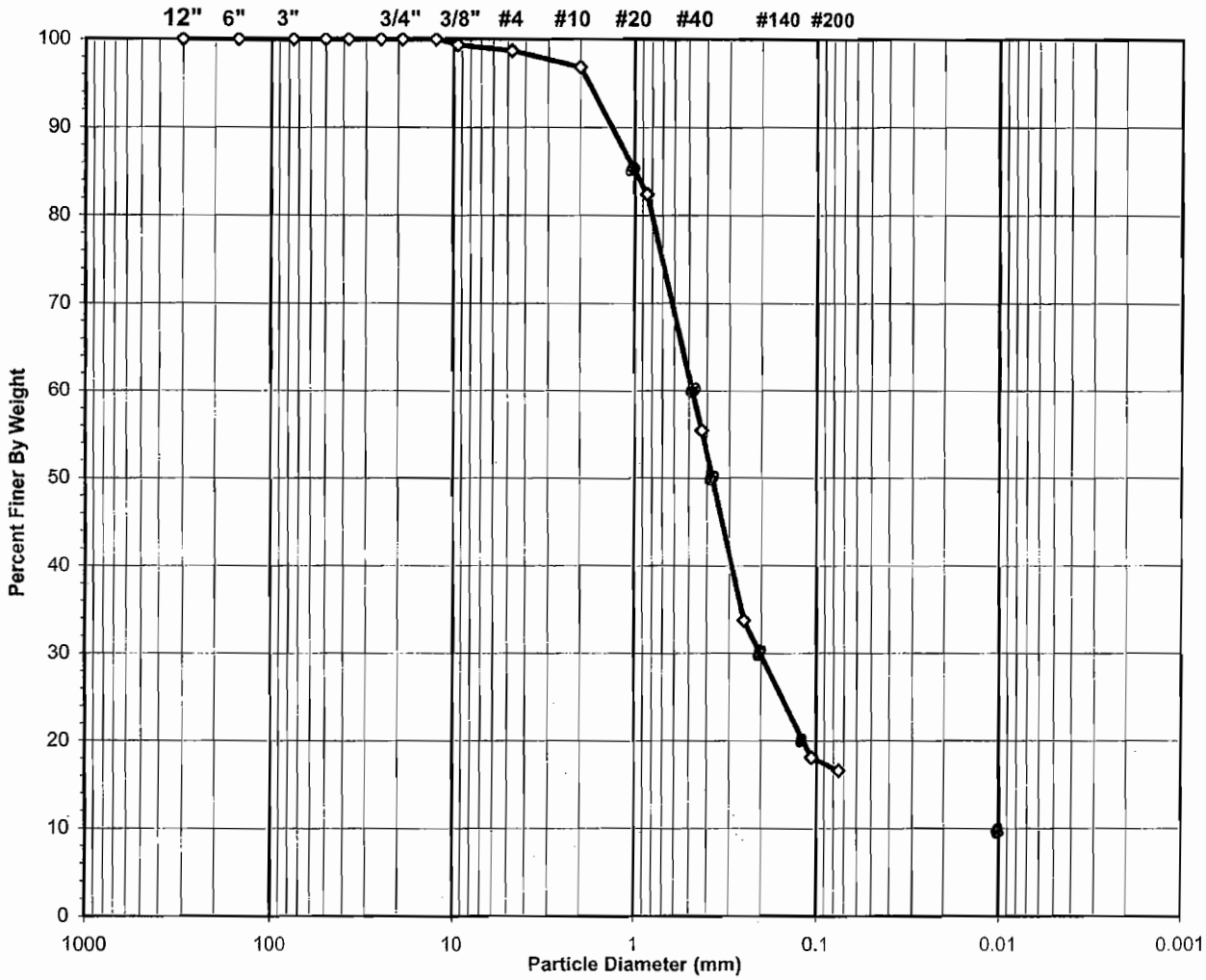
INTEGRITY IN TESTING

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

Client	G.N. RICHARDSON & ASSOC.	Boring No.	NA
Client Reference	JOHNSTON CO. C&D LF AREA 2 CELL 1	Depth (ft)	SURFACE
Project No.	2006-643-04	Sample No.	NA
Lab ID	2006-643-04-01	Soil Color	TAN

USCS	SIEVE ANALYSIS		HYDROMETER
	gravel	sand	silt and clay



USCS Symbol ***SC, TESTED***

USCS Classification ***CLAYEY SAND***

Tested By JBD Date 11/21/06 Checked By MCW Date 11/21/06

 DCN: CT-S3C DATE 6-25-98 REVISION: 2 *C:\2006 PROJECTS\2006-643 GNRA JOHNSTON CO\[2006-643-04-01 SIEVE.XLS]Sheet1*

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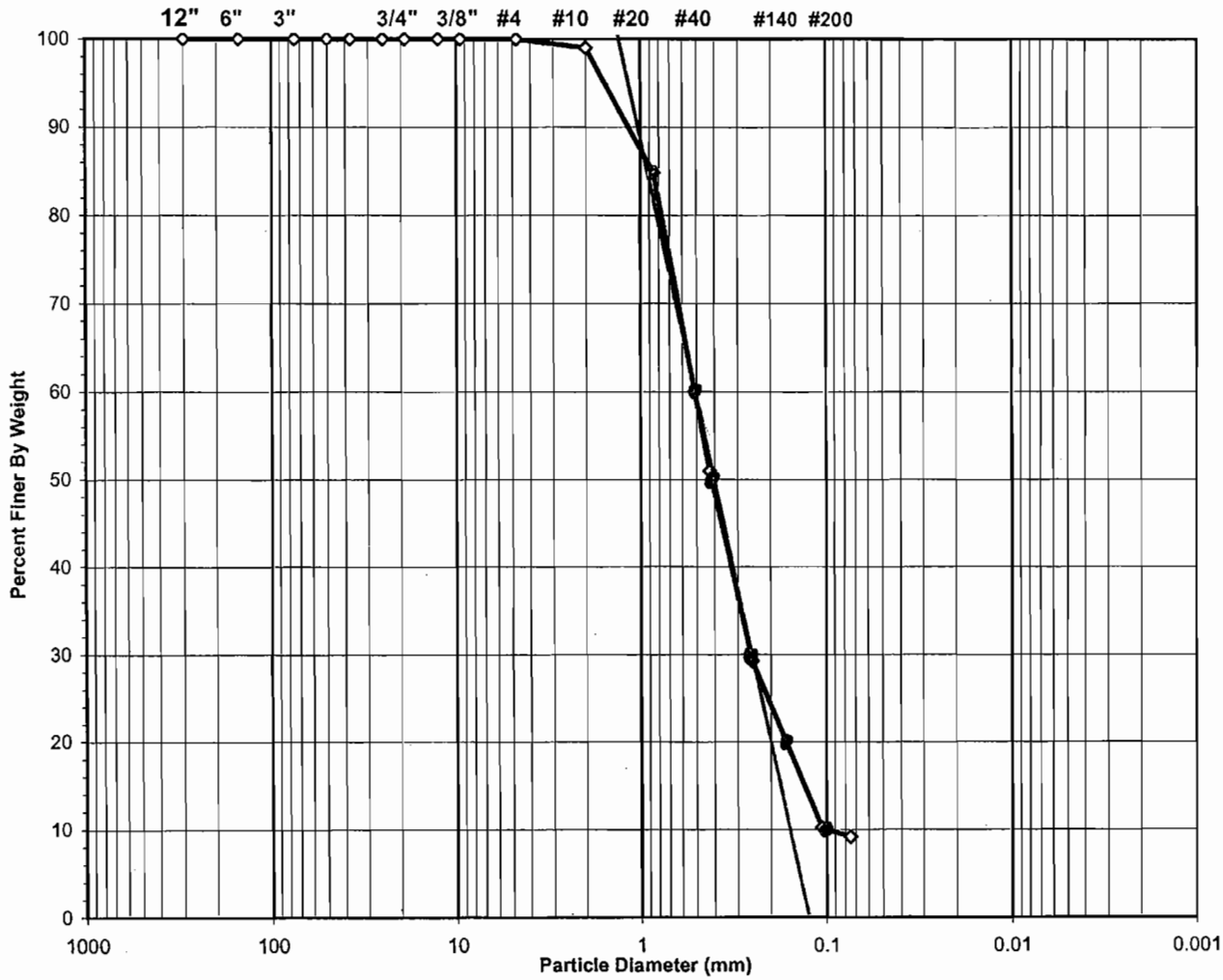
geotechnics
INTEGRITY IN TESTING

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

Client	GN RICHARDSON & ASSOC.	Boring No.	TP-10
Client Reference	JOHNSTON CO. C&D LF AREA 2 CELL 1	Depth (ft)	2-3
Project No.	2006-643-06	Sample No.	12-04-06
Lab ID	2006-643-06-01	Soil Color	**REDDISH TAN**

USCS	SIEVE ANALYSIS		HYDROMETER
	gravel	sand	silt and clay



USCS Symbol	***SP-SM, TESTED***	**D60 =**	**0.5**	**CC =**	**1.3**
USCS Classification	***POORLY GRADED SAND WITH SILT***	**D30 =**	**0.3**	**CU =**	**5.1**
		D10 =	**0.1**		

Tested By SGH Date 12/11/2006 Checked By GSM Date 12-12-06

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PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Cushion Geotextile Analysis

JOB NO. JOHNSTON-07-2
DATE 2/16/07
COMPUTED BY PKS
CHECKED BY

Objective To evaluate the required weight of cushion geotextile to adequately protect the base geomembrane against the possibility of puncture.

References

Koerner, R.M., Designing With Geosynthetics (1999), Fourth Ed., Prentice Hall, Upper Saddle River, N.J., pp. 535-537.

Richardson, G.N. (1996), "Field Evaluation of Geosynthetic Protective Cushions," *Geotechnical Fabrics Report*, (vol. 14, no. 2, March), pp. 20-25.

Richardson, G.N. and Johnson, S. (1998), "Field Evaluation of Geosynthetic Protective Cushions: Phase 2," *Geotechnical Fabrics Report*, (October - November), pp. 44-49.

Analysis Use the equation given below to determine the required mass per unit area of a cushion geotextile to protect a 60 mil HDPE geomembrane under final design loads. The selected cushion geotextile should be a minimum of 12 oz. per square yard to provide adequate protection during construction loading (Richardson, 1996 & 1998).

$$p_{allow} = (50 + 0.00045\frac{M}{H^2})\frac{1}{MS_S MF_{PD} MF_A} \bullet \frac{1}{RF_{CR} RF_{CBD}}$$ (Koerner Eqn. 5.33)

where:

p_{allow}	=	allowable pressure (kPa)
	=	$p_{actual} \times FS$
p_{actual}	=	actual pressure (kPa)
FS	=	factor of safety
M	=	geotextile mass per unit area (g/m^2)
H	=	protrusion height (m) (assume H = d_{50} = soil particle size (mm) for which 50% of the total soil is finer)
MF_S	=	modification factor for protrusion shape*
MF_{PD}	=	modification factor for packing density*
MF_A	=	modification factor for arching in solids*
RF_{CR}	=	reduction factor for long-term creep*
RF_{CBD}	=	reduction factor for long-term chemical/biological degradation*

*(see attached table from Koerner)

GT CUSHION.WPD

TABLE 5.18 MODIFICATION FACTORS AND REDUCTION FACTORS FOR GEOMEMBRANE PROTECTION DESIGN USING NONWOVEN NEEDLE-PUNCHED GEOTEXTILES

Modification Factors

MF_S		MF_{PD}		MF_A	
Angular	1.0	Isolated	1.0	Hydrostatic	1.0
Subrounded	0.5	Dense, 38 mm	0.83	Geostatic, shallow	0.75
Rounded	0.25	Dense, 25 mm	0.67	Geostatic, mod.	0.50
		Dense, 12 mm	0.50	Geostatic, deep	0.25

Reduction Factors

			RF_{CR}		
			Protrusion (mm)		
RF_{CBD}		Mass per unit area (g/m^2)	38	25	12
Mild leachate	1.1	Geomembrane alone	N/R	N/R	N/R
Moderate leachate	1.3	270	N/R	N/R	> 1.5
Harsh leachate	1.5	550	N/R	1.5	1.3
		1100	1.3	1.2	1.1
		> 1100	≅ 1.2	≅ 1.1	≅ 1.0

N/R = Not recommended

Ref: Designing With Geosynthetics

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JOB #: JOHNSTON-07-2
DATE: 2/28/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
Cushion Geotextile Analysis

Input Parameters:

Maximum Height of Waste (ft) =	150	**(> Max. Waste Thickness over Cell 1; Conservative for Cell 3)**
Waste Density (pcf) =	70	
P_{actual} (psf) =	10,500	**(=Max Height x Waste Density)**
P_{actual} (kPa) =	503	
Factor of Safety, FS =	3	
P_{allow} (kPa) =	1,509	

Type of Stone	Stone Angularity	Stone Information: Stone d50 (in)	Stone d50 (mm)	Protrusion Height (m)	Modification Factors: MF_S	MF_{PD}	MF_A	Reduction Factors: RF_{CR}	RF_{CBD}	Geotextile Mass Per Unit Area: (g/m^3)	(oz/sy)
Coarse Aggregate (NCDOT No. 57)	Angular	0.750	19.1	0.019	1.00	0.67	0.25	1.5	1.3	357	**10.5**
Leachate Collection Media (NCDOT No. 78)	Angular	0.375	9.5	0.010	1.00	0.50	0.25	1.5	1.3	64	**1.9**

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT LDS/LCS Drainage Layer Analysis

JOB NO. JOHNSTON-07-2
DATE 3/21/07
COMPUTED BY PKS
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Objective

To evaluate the ability of the leak detection system (LDS) and the leachate collection system (LCS) to maintain at most 1 foot of head on the geomembrane under Normal Operating Conditions (for drainage geocomposites head should be maintained within the thickness of the geonet drainage core). The analysis determines the maximum head using input values for permeability (natural drainage media - stone/sand) or transmissivity (drainage geocomposite) and selected slope and collection pipe spacing combinations.

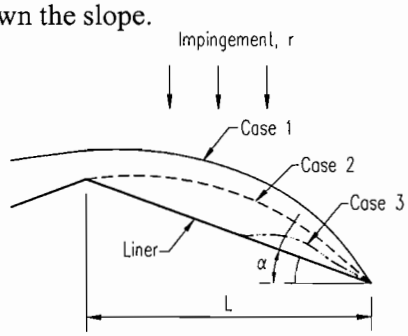
References

McEnroe, Bruce (1993), "Maximum Saturated Depth Over Landfill Liners," Journal of Environmental Engineering, Vol. 119, No. 2, pp. 262-270.

Richardson, G.N., Giroud, J-P. and Zhao, A. (2000), Design of Lateral Drainage Systems for Landfills, Tenax Corp., Baltimore.

Analysis

The McEnroe equations require the input of an impingement rate, a drainage media permeability, pipe spacing, and a liner slope. This information is used to find the maximum head on the liner. The McEnroe solution is for three cases (see figure below). Case 1 is for a saw-tooth bottom, with the liquid mound overtopping the peak. Case 2 has the liquid mound starting at the peak of the saw-tooth. Case three has the mound starting below the peak of the tooth. Cases two and three are appropriate for modeling a liner on an infinite slope with collector pipes uniformly spaced down the slope.



Step 1: Input the necessary physical factors: slope, permeability and impingement rate.

Step 2: The controlling value R is calculated

$$R = \frac{r}{k \sin^2 \alpha}$$

where:

r	=	impingement rate
k	=	design permeability of the drainage media (for Drainage Geocomposite, k = transmissivity/thickness) (See Note 1)
α	=	slope angle of the liner

LDS-LCS DRAIN LAYER.WPD

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Note:

1. For stone/sand: The design permeability (k) = (specified minimum permeability)/(overall reduction factor (RF))
   For drainage geocomposites: k = (specified minimum transmissivity/thickness of geonet drainage core)/(RF)

$$RF = RF_{IN} \times RF_{CR} \times RF_{CC} \times RF_{BC} \times FS$$

where:

RF_{IN}	=	reduction factor for intrusion
RF_{CR}	=	reduction factor for creep
RF_{CC}	=	reduction factor for chemical clogging
RF_{BC}	=	reduction factor for biological clogging
FS	=	overall factor of safety

Based on the recommendations of Richardson, Giroud, & Zhao, use the following values for a leachate collection system (LCS). An overall factor of safety of 2.0 for long-term conditions is also recommended. For shorter term (lower load) conditions, lower values may be used.

	RF_{IN}	RF_{CR}	RF_{CC}	RF_{BC}
Stone/Sand:	1.0	1.0	1.5-2.0	1.5-2.0
Dr. Geocomposite:	1.0-1.2	1.4-2.0	1.5-2.0	1.5-2.0

Step 3: The maximum head is calculated, using a formula dependent on the value of R:

For R > 1/4 (Case 1):

$$h_{max} = SL\left(R - RS + R^2S^2\right)^{\frac{1}{2}} \exp\left[\frac{1}{B}\arctan\left(\frac{2RS-1}{B}\right) - \frac{1}{B}\arctan\left(\frac{2R-1}{B}\right)\right]$$

For R = 1/4 (Case 2):

$$h_{max} = SL\frac{R(1-2RS)}{1-2R}\exp\left[\frac{2R(S-1)}{(1-2RS)(1-2R)}\right]$$

For R < 1/4 (Case 3):

$$h_{\max} = SL\left(R - RS + R^2S^2\right)^{\frac{1}{2}}\left[\frac{(1-A-2R)(1+A-2RS)}{(1+A-2R)(1-A-2RS)}\right]^{\frac{1}{2A}}$$

where:

h_{max}	=	maximum head (m - convert to desired units)
L	=	horizontal length of pipe spacing or distance to peak (m) (see figure above)
S	=	liner slope (m/m)
A	=	$(1 - 4R)^{0.5}$
B	=	$(4R - 1)^{0.5}$

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BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
Leak Detection System (LDS) Drainage Layer Analysis

Drainage Geocomposite:

Maximum Allowable Head (h_{max}):	0.25	inches	(= Thickness of Geonet Drainage Core)
Impingement (r):	1.1E-07	cm/sec	(= 100 gpad >> HELP Model)
Drainage Geocomposite Transmissivity (θ):	5.0E-04	m^3/m/sec	(Specified Minimum)
Thickness of Geonet Drainage Core:	0.25	inches	(Specified Minimum)
Reduction Factors for Drainage Geocomposite:			(Per Richardson, Zhao, & Giroud)
$RF_{intrusion}$:	1.2		
RF_{creep}:	2.0		
$RF_{chemical\ clogging}$:	1.5		
$RF_{biological\ clogging}$:	1.5		
Overall Factor of Safety:	2.0		
Reduction Factor for Drainage Geocomposite in LCS:	10.8		
Design Drainage Geocomposite Transmissivity (θ):	4.6E-05	m^3/m/sec	
Design Drainage Geocomposite Permeability (k):	0.73	cm/sec	(Design Transmissivity/Thickness of Geonet Drainage Core)

Slope (%)	Slope (Deg.)	S	R	Pipe Spacing (ft)	Pipe Spacing (m)	A	B	h_{max} (in) R < 0.25	R = 0.25	R > 0.25	Comment
2.5	1.43	0.025	0.00024	400	121.9	1.000	NA	0.03	N/A	N/A	O.K.
3	1.72	0.030	0.00017	400	121.9	1.000	NA	0.02	N/A	N/A	O.K.
4	2.29	0.040	0.00009	400	121.9	1.000	NA	0.02	N/A	N/A	O.K.
6	3.43	0.060	0.00004	400	121.9	1.000	NA	0.01	N/A	N/A	O.K.

Typ. Ranges

Note: Spreadsheet Converts Units as Required.

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Johnston County MSW Landfill - Phase 4A - Cell 3
Leachate Collection System (LCS) Drainage Layer Analysis - Active Condition

Drainage Geocomposite:

Maximum Allowable Head (h_{max}):	0.25	inches	(= Thickness of Geonet Drainage Core)
Impingement (r):	1.6E-05	cm/sec	(Peak Daily Flow from HELP Model - Active Case)
Drainage Geocomposite Transmissivity (θ):	5.0E-04	m^3/m/sec	(Specified Minimum)
Thickness of Geonet Drainage Core:	0.25	inches	(Specified Minimum)
Reduction Factors for Drainage Geocomposite:			(Per Richardson, Zhao, & Giroud)
$RF_{intrusion}$:	1.0		
RF_{creep}:	1.0		
$RF_{chemical\ clogging}$:	1.0		
$RF_{biological\ clogging}$:	1.0		
Overall Factor of Safety:	1.0		
Reduction Factor for Drainage Geocomposite in LCS:	1.0		
Design Drainage Geocomposite Transmissivity (θ):	5.0E-04	m^3/m/sec	
Design Drainage Geocomposite Permeability (k):	7.87	cm/sec	(Design Transmissivity/Thickness of Geonet Drainage Core)

Slope (%)	Slope (Deg.)	S	R	Pipe Spacing (ft)	Pipe Spacing (m)	A	B	h_{max} (in) R < 0.25	R = 0.25	R > 0.25	Comment
2.5	1.43	0.025	0.00325	200	61.0	0.993	NA	0.19	N/A	N/A	O.K.
3	1.72	0.030	0.00226	200	61.0	0.995	NA	0.16	N/A	N/A	O.K.
4	2.29	0.040	0.00127	200	61.0	0.997	NA	0.12	N/A	N/A	O.K.
6	3.43	0.060	0.00057	200	61.0	0.999	NA	0.08	N/A	N/A	O.K.
25	14.04	0.250	0.00003	200	61.0	1.000	NA	0.02	N/A	N/A	O.K.

Typ. Ranges

Note: Spreadsheet Converts Units as Required.

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Johnston County MSW Landfill - Phase 4A - Cell 3
Leachate Collection System (LCS) Drainage Layer Analysis - Intermediate Condition

Drainage Geocomposite:

Maximum Allowable Head (h_{max}):	0.25	inches	(= Thickness of Geonet Drainage Core)
Impingement (r):	5.1E-06	cm/sec	(Peak Daily Flow from HELP Model - Intermediate Case)
Drainage Geocomposite Transmissivity (θ):	5.0E-04	m^3/m/sec	(Specified Minimum)
Thickness of Geonet Drainage Core:	0.25	inches	(Specified Minimum)
Reduction Factors for Drainage Geocomposite:			(Per Richardson, Zhao, & Giroud)
$RF_{intrusion}$:	1.1		
RF_{creep}:	1.3		
$RF_{chemical\ clogging}$:	1.3		
$RF_{biological\ clogging}$:	1.3		
Overall Factor of Safety:	1.5		
Reduction Factor for Drainage Geocomposite in LCS:	3.6		
Design Drainage Geocomposite Transmissivity (θ):	1.4E-04	m^3/m/sec	
Design Drainage Geocomposite Permeability (k):	2.17	cm/sec	(Design Transmissivity/Thickness of Geonet Drainage Core)

Slope (%)	Slope (Deg.)	S	R	Pipe Spacing (ft)	Pipe Spacing (m)	A	B	h_{max} (in) R < 0.25	R = 0.25	R > 0.25	Comment
2.5	1.43	0.025	0.00376	200	61.0	0.992	NA	0.22	N/A	N/A	**O.K.**
4	2.29	0.040	0.00147	200	61.0	0.997	NA	0.14	N/A	N/A	**O.K.**
5	2.86	0.050	0.00094	200	61.0	0.998	NA	0.11	N/A	N/A	**O.K.**
6	3.43	0.060	0.00065	200	61.0	0.999	NA	0.09	N/A	N/A	**O.K.**
25	14.04	0.250	0.00004	200	61.0	1.000	NA	0.02	N/A	N/A	**O.K.**

Note: Spreadsheet Converts Units as Required.

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Johnston County MSW Landfill - Phase 4A - Cell 3
Leachate Collection System (LCS) Drainage Layer Analysis - Final Condition

Drainage Geocomposite:

Maximum Allowable Head (h_{max}):	0.25	inches	(= Thickness of Geonet Drainage Core)
Impingement (r):	1.1E-07	cm/sec	(= 100 gpad >> HELP Model)
Drainage Geocomposite Transmissivity (θ):	7.0E-04	m^3/m/sec	(Specified Minimum)
Thickness of Geonet Drainage Core:	0.25	inches	(Specified Minimum)
Reduction Factors for Drainage Geocomposite:			(Per Richardson, Zhao, & Giroud)
$RF_{intrusion}$:	1.2		
RF_{creep}:	2.0		
$RF_{chemical\ clogging}$:	2.0		
$RF_{biological\ clogging}$:	2.0		
Overall Factor of Safety:	2.0		
Reduction Factor for Drainage Geocomposite in LCS:	19.2		
Design Drainage Geocomposite Transmissivity (θ):	3.6E-05	m^3/m/sec	
Design Drainage Geocomposite Permeability (k):	0.57	cm/sec	(Design Transmissivity/Thickness of Geonet Drainage Core)

Slope (%)	Slope (Deg.)	S	R	Pipe Spacing (ft)	Pipe Spacing (m)	A	B	h_{max} (in) R < 0.25	R = 0.25	R > 0.25	Comment
2.5	1.43	0.025	0.00031	200	61.0	0.999	NA	0.02	N/A	N/A	O.K.
4	2.29	0.040	0.00012	200	61.0	1.000	NA	0.01	N/A	N/A	O.K.
5	2.86	0.050	0.00008	200	61.0	1.000	NA	0.01	N/A	N/A	O.K.
6	3.43	0.060	0.00005	200	61.0	1.000	NA	0.01	N/A	N/A	O.K.
25	14.04	0.250	0.00000	200	61.0	1.000	NA	0.00	N/A	N/A	O.K.

Note: Spreadsheet Converts Units as Required.

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT LDS/LCS Collection Pipe Sizing

JOB NO. JOHNSTON-07-2
DATE 3/21/07
COMPUTED BY PKS
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Objective To design leachate collection pipes to handle the maximum leachate generation rate.

References

Cedargren, Harry R. (1974), Drainage of Highway and Airfield Pavements, John Wiley & Sons, New York, pp. 166-167.

Debo, T.N., and Reese, A.J. (1995), Municipal Storm Water Management, Lewis Publishers, Boca Raton, FL, pp. 438-442.

Malcom, H. Rooney (1989), Elements of Urban Stormwater Design, N.C. State University, Raleigh, NC.

Analysis

1. For each pipe size, determine the maximum area (A), to handle the predicted flow (Q) with an added factor of safety. Compare the full flow capacity of each pipe size with the calculated peak flow rate to verify the desired factor of safety. Also, analyze leachate collection pipes based on partial flow to determine flow depth and velocity.

2. Determine the allowable perforation size for leachate collection pipes based on the size of the stone in the gravel columns.

3. Analyze leachate collection pipe perforations as orifice flow to ensure adequate flow capacity into collection piping.

Calculations

- Determine Peak Flow Rate:

Use the peak daily leachate generation rate from the active condition (see leachate generation calculations).

Determine the drainage area (A) to each pipe such that $Q_{max}/Q \geq 2.0$, where Q_{max} is the full flow capacity (see below).

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- Leachate Collection Pipes:

Determine Flow Capacity of Pipe:

$$Q_{max} = \frac{0.463 D^{8/3} S^{1/2}}{n}$$ (D&R Equation 8.24)

where:
Q_{max} = flow capacity of pipe (cfs)
D = inside diameter of pipe (ft)
S = pipe slope (ft/ft)
n = Manning's roughness coefficient

Determine Factor of Safety (FS):

$$FS = \frac{Q_{max}}{Q}$$

Iterate the drainage area (A) to each pipe such that $Q_{max}/Q \geq$ the desired factor of safety.

Determine Flow Depth:

$$h = \frac{1}{2}\left(1 - \cos\left(\frac{\theta}{2}\right)\right) D$$ (D&R Equation 8.29)

where:
h = flow depth (inches)
θ = central angle

$$\theta = \frac{3\pi}{2}\left[1 - \left(1 - (\pi K)^{1/2}\right)^{1/2}\right]^{1/2}$$ (D&R Equation 8.28)

K = constant

$$K = 0.673 Q n D^{-8/3} S^{-1/2}$$ (D&R Equation 8.27)

Determine Flow Velocity:

$$V = \frac{Q}{A} = \frac{Q}{D^2 \frac{(\theta - \sin\theta)}{8}}$$ (D&R Equation 8.30 for "A")

where:
V = flow velocity (ft/sec)
A = cross-sectional area of flow (ft^3)

- Leachate Collection Pipe Perforations:

Determine Maximum Allowable Size of Perforations (D_{max}):

$$D_{max} = \frac{D_{85}}{F}$$ (Reformulation of Cedargren Equation 5.11)

where:
D_{max} = maximum perforation size (hole diameter or slot width) to provide particle retention
D_{85} = particle size of pipe bedding material for which 85% by weight of the particles are finer
F = factor varying between 1 and 2 (F >/= 1.2 for slots)

Determine Flow Capacity (Q_{max}):

$$Q_{max} = C_d A\sqrt{2gh}$$ (Malcom Equation I-7)

where:
C_d = coefficient of discharge
A = cross-sectional area of flow (ft^3)
g = acceleration of gravity (32.2 ft/sec^2)
h = driving head - centroid of orifice to water surface (ft)

Determine Factor of Safety (FS):

$$FS = \frac{Q_{max}}{Q}$$

Iterate the perforation spacing and/or other factors such that $Q_{max}/Q \geq$ the desired factor of safety.

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Johnston County MSW Landfill - Phase 4A - Cell 3
Leak Detection System (LDS) Pipe Sizing - HDPE Pipe

Input Parameters:

Manning's Rougness Coefficient =	**0.009**		**(HDPE Pipe)**
Design Leachate Flow =	**100**	gal/acre/day	**(Assumed >> HELP Model Predictions)**
Design Leachate Flow =	0.00	cfs/acre	
Orifice Coef. Of Discharge (LCS Pipe Perforations) =	**0.6**		

LCS Piping

ID	Drainage Area (AC)	Peak Flow Rate (Q) (CFS)	Pipe I.D. (IN)	Pipe Slope (%)	Flow Capacity (Q_{max}) (CFS)	Factor of Safety (>/= 2.0)	K (CONSTANT)	θ (< 265°)	Flow Depth (IN)	Flow Area (SF)	Flow Velocity (FPS)
Max. Area - 4"	**50.0**	0.01	**4.0**	**2**	0.39	50.2	0.006	73	0.39	0.00	1.78

LCS Pipe Perforations

Determine Maximum Perforation Size:

Stone Used for Pipe Bedding:	**No. 78**		
D_{85} =	**0.375**	inches	**(Typ. for No. 57 Stone)**
F =	**1.0**		
Max. Diameter - Circular Holes/Max. Width - Slots =	0.38	inches	

Circular Holes

ID	Drainage Area (AC)	Peak Flow Rate (Q) (CFS)	Hole Diameter (IN)	Allowable Head (IN)	X-Sectional Area (SF/Hole)	Flow Capacity (Q_{max}) (CFS/Hole)	No. Holes/LF	Min. Length of Collection Pipe (FT)	Actual Length of Collection Pipe (FT)	Factor of Safety (>/= 2.0)
Max. Area - 4"	**50.0**	0.01	**0.38**	**4**	0.001	0.002	**4**	**1**	1,000	1102.4

Note: Conservatively Neglects Upper Holes (Where Used).

LCS Pipe Dimensions

Standard Dimension Ratio (SDR) of Pipe = **17** **(From Pipe Stress Calculations)**

Nominal Pipe Size (IN)	Pipe O.D. (IN)	Min. Wall Thickness (IN)	Pipe I.D. (IN)
4	**4.5**	0.265	4.0

Note: User Input Values are in **Bold**.

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Johnston County MSW Landfill - Phase 4A - Cell 3
Leachate Collection System (LCS) Pipe Sizing - HDPE Pipe

Input Parameters:

Manning's Rougness Coefficient =	**0.009**		**(HDPE Pipe)**
Design Leachate Flow =	**14,900**	gal/acre/day	**(Peak Daily Leachate Generation - Active Condition)**
Design Leachate Flow =	0.02	cfs/acre	
Orifice Coef. Of Discharge (LCS Pipe Perforations) =	**0.6**		

LCS Piping

ID	Drainage Area (AC)	Peak Flow Rate (Q) (CFS)	Pipe I.D. (IN)	Pipe Slope (%)	Flow Capacity (Q_{max}) (CFS)	Factor of Safety (>/= 2.0)	K (CONSTANT)	θ (< 265°)	Flow Depth (IN)	Flow Area (SF)	Flow Velocity (FPS)
Max. Area - 6"	**22.5**	0.52	**5.8**	**2**	1.05	2.0	0.154	181	2.92	0.09	5.60

LCS Pipe Perforations

Determine Maximum Perforation Size:

Stone Used for Pipe Bedding:	**No. 57**		
D_{85} =	**0.750**	inches	**(Typ. for No. 57 Stone)**
F =	**1.5**		
Max. Diameter - Circular Holes/Max. Width - Slots =	0.50	inches	

Circular Holes

ID	Drainage Area (AC)	Peak Flow Rate (Q) (CFS)	Hole Diameter (IN)	Allowable Head (IN)	X-Sectional Area (SF/Hole)	Flow Capacity (Q_{max}) (CFS/Hole)	No. Holes/LF	Min. Length of Collection Pipe (FT)	Actual Length of Collection Pipe (FT)	Factor of Safety (>/= 2.0)
Max. Area - 6"	**22.5**	0.52	**0.50**	**4**	0.001	0.004	**4**	34	1,000	29.2

Note: Conservatively Neglects Upper Holes (Where Used).

LCS Pipe Dimensions

Standard Dimension Ratio (SDR) of Pipe = **17** **(From Pipe Stress Calculations)**

Nominal Pipe Size (IN)	Pipe O.D. (IN)	Min. Wall Thickness (IN)	Pipe I.D. (IN)
6	**6.625**	0.390	5.8

Note: User Input Values are in **Bold**.

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT HDPE Pipe Stress Analysis

JOB NO. JOHNSTON-07-2
DATE 2/16/07
COMPUTED BY PKS
CHECKED BY

Objective Evaluate collection pipe stresses due to long-term static (overburden) and short-term dynamic (equipment) loads. For long-term static loads, check crushing and buckling failure modes as well as ring deflection. For short-term dynamic loads, check crushing failure mode.

References CPChem Performance Pipe (2003), The Performance Pipe Engineering Manual, Chapters 5 and 7.

Chevron Phillips Chemical Co. (1998), Guidelines for HDPE Pipes in Deep Fills.

Holtz, R.D., & Kovacs, W.D. (1981), An Introduction To Geotechnical Engineering, Prentice-Hall, Englewood Cliffs, NJ, p. 348.

Phillips Driscopipe (1998), Polyethylene Piping Systems Manual, pp. 35-46.

Requirements FS_{min} (Static) = 2.0; FS_{min} (Dynamic) = 2.0.

Analysis

- Crushing Failure:

$$S = \left(\frac{P_T}{288}\right) DR$$ (Perf. Pipe Eng. Man. Eq. 7-23)

where:
S = compressive stress in pipe wall (psi)
DR = pipe dimension ratio
= outside diameter/wall thickness
P_T = external pressure (psf)

$$FS_{crush} = \frac{\sigma_{yield}\left(HDPE = 1{,}600\,psi\right)}{S}$$

- Buckling Failure (Constrained Wall):

$$P_{CR} = 1.63\sqrt{\frac{RB'E'E}{(DR-1)^3}}$$ (Perf. Pipe Eng. Man. Eq. 7-32 Mod.)

PIPE STRESS - HDPE.WPD

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where: P_{CR} = critical buckling soil pressure (psi)
R = groundwater buoyancy reduction factor

$$= 1 - 0.33\frac{H_{GW}}{H}$$ (Perf. Pipe Eng. Man. Eq. 7-34)

B' = elastic support coefficient

$$= \frac{1}{1 + 4e^{(-0.065H)}}$$ (Perf. Pipe Eng. Man. Eq. 7-35)

E' = constrained soil modulus (psi) (see attached table)
H = height of cover above pipe (ft)
H_{GW} = height of groundwater (ft)
E = long-term modulus of elasticity of pipe (psi) (see attached table)

$$FS_{buckle} = \frac{P_{CR}}{P_T}$$

- Ring Deflection:

For constrained HDPE pipe, pipe deflection equals the strain in the surrounding bedding soil. The safe pipe deflection for each DR is shown on the attached table.

$$Deflection = \frac{P_T}{E'} \times 100$$ (%) (Driscopipe p. 47)

-Equipment Loading:

Line Loads: (H&K Eq. 8-26)

$$P_T = P_L = \frac{2WZ^3}{\pi Z^4}$$

Point Loads: (Perf. Pipe Eng. Man. Eq. 7-13)

$$P_T = P_P = \frac{3WZ^3}{2\pi Z^5}$$

where: W = dynamic equipment load (lbs/ft or lbs) (= 1.5 times weight of machine)
Z = vertical distance from the point of loading to the top of the pipe (feet)

Note: The equations conservatively assumes loads are applied directly over the pipe)

Using the above calculations for P_T, calculate the factor of safety for crushing failure as shown above.

Table : Typical Design Values* for Constrained Modulus, E'

Vertical Soil Stress (psi)	Gravelly Sand/Gravels 95% Std. Proctor (psi)	Gravelly Sand/Gravels 90% Std. Proctor (psi)	Gravelly Sand/Gravels 85% Std. Proctor (psi)
10	3000	1500	500
20	3500	1700	650
40	4500	2100	900
60	5500	2500	1150
80	6000	2900	1300
100	6500	3200	1450

Ref: Guidelines for HDPE Pipe in Deep Fills

Table 5-1 Typical Elastic Modulus for DriscoPlex® PE 3408

Load Duration	Elastic Modulus†, 1000 psi (MPa), at Temperature, °F (°C)							
	-20 (-29)	0 (-18)	40 (4)	60 (16)	73 (23)	100 (38)	120 (49)	140 (60)
Short-Term	300.0 (2069)	260.0 (1793)	170.0 (1172)	130.0 (896)	110.0 (758)	100.0 (690)	65.0 (448)	50.0 (345)
10 h	140.8 (971)	122.0 (841)	79.8 (550)	61.0 (421)	57.5 (396)	46.9 (323)	30.5 (210)	23.5 (162)
100 h	125.4 (865)	108.7 (749)	71.0 (490)	54.3 (374)	51.2 (353)	41.8 (288)	27.2 (188)	20.9 (144)
1000 h	107.0 (738)	92.8 (640)	60.7 (419)	46.4 (320)	43.7 (301)	35.7 (246)	23.2 (160)	17.8 (123)
1 y	93.0 (641)	80.6 (556)	52.7 (363)	40.3 (278)	38.0 (262)	31.0 (214)	20.2 (139)	15.5 (107)
10 y	77.4 (534)	67.1 (463)	43.9 (303)	33.5 (231)	31.6 (218)	25.8 (178)	16.8 (116)	12.9 (89)
50 y	69.1 (476)	59.9 (413)	39.1 (270)	29.9 (206)	28.2 (194)	23.0 (159)	15.0 (103)	11.5 (79)

† Typical values based on ASTM D 638 testing of molded plaque material specimens.

Ref: Performance Pipe Engineering Manual

Table 7-9 Safe Pressure Pipe Deflection

DR	Safe Deflection as % of Diameter
32.5	8.5
26	7.0
21	6.0
17	5.0
13.5	4.0
11	3.0
9	2.5

Ref: Performance Pipe Engineering Manual

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Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 4 / 4
JOB #: JOHNSTON-07-2
DATE: 3/19/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
HDPE Pipe Stress Analysis

Case 1: Long-Term Static Loading

Max. Height of Fill (H) (ft) = 150 **(> Max. Above Cell 1)** (*)
Avg. Unit Weight (pcf) = 70

Max. Vertical Stress (P_T) (psf) = 10,500
Max. Vertical Stress (P_T) (psi) = 73

Height of Groundwater (H_{GW}) (ft) = 1 **(12" Max. Head)**
Constrained Soil Modulus (E') (psi) = 5,800
Groundwater Buoyancy Factor (R) = 0.998
Elastic Support Coefficient (B') = 1.000

Calculate Safety Factors Against Crushing, Buckling, and Ring Deflection:

DR	Long-Term Elastic Modulus E (psi)	Allowable Ring Defl. (%)	Comp. Stress in Pipe Wall S (psi)	Critical Buckling Pressure P_{CR} (psi)	FS_{Crush}	FS_{Buckle}	Ring Defl. (%)	Comment
19	28,200	5.5	693	273	2.3	3.7	1.3	**O.K.**
17	28,200	5.0	620	325	2.6	4.5	1.3	**O.K.**
13.5	28,200	4.0	492	471	3.3	6.5	1.3	**O.K.**
11	28,200	3.0	401	658	4.0	9.0	1.3	**O.K.**

(*) ← Cell 1 O.K.

Case 2: Short-Term Dynamic (Equipment) Loading

DR (Determine From Static Loading Analysis) = 17 → Same Holds True For LCS Piping & GCS Piping Under Cell 3.

Line Loads:

Equipment	Weight* (lbs)	Track Length (ft)	Dynamic Line Loads (psi) 6" Cover	12" Cover	18" Cover	S 6" Cover	12" Cover	18" Cover	FS 6" Cover	12" Cover	18" Cover
D4 Bulldozer (D4C-II)	19,485	6.74	19	10	6	163	81	54	9.8	19.6	29.5
D6 Bulldozer (D6H-II)	46,305	8.63	36	18	12	302	151	101	5.3	10.6	15.9
D8 Bulldozer (D8L)	95,838	10.5	61	30	20	514	257	171	3.1	6.2	9.3
953 Track Loader	37,560	7.5	33	17	11	282	141	94	5.7	11.3	17.0
963Track Loader	48,914	8.08	40	20	13	341	171	114	4.7	9.4	14.1

Point Loads:

Equipment	Weight* (lbs)	Number of Tires	Dynamic Point Loads (psi) 6" Cover	12" Cover	18" Cover	S 6" Cover	12" Cover	18" Cover	FS 6" Cover	12" Cover	18" Cover
950 Wheel Loader	48,628	4	242	60	27	2,056	514	228	0.8	3.1	7.0
615 Scraper	91,000	4	453	113	50	3,847	962	427	0.4	1.7	3.7
621 Scraper	115,195	4	573	143	64	4,870	1,217	541	0.3	1.3	3.0
816B Compactor	45,477	4	226	57	25	1,923	481	214	0.8	3.3	7.5
826C Compactor	69,733	4	347	87	39	2,948	737	328	0.5	2.2	4.9

* Includes Blades, Loaded Buckets, etc.

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Evaluation of Leachate Generation Rates

JOB NO. JOHNSTON-07-2
DATE 3/21/07
COMPUTED BY PKS
CHECKED BY

Objective To predict leachate generation rates for various operational conditions and evaluate rates of removal for the "surge" condition.

Assumptions Assume four operational conditions as follows:

Open - Small quantity of waste in cell; almost all of runoff is leachate
Active - One 10 foot lift of waste in place; no runoff
Interim - 40 feet of waste in place under intermediate cover
Final - Final cover in-place; minimal infiltration.

Assume that the design storm for the landfill unit during initial filling (placement of initial lift of waste over open cells) is the 1-year 24-hour storm. This value is used to estimate leachate generation for "open" conditions.

Assumed empirical leachate generation rates are as follows for the above operational conditions:

Active - 1,200 gallons/acre/day
Interim - 500 gallons/acre/day
Final - 100 gallons/acre/day.

These rates are based on back calculations from observed generation rates from High Point, NC (Phase 1), Alamance County, NC, and several New York facilities (Reference Robert Pheneuf (NY-DEC)).

Analysis

Step 1: Determine the leachate generation rates for the above conditions using the HELP (v. 3.07) Model. These rates are as follows (see attached computer output files):

Active - 683 gallons/acre/day
Interim - 292 gallons/acre/day
Final - 0.04 gallons/acre/day (see Final Cover Infiltration Analysis for output).

Step 2: Compare results from the HELP Model with the empirical rates shown above. In that the empirical results are greater, use the empirical values in estimating the leachate generation rates.

Step 3: Estimate leachate generation rates using empirical values for the various conditions expected before, during, and after landfill operations. In this case, leachate generation rates are predicted for the following scenarios:

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A. Initial filling of Phase 4A - Cell 3 (various areas under Open, Interim, Active, and Interim conditions) (maximum value is taken as the surge event for Phase 4A);

B. Waste covers Phase 4A (no areas open; various areas under active and interim conditions) (maximum value is taken as the typical generation rate for Phase 4A);

C. Completion of Phase 4A operations (Phase 4A under Interim conditions);

E. Closure of Phase 4A (Phase 4A under Final conditions) (this value is taken as the typical generation rate for Post-Closure conditions).

Step 4: Based on the leachate generation rates determined above, estimate the pumping rates required to ensure that enough capacity remains in the leachate storage lagoon to handle the surge event. Also, estimate the days of capacity for the lagoon under typical Phase 4A operations and under post-closure conditions.

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SHEET: 3/13
JOB #: JOHNSTON-07-2
DATE: 5/11/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
Evaluation of Leachate Generation Rates

LEACHATE GENERATION RATES:

1-Year, 24-Hour Design Storm Depth = 3.20 inches **(US Weather Bureau TP-40)**

Open:	86,888 gallons/acre/day
Active:	1,200 gallons/acre/day
Interim:	500 gallons/acre/day
Final:	100 gallons/acre/day

OPEN		ACTIVE		INTERIM		FINAL		TOTAL
Acres	GPD	Acres	GPD	Acres	GPD	Acres	GPD	GPD
A. Initial Filling of Phase 4A - Cell 3 (Maximum Value is "Surge" Event)								
2.0	173,775	0.0	0	22.0	11,000	0.0	0	184,775
2.0	173,775	1.4	1,680	22.0	11,000	0.0	0	186,455
2.0	173,775	3.4	4,080	22.0	11,000	0.0	0	188,855
2.0	173,775	5.4	6,480	22.0	11,000	0.0	0	191,255
B. Waste Covers Phase 4A (Maximum Value is "Typical" for Phase 4A)								
0.0	0	7.4	8,880	22.0	11,000	0.0	0	19,880
0.0	0	6.0	7,200	23.4	11,700	0.0	0	18,900
0.0	0	4.0	4,800	25.4	12,700	0.0	0	17,500
0.0	0	2.0	2,400	27.4	13,700	0.0	0	16,100
C. Completion of Phase 4A Operations								
0.0	0	0.0	0	29.4	14,700	0.0	0	14,700
D. Closure of Phase 4A (Value is "Typical" for Post-Closure Conditions)								
0.0	0	0.0	0	0.0	0	29.4	2,940	2,940

SHEET:	4 / 13
JOB #:	JOHNSTON-07-2
DATE:	5/11/07
BY:	PKS
CHKD BY:	

REQUIRED REMOVAL RATES:

Case 1: Surge Event:

Quantity of Leachate Produced = 191,255 gallons **(See Above)**
Maximum Storage Capacity = 4,300,000 gallons **(See Below)**

Before Surge Event		After Surge Event		Maximum Detention Time In in Landfill (days)	
Available Storage Capacity (gallons)	Volume Retained in Lagoon (gallons)	Volume Retained in Lagoon (gallons)	Volume Retained in Landfill (gallons)	Pump Rate = 15,000 gpd	Pump Rate = 30,000 gpd
4,000,000	300,000	491,255	0	0.0	0.0
3,000,000	1,300,000	1,491,255	0	0.0	0.0
2,000,000	2,300,000	2,491,255	0	0.0	0.0
1,500,000	2,800,000	2,991,255	0	0.0	0.0
1,000,000	3,300,000	3,491,255	0	0.0	0.0
800,000	3,500,000	3,691,255	0	0.0	0.0
600,000	3,700,000	3,891,255	0	0.0	0.0
400,000	3,900,000	4,091,255	0	0.0	0.0
300,000	4,000,000	4,191,255	0	0.0	0.0
200,000	4,100,000	4,291,255	0	0.0	0.0
150,000	4,150,000	4,300,000	41,255	2.8	1.4
100,000	4,200,000	4,300,000	91,255	6.1	3.0
50,000	4,250,000	4,300,000	141,255	9.4	4.7
25,000	4,275,000	4,300,000	166,255	11.1	5.5
0	4,300,000	4,300,000	191,255	12.8	6.4

Case 2: Typical Phase 4A Leachate Generation:

Typical Leachate Generation Rate = 19,880 gallons/day **(See Above)**

Days of Storage Capacity = 216.3 days

Case 3: Typical Post-Closure Leachate Generation:

Typical Leachate Generation Rate = 2,940 gallons/day **(See Above)**

Days of Storage Capacity = 1462.6 days

STORAGE CAPACITY OF LEACHATE LAGOON:

Capacity = 4,300,000 gallons **(See Attached)**
(@ 2' Freeboard)

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SHEET: 5 / 13
JOB #: JOHNSTON-07-2
DATE: 2/28/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
Volume of Leachate Storage Lagoon

STORAGE CAPACITY OF LEACHATE STORAGE LAGOON:

Contour	Area (SF)	Incr Vol (CF)	Accum Vol (CF)	Accum Vol (Gallons)	Stage (FT)
146.5	13,725		0	0	0
148.5	71,675	85,400	85,400	638,792	2
150.5	78,450	150,125	235,525	1,761,727	4
152.5	85,075	163,525	399,050	2,984,894	6
154.5	91,925	177,000	576,050	4,308,854	8
156.5	97,988	189,913	765,963	5,729,403	10

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:      C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:  C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:    C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:  C:\PROGRA~1\HELP3\JCACT.D10
OUTPUT DATA FILE:           C:\PROGRA~1\HELP3\JCACT.OUT


TIME:  15:56     DATE:   3/19/2007


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

     TITLE:  Johnston County MSWLF - Phase 4A - Active Condition

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


     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  10
          THICKNESS                  =      6.00   INCHES
          POROSITY                   =      0.3980 VOL/VOL
          FIELD CAPACITY             =      0.2440 VOL/VOL
          WILTING POINT              =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2550 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

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

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  18
THICKNESS                    =    120.00   INCHES
POROSITY                     =      0.6710 VOL/VOL
FIELD CAPACITY               =      0.2920 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3068 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                                  LAYER  3
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2535 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                                  LAYER  4
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER  20
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.    =   10.0000000000     CM/SEC
SLOPE                        =      4.00   PERCENT
DRAINAGE LENGTH              =    250.0    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          =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      8.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD
```

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08	CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

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.	=	10.0000000000	CM/SEC
SLOPE	=	4.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 8

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

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.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	8.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 4.% AND A SLOPE LENGTH OF 300. FEET.

SCS RUNOFF CURVE NUMBER	=	94.00	
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	=	6.094	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	13.124	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.048	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	44.591	INCHES
TOTAL INITIAL WATER	=	44.591	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	=	2.00	
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
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

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
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
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	1.411	1.734	2.964	2.740	4.229	4.636
	4.132	4.167	2.651	1.283	1.147	1.028
STD. DEVIATIONS	0.153	0.244	0.312	0.928	0.790	1.492
	1.506	1.289	1.115	0.413	0.153	0.170
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	1.3087	1.7061	1.6026	1.2675	0.5253	0.5382
	0.2149	0.0762	0.7054	0.2418	0.2205	0.7641
STD. DEVIATIONS	0.8402	1.2275	1.0796	1.0775	0.4081	0.9068
	0.3136	0.1266	2.0960	0.6877	0.4067	1.1743
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
LATERAL DRAINAGE COLLECTED FROM LAYER 7						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5						
AVERAGES	0.0047	0.0067	0.0057	0.0047	0.0019	0.0020
	0.0008	0.0003	0.0026	0.0009	0.0008	0.0027
STD. DEVIATIONS	0.0030	0.0047	0.0038	0.0040	0.0015	0.0033
	0.0011	0.0005	0.0077	0.0024	0.0015	0.0042
DAILY AVERAGE HEAD ON TOP OF LAYER 8						
AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	32.123	(3.6400)	116604.97	77.874
LATERAL DRAINAGE COLLECTED FROM LAYER 4	9.17133	(5.29157)	33291.934	22.23380
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.003	(0.002)		

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8/3

LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00000 (	0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00000 (	0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 8	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-0.044 (	1.8910)	-161.23	-0.108

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 4	0.54818	1989.88538
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00019
AVERAGE HEAD ON TOP OF LAYER 5	0.061	
MAXIMUM HEAD ON TOP OF LAYER 5	0.120	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	2.2 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.00019
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.80	6547.7266

$\rightarrow 1.6 \times 10^{-5}$ cm/sec

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4238

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0931

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

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

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	1.4896	0.2483
2	34.8564	0.2905
3	7.1899	0.2996
4	0.0142	0.0566
5	0.0000	0.0000
6	0.1500	0.7500
7	0.0025	0.0100
8	0.0000	0.0000
SNOW WATER	0.000	

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


PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\JCINT.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\JCINT.OUT


TIME:  16: 0     DATE:   3/19/2007

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

     TITLE:  Johnston County MSWLF - Phase 4A - Interim Condition

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


     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  10
          THICKNESS                  =     12.00   INCHES
          POROSITY                   =      0.3980 VOL/VOL
          FIELD CAPACITY             =      0.2440 VOL/VOL
          WILTING POINT              =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2473 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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                                  LAYER  2
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  18
          THICKNESS                  =    480.00   INCHES
          POROSITY                   =      0.6710 VOL/VOL
          FIELD CAPACITY             =      0.2920 VOL/VOL
          WILTING POINT              =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2942 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC

                                  LAYER  3
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
          THICKNESS                  =     24.00   INCHES
          POROSITY                   =      0.3980 VOL/VOL
          FIELD CAPACITY             =      0.2440 VOL/VOL
          WILTING POINT              =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2549 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC

                                  LAYER  4
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
                        MATERIAL TEXTURE NUMBER  20
          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.  =   10.0000000000     CM/SEC
          SLOPE                      =      4.00   PERCENT
          DRAINAGE LENGTH            =    250.0    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        =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS   =      8.00   HOLES/ACRE
          FML PLACEMENT QUALITY      =  3 - GOOD
```

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.20	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999997000E-08	CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

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.	=	10.0000000000	CM/SEC
SLOPE	=	4.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 8

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

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.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	8.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 4.% AND A SLOPE LENGTH OF 300. FEET.

SCS RUNOFF CURVE NUMBER	=	94.00	
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	=	5.847	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	11.486	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.402	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	150.439	INCHES
TOTAL INITIAL WATER	=	150.439	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	=	2.00	
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
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

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
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.936	0.457	0.637	0.279	0.985	0.634
	0.700	1.397	0.519	0.596	0.739	0.498
STD. DEVIATIONS	1.050	0.376	0.534	0.391	1.078	0.548
	0.626	1.809	0.579	0.719	0.624	0.348
EVAPOTRANSPIRATION						
TOTALS	1.338	1.676	2.902	2.642	3.964	3.814
	3.543	3.585	2.208	1.229	1.133	0.944
STD. DEVIATIONS	0.215	0.266	0.267	0.907	0.852	1.441
	1.284	1.203	1.091	0.414	0.170	0.149
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.5402	0.7473	1.0216	0.8510	0.3302	0.0916
	0.0067	0.0012	0.0361	0.0802	0.0364	0.1888
STD. DEVIATIONS	0.4870	0.4807	0.7485	0.7366	0.2479	0.0969
	0.0198	0.0019	0.1110	0.2670	0.0811	0.3226
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
LATERAL DRAINAGE COLLECTED FROM LAYER 7						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5						
AVERAGES	0.0019	0.0029	0.0036	0.0031	0.0012	0.0003
	0.0000	0.0000	0.0001	0.0003	0.0001	0.0007
STD. DEVIATIONS	0.0017	0.0019	0.0027	0.0027	0.0009	0.0004
	0.0001	0.0000	0.0004	0.0010	0.0003	0.0011
DAILY AVERAGE HEAD ON TOP OF LAYER 8						
AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	8.376	(3.6493)	30403.85	20.305
EVAPOTRANSPIRATION	28.980	(3.7250)	105197.30	70.255
LATERAL DRAINAGE COLLECTED FROM LAYER 4	3.93122	(1.89696)	14270.332	9.53035
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.006	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.001	(0.001)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00000	(0.00000)	0.000	0.00000

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PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00000	(0.00000)	0.006	0.00000
AVERAGE HEAD ON TOP OF LAYER 8	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.037	(1.5183)	-135.80	-0.091

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	3.935	14285.0703
DRAINAGE COLLECTED FROM LAYER 4	0.17334	629.23462
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00008
AVERAGE HEAD ON TOP OF LAYER 5	0.019	
MAXIMUM HEAD ON TOP OF LAYER 5	0.040	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.00008
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.80	6547.7266

$\rightarrow 5.1 \times 10^{-6}$ cm/sec

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3374

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1092

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

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

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	3.0050	0.2504
2	139.9430	0.2915
3	6.5878	0.2745
4	0.0025	0.0100
5	0.0000	0.0000
6	0.1500	0.7500
7	0.0025	0.0100
8	0.0000	0.0000
SNOW WATER	0.000	

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PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Leak Detection Travel Time Analysis

JOB NO. JOHNSTON-07-2
DATE 2/16/07
COMPUTED BY PKS
CHECKED BY

Objective To evaluate the maximum travel (detection) time to each sump for leachate within the leak detection system (LDS). The maximum travel (detection) time is the sum of times through collection media and piping.

Reference

Lindeburg, M.R. (1994), Civil Engineering Reference Manual, Sixth Edition, Professional Publications, Inc., Belmont, CA, p. 5-25.

Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

Richardson, G.N., Giroud, J-P. and Zhao, A. (2000), Design of Lateral Drainage Systems for Landfills, Tenax Corp., Baltimore.

Assumptions

1. Leakage is uniform over the entire landfill.
2. Darcy's Law is valid for all flow conditions considered.
3. For the purpose of determining the travel time in piping, assume that pipes are flowing at a depth to diameter (d/D) ratio of 0.10.

Analysis

- Flow in Collection Media (Natural Drainage Media and/or Drainage Geocomposite):

Based on the method described in Richardson, Giroud, and Zhao use Darcy's Law ($Q = kiA$) to determine the travel (detection) time along the longest flow path.

Darcy's Law:

$$Q = kiA = (kt)iw = \theta iw$$

where:

Q	=	flow
k	=	design permeability of the collection media (See Note 1)
i	=	hydraulic gradient (assume equal to slope)
A	=	area of flow (= $t \times w$)
t	=	thickness of drainage layer
w	=	width of drainage layer
θ	=	design transmissivity of the collection media (See Note 1)

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

Travel Time:

In that continuity must exist:

$$Q = VA = Vwt$$

where: V = flow velocity

For natural drainage media (stone/sand):

$$V = ki$$

For a drainage geocomposite:

$$V = \frac{\theta \times i}{t}$$

For a drainage geocomposite use the true flow velocity:

$$V_{true} = \frac{V}{n}$$

where: V_{true} = true flow velocity
n = porosity (0.4 to 0.8 is typical)

Note:

1. For stone/sand: The design permeability (k) = (specified minimum permeability)/(overall reduction factor (RF))
   For drainage geocomposites: The design transmissivity (θ) = (specified minimum transmissivity)/(RF)

$$RF = RF_{IN} \times RF_{CR} \times RF_{CC} \times RF_{BC} \times FS$$

where: RF_{IN} = reduction factor for intrusion
RF_{CR} = reduction factor for creep
RF_{CC} = reduction factor for chemical clogging
RF_{BC} = reduction factor for biological clogging
FS = overall factor of safety

Based on the recommendations of Richardson, Giroud, & Zhao, use the following values for a leak detection system (LDS). For the LDS, the lower bound values for chemical and biological clogging are typically used as the LDS is subject to minimal flow. An overall factor of safety of 2.0 for long-term conditions is also recommended. For shorter term (lower load) conditions, lower values may be used.

	RF_{IN}	RF_{CR}	RF_{CC}	RF_{BC}
Stone/Sand:	1.0	1.0	1.5-2.0	1.5-2.0
Dr. Geocomposite:	1.0-1.2	1.4-2.0	1.5-2.0	1.5-2.0

- Flow in Piping:

Using Manning's equation for pipe flow and relationships between full and partial flow in circular pipes, determine the travel (detection) time along the longest flow path.

Manning's Equation (Reformulated to Determine Flow Velocity):

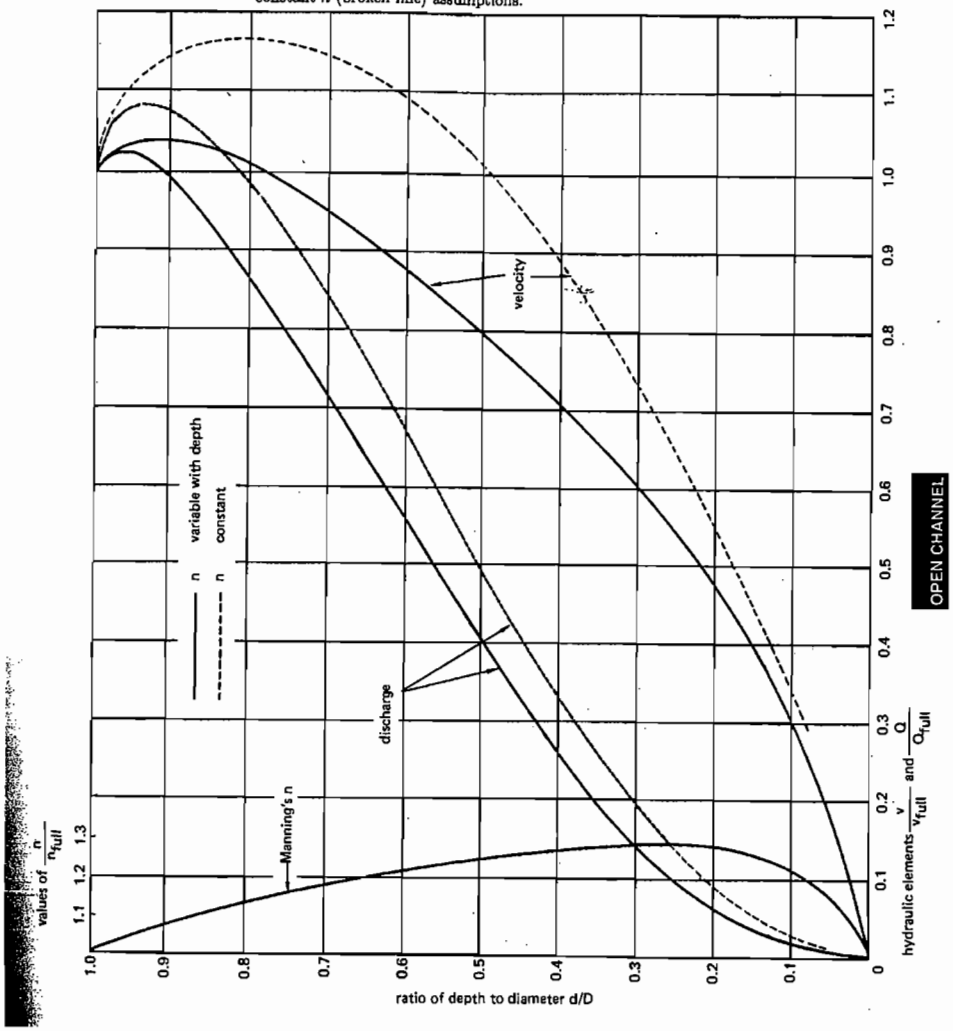
$$V = \frac{s^{0.5} D^{2/3}}{8.9n}$$ (Malcom Eq. I-10)

where: V = full flow velocity (ft/sec)
s = pipe slope (ft/ft)
D = pipe diameter (inches)
n = Manning's roughness coefficient

To estimate partial flow velocity, use the design chart for circular pipes (see below).

Appendix C: Circular Channel Ratios

Experiments have shown that n varies slightly with depth. This figure gives velocity and flow rate ratios for varying n (solid line) and constant n (broken line) assumptions.



Ref: Civil Engineering Reference Manual

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 5 / 7
JOB #: JOHNSTON-07-2
DATE: 5/11/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
Leak Detection System Travel Time Analysis

Drainage Geocomposite Information:

Drainage Geocomposite Transmissivity (θ):	5.0E-04	m^3/m/sec	(Specified Minimum)
Thickness of Geonet Drainage Core:	0.25	inches	(Specified Minimum)
Porosity of Geonet Drainage Core:	0.60		(Assumed - Typical for Drainage Geocomposites)
Reduction Factors for Drainage Geocomposite:			(Per Richardson, Zhao, & Giroud)
$RF_{intrusion}$:	1.2		
RF_{creep}:	2.0		
$RF_{chemical\ clogging}$:	1.5		
$RF_{biological\ clogging}$:	1.5		
Overall Factor of Safety:	2.0		
Reduction Factor for Drainage Geocomposite in LDS:	10.8		
Design Drainage Geocomposite Transmissivity (θ):	4.6E-05	m^3/m/sec	

Pipe Information:

Type of Pipe:	HDPE		
Pipe Diameter (D):	4	in	
Manning's Roughness Coefficient (n):	0.009		(Typical for HDPE Pipe - Smooth Interior Wall)
Ratio of Flow Depth to Diameter (d/D):	10	%	(Assumed)
Flow Ratio (Q/Q_{full}):	0.34		(From Chart based on d/D)

Note: Spreadsheet Converts Units as Required.

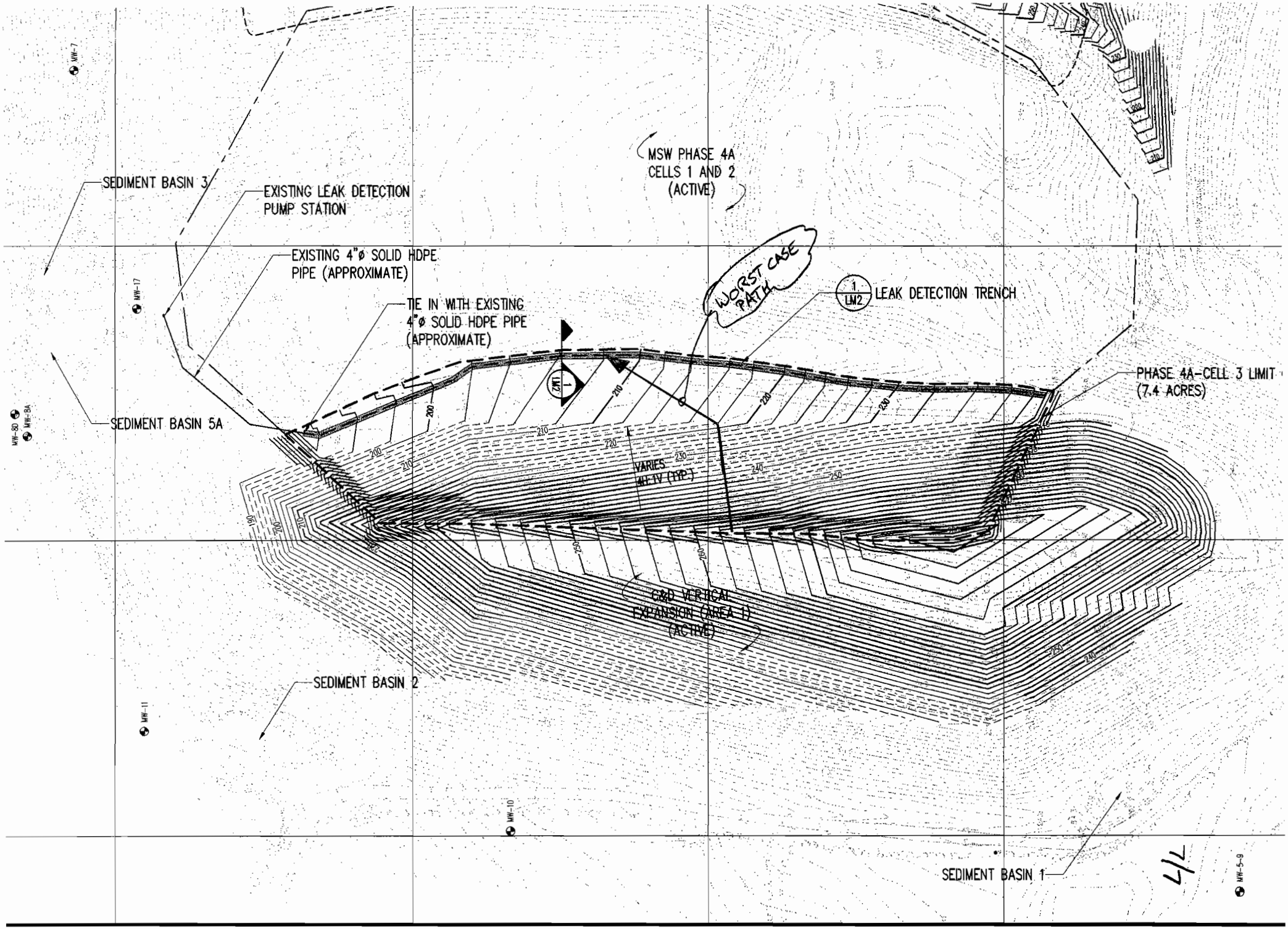
SHEET:	6 / 7
JOB #:	JOHNSTON-07-2
DATE:	5/11/07
BY:	PKS
CHKD BY:	

Travel Time Calculations:

Landfill Unit: Cell 3

LDS Component	Flow Distance (ft) (*)	Slope (%)	Gradient (ft/ft)		Drainage Geocomposite: Apparent Flow Velocity (ft/sec)	Drainage Geocomposite: True Flow Velocity (ft/sec)	Pipe: Full Flow Velocity (ft/sec)	Pipe: Partial Flow Velocity (ft/sec)	Travel Time (min)	Travel Time (days)
Drainage Geocomposite:										
	180	25	0.250		6.0E-03	1.0E-02	----	----	301	0.21
	220	4	0.040		9.6E-04	1.6E-03	----	----	2,299	1.60
Piping:										
	725	2	0.020		----	----	0.8	0.3	42	0.03
	150	20	0.200		----	----	2.7	0.9	3	0.00
								Total:	**2,645**	**1.84**

(*) Based on Worst Case Flow Path → See Attached.


SEDIMENT BASIN 3
EXISTING LEAK DETECTION PUMP STATION
EXISTING 4"ø SOLID HDPE PIPE (APPROXIMATE)
TIE IN WITH EXISTING 4"ø SOLID HDPE PIPE (APPROXIMATE)
SEDIMENT BASIN 5A
MSW PHASE 4A CELLS 1 AND 2 (ACTIVE)
WORST CASE PATH
1 LM2 LEAK DETECTION TRENCH
PHASE 4A-CELL 3 LIMIT (7.4 ACRES)
VARIES 4H:1V (TYP.)
C&D VERTICAL EXPANSION (AREA 1) (ACTIVE)
SEDIMENT BASIN 2
SEDIMENT BASIN 1
MW-7
MW-17
MW-8D
MW-8A
MW-11
MW-10
MW-5-9

7/7

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Final Cover Infiltration Analysis

JOB NO. JOHNSTON-07-2
DATE 3/21/07
COMPUTED BY PKS
CHECKED BY

Objective

To determine the expected average annual infiltration into the landfill through the proposed final cover system. In that the proposed final cover system is an alternate system to the regulatory final cover, the infiltration through the proposed system is compared to the infiltration through the regulatory system. Use the EPA HELP Model (v. 3.07) in the analysis.

References

Schroeder, P.R., Lloyd, C.M., et. al, (1994), "The Hydrologic Evaluation of Landfill Performance (HELP) Model - User's Guide for Version 3," EPA/600/9-94/168a, USEPA Risk Reduction Laboratory, Cincinnati, Ohio.

Schroeder, P.R., Lloyd, C.M., et. al, (1994), "The Hydrologic Evaluation of Landfill Performance (HELP) Model - Engineering Documentation for Version 3," EPA/600/9-94/168b, USEPA Risk Reduction Laboratory, Cincinnati, Ohio.

Analysis

Final Cover Systems Analyzed:

1. Proposed Final Cover System: (Top Down)

   A. 24 inches Vegetative Soil Layer
   B. Drainage Geocomposite
   C. 30 mil Textured LLDPE Geomembrane
   D. 12 inches Intermediate Cover

2. Regulatory Final Cover System: (Top Down)

   A. 24 inches Vegetative Soil Layer
   B. 30 mil LLDPE Geomembrane
   C. 18 inches Compacted Soil Barrier ($k = 1 \times 10^{-5}$ cm/sec)
   D. 12 inches Intermediate Cover

Results

Case	Slope of Final Cover System (percent)	Average Annual Infiltration (inches)
1.	8.0	0.00058
1A.	25.0	0.00017
2.	8.0	0.540
2A.	25.0	0.536

The results show that the proposed final cover system allows less infiltration than the regulatory final cover system. HELP Model runs are attached.

FCS HELP.WPD

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577

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


PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\JCCLD08.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\JCCLD08.OUT


TIME:  16:50     DATE:   3/19/2007


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     TITLE:  Johnston County MSWLF - 8% Slope - Final Cover

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


     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  10
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2650 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                   TYPE 2 - LATERAL DRAINAGE LAYER
                       MATERIAL TEXTURE NUMBER  20
          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   =      0.0200 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   10.0000000000     CM/SEC
          SLOPE                        =      8.00   PERCENT
          DRAINAGE LENGTH              =    200.0    FEET


                                  LAYER  3
                                  --------

                   TYPE 4 - FLEXIBLE MEMBRANE LINER
                       MATERIAL TEXTURE NUMBER  36
          THICKNESS                    =      0.03   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.    =  0.399999993000E-12 CM/SEC
          FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS     =      8.00   HOLES/ACRE
          FML PLACEMENT QUALITY        =  3 - GOOD


                                  LAYER  4
                                  --------

                   TYPE 3 - BARRIER SOIL LINER
                       MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3980 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


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

      NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
               SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
               FAIR STAND OF GRASS, A SURFACE SLOPE OF  8.%
               AND A SLOPE LENGTH OF  200. FEET.

     SCS RUNOFF CURVE NUMBER                =     86.50
     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	=	5.764	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	11.141	INCHES
TOTAL INITIAL WATER	=	11.141	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	=	2.00	
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
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

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
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.359	0.098	0.158	0.054	0.327	0.151
	0.156	0.532	0.142	0.165	0.236	0.127
STD. DEVIATIONS	0.472	0.112	0.207	0.139	0.547	0.201
	0.236	1.066	0.308	0.297	0.273	0.165
EVAPOTRANSPIRATION						
TOTALS	1.477	1.780	3.008	2.702	3.993	3.689
	3.869	4.083	2.424	1.281	1.236	1.084
STD. DEVIATIONS	0.151	0.254	0.329	0.971	0.964	1.704
	1.420	1.285	1.236	0.466	0.161	0.141
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.7564	1.2166	1.0441	0.3527	0.3096	0.1048
	0.0695	0.5593	0.2123	0.2393	0.9954	1.2714
STD. DEVIATIONS	1.3024	1.0383	0.8780	0.5139	0.6269	0.1991
	0.1691	1.3196	0.6020	0.6533	1.0929	0.9345
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0001	0.0000	0.0000	0.0001	0.0001

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0025	0.0019	0.0015	0.0005	0.0004	0.0002
	0.0001	0.0008	0.0003	0.0003	0.0015	0.0018

STD. DEVIATIONS	0.0019	0.0016	0.0013	0.0008	0.0009	0.0003
	0.0002	0.0019	0.0009	0.0009	0.0016	0.0013

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	2.504	(1.8955)	9090.71	6.071
EVAPOTRANSPIRATION	30.627	(3.6083)	111174.84	74.247
LATERAL DRAINAGE COLLECTED FROM LAYER 2	8.13130	(4.24176)	29516.629	19.71249
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00058	(0.00028)	2.096	0.00140
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.001)		
CHANGE IN WATER STORAGE	-0.013	(0.8851)	-48.58	-0.032

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	2.901	10531.6211
DRAINAGE COLLECTED FROM LAYER 2	1.06056	3849.81836
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000059	0.21280
AVERAGE HEAD ON TOP OF LAYER 3	0.047	
MAXIMUM HEAD ON TOP OF LAYER 3	0.091	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	4.5 FEET	
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3557

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

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

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

****

****

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	6.0943	0.2539
2	0.0033	0.0131
3	0.0000	0.0000
4	4.7760	0.3980
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\JCCLD25.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\JCCLD25.OUT


TIME:  16:51     DATE:   3/19/2007


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

     TITLE:  Johnston County MSWLF -25% Slope - Final Cover

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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  10
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2653 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                   TYPE 2 - LATERAL DRAINAGE LAYER
                       MATERIAL TEXTURE NUMBER  20
          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   =      0.0126 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =   10.0000000000     CM/SEC
          SLOPE                        =     25.00   PERCENT
          DRAINAGE LENGTH              =    150.0    FEET


                                  LAYER  3
                                  --------

                   TYPE 4 - FLEXIBLE MEMBRANE LINER
                       MATERIAL TEXTURE NUMBER  36
          THICKNESS                    =      0.03   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.    =  0.399999993000E-12 CM/SEC
          FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS     =      8.00   HOLES/ACRE
          FML PLACEMENT QUALITY        =  3 - GOOD


                                  LAYER  4
                                  --------

                   TYPE 3 - BARRIER SOIL LINER
                       MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3980 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


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

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
              SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
              FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.%
              AND A SLOPE LENGTH OF  150. FEET.

     SCS RUNOFF CURVE NUMBER              =     87.10
     FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
     EVAPORATIVE ZONE DEPTH               =     22.0    INCHES
```

6/15

INITIAL WATER IN EVAPORATIVE ZONE	=	5.770	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.756	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.992	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	11.147	INCHES
TOTAL INITIAL WATER	=	11.147	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	=	2.00	
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
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

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
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	0.394	0.115	0.181	0.063	0.361	0.171
	0.179	0.581	0.160	0.187	0.263	0.144
STD. DEVIATIONS	0.514	0.128	0.233	0.158	0.587	0.220
	0.259	1.129	0.331	0.328	0.297	0.177
EVAPOTRANSPIRATION						
TOTALS	1.475	1.778	3.006	2.704	3.984	3.679
	3.845	4.067	2.418	1.269	1.233	1.081
STD. DEVIATIONS	0.156	0.253	0.330	0.971	0.961	1.704
	1.410	1.287	1.221	0.466	0.163	0.142
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.7163	1.2063	1.0244	0.3458	0.2864	0.0991
	0.0708	0.5313	0.2056	0.2181	0.9603	1.2620
STD. DEVIATIONS	1.2574	1.0359	0.8498	0.4948	0.5752	0.1759
	0.1556	1.2396	0.5801	0.6229	1.0802	0.9342
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

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0006	0.0005	0.0004	0.0001	0.0001	0.0000
	0.0000	0.0002	0.0001	0.0001	0.0004	0.0005

STD. DEVIATIONS	0.0005	0.0004	0.0003	0.0002	0.0002	0.0001
	0.0001	0.0004	0.0002	0.0002	0.0004	0.0003

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	2.798	(2.0344)	10155.29	6.782
EVAPOTRANSPIRATION	30.539	(3.6077)	110855.87	74.034
LATERAL DRAINAGE COLLECTED FROM LAYER 2	7.92628	(4.08113)	28772.396	19.21546
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00017	(0.00008)	0.602	0.00040
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.013	(0.8740)	-48.49	-0.032

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	2.989	10850.7207
DRAINAGE COLLECTED FROM LAYER 2	0.94199	3419.43384
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000015	0.05543
AVERAGE HEAD ON TOP OF LAYER 3	0.011	
MAXIMUM HEAD ON TOP OF LAYER 3	0.043	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3564

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

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

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

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	6.1012	0.2542
2	0.0027	0.0108
3	0.0000	0.0000
4	4.7760	0.3980
SNOW WATER	0.000	

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**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\JCRMC08.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\JCRMC08.OUT


TIME:  10:42     DATE:   3/20/2007


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     TITLE:  Johnston County MSWLF - 8% Slope - RMC

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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  10
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3894 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                   TYPE 4 - FLEXIBLE MEMBRANE LINER
                       MATERIAL TEXTURE NUMBER  36
          THICKNESS                    =      0.03   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.    =  0.399999993000E-12 CM/SEC
          FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS     =      8.00   HOLES/ACRE
          FML PLACEMENT QUALITY        =  3 - GOOD


                                  LAYER  3
                                  --------

                   TYPE 3 - BARRIER SOIL LINER
                       MATERIAL TEXTURE NUMBER   0
          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.    =  0.999999975000E-05 CM/SEC


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

       NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
                FAIR STAND OF GRASS, A SURFACE SLOPE OF  8.%
                AND A SLOPE LENGTH OF  200. FEET.

      SCS RUNOFF CURVE NUMBER              =     86.50
      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    =      8.551  INCHES
      UPPER LIMIT OF EVAPORATIVE STORAGE   =      8.756  INCHES
      LOWER LIMIT OF EVAPORATIVE STORAGE   =      2.992  INCHES
      INITIAL SNOW WATER                   =      0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS     =     17.645  INCHES
      TOTAL INITIAL WATER                  =     17.645  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	=	2.00
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
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

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
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	1.695	1.181	1.049	0.299	0.705	0.222
	0.147	0.762	0.238	0.217	0.637	0.468
STD. DEVIATIONS	1.797	0.953	1.069	0.647	1.206	0.325
	0.212	1.679	0.728	0.419	1.060	0.436
EVAPOTRANSPIRATION						
TOTALS	1.451	1.764	2.986	2.657	4.178	5.544
	4.481	4.132	2.470	1.221	1.150	1.062
STD. DEVIATIONS	0.152	0.256	0.331	0.932	0.782	0.869
	1.536	1.279	1.213	0.427	0.147	0.142
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0774	0.0717	0.0756	0.0625	0.0570	0.0330
	0.0149	0.0163	0.0165	0.0184	0.0362	0.0602
STD. DEVIATIONS	0.0143	0.0074	0.0065	0.0068	0.0080	0.0150
	0.0124	0.0157	0.0163	0.0159	0.0285	0.0253

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	20.4395	20.7831	19.9665	16.9915	14.9386	8.7824
	3.6478	4.0189	4.2237	4.5979	9.6865	15.8028
STD. DEVIATIONS	3.8443	2.1197	1.7499	1.8891	2.1560	4.1764
	3.3118	4.2172	4.4969	4.2604	7.9088	6.8019

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	7.619	(5.6068)	27657.79	18.471
EVAPOTRANSPIRATION	33.095	(3.5981)	120134.73	80.231
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.53981	(0.10670)	1959.510	1.30865
AVERAGE HEAD ON TOP OF LAYER 2	11.990	(2.425)		
CHANGE IN WATER STORAGE	-0.005	(1.6045)	-16.35	-0.011

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	2.870	10416.4375
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.002927	10.62599
AVERAGE HEAD ON TOP OF LAYER 2	24.000	
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3980

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	9.2566	0.3857
2	0.0000	0.0000
3	8.2980	0.4610
SNOW WATER	0.000	

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\RALNCP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\RALNCT.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\RALNCS.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\RALNCE.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\JCRMC25.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\JCRMC25.OUT


TIME:  10:42     DATE:   3/20/2007


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     TITLE:  Johnston County MSWLF -25% Slope - RMC

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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  10
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3894 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                    TYPE 4 - FLEXIBLE MEMBRANE LINER
                        MATERIAL TEXTURE NUMBER  36
          THICKNESS                    =      0.03   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.    =  0.399999993000E-12 CM/SEC
          FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS     =      8.00   HOLES/ACRE
          FML PLACEMENT QUALITY        =  3 - GOOD


                                  LAYER  3
                                  --------

                    TYPE 3 - BARRIER SOIL LINER
                        MATERIAL TEXTURE NUMBER   0
          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.    =  0.999999975000E-05 CM/SEC


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

       NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
                FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.%
                AND A SLOPE LENGTH OF  150. FEET.

      SCS RUNOFF CURVE NUMBER              =     87.10
      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    =      8.550  INCHES
      UPPER LIMIT OF EVAPORATIVE STORAGE   =      8.756  INCHES
      LOWER LIMIT OF EVAPORATIVE STORAGE   =      2.992  INCHES
      INITIAL SNOW WATER                   =      0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS     =     17.643  INCHES
      TOTAL INITIAL WATER                  =     17.643  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	=	2.00
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
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

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
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	2.92	3.81	2.20	4.34	3.74
	4.24	5.43	2.40	2.87	3.05	2.80
STD. DEVIATIONS	2.07	1.23	1.51	1.52	2.22	1.98
	1.91	3.72	1.67	2.00	1.79	1.04
RUNOFF						
TOTALS	1.679	1.174	1.052	0.302	0.721	0.241
	0.168	0.775	0.249	0.227	0.635	0.472
STD. DEVIATIONS	1.785	0.948	1.065	0.641	1.198	0.339
	0.231	1.665	0.728	0.418	1.053	0.434
EVAPOTRANSPIRATION						
TOTALS	1.450	1.763	2.986	2.647	4.170	5.542
	4.454	4.119	2.461	1.221	1.151	1.061
STD. DEVIATIONS	0.153	0.256	0.332	0.938	0.808	0.879
	1.537	1.282	1.219	0.427	0.148	0.142
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0769	0.0715	0.0755	0.0622	0.0566	0.0328
	0.0147	0.0160	0.0164	0.0180	0.0356	0.0594
STD. DEVIATIONS	0.0146	0.0075	0.0066	0.0068	0.0081	0.0148
	0.0120	0.0152	0.0162	0.0156	0.0284	0.0256

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	20.2908	20.7283	19.9223	16.9295	14.8554	8.7066
	3.5854	3.9388	4.1999	4.4888	9.4994	15.5833
STD. DEVIATIONS	3.9259	2.1215	1.7578	1.8812	2.1809	4.1257
	3.2204	4.0755	4.4826	4.1830	7.8959	6.8923

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.25	(8.104)	149735.7	100.00
RUNOFF	7.694	(5.5988)	27928.45	18.652
EVAPOTRANSPIRATION	33.024	(3.6036)	119877.87	80.060
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.53558	(0.10661)	1944.154	1.29839
AVERAGE HEAD ON TOP OF LAYER 2	11.894	(2.422)		
CHANGE IN WATER STORAGE	-0.004	(1.6087)	-14.80	-0.010

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	2.945	10690.1592
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.002927	10.62599
AVERAGE HEAD ON TOP OF LAYER 2	24.000	
SNOW WATER	1.80	6547.7266

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3980

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

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FINAL WATER STORAGE AT END OF YEAR 20

LAYER	(INCHES)	(VOL/VOL)
1	9.2639	0.3860
2	0.0000	0.0000
3	8.2980	0.4610
SNOW WATER	0.000	

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PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Final Cover Drainage Layer Analysis

JOB NO. JOHNSTON-07-2
DATE 2/16/07
COMPUTED BY PKS
CHECKED BY

Objective To evaluate the required transmissivity for the drainage geocomposite placed in the final cover system.

Reference Richardson, G.N., Giroud, J-P., and Zhao, A. (2000), Design of Lateral Drainage Systems for Landfills, Tenax Corp., Baltimore.

Analysis

Step 1:

Determine the required transmissivity (θ_{reqd}) of the drainage geocomposite based on the following equation:

$$\theta_{reqd} = \frac{RF_{dc} q_n L i}{\sin\beta} = \frac{RF_{dc} q_n L \cos\beta}{\sin\beta} = \frac{RF_{dc} q_n L}{\tan\beta}$$ (Richardson et. al. Eq. 4-6 Mod.)

where:
- θ_{reqd} = required transmissivity ($m^3/m/sec$)
- RF_{dc} = drainage geocomposite reduction factor (See Note 1)
- q_n = fluid input rate/impingement rate (m/s) (See Note 2)
- L = flow length/drain spacing (horizontally projected) (m)
- β = slope angle of final cover (degrees).

Notes:

1. Based on the recommendations of Richardson, Giroud, & Zhao, use $RF_{dc} = 6$. This accounts for an overall factor of safety of 2, plus a factor of safety of 3 for long-term intrusion, creep, and clogging concerns.

2. Typically the impingement into the drainage geocomposite is determined by the **lessor** of:

   a. Permeability of the overlying vegetative soil layer(k_{veg}) or
   b. Design rainfall.

   Per Richardson,Giroud, & Zhao, use $q_n = k_{veg}$ except in arid/semi-arid areas.

Step 2:

Determine the required transmissivity test parameters:

- Normal Stress (cover thickness x unit weight of cover soil) and
- Hydraulic Gradient (equals slope of cover system).

FCS DRAIN LAYER.WPD

Step 3:

Calculate the required total flow capacity (Q) of the drain based on the following equation:

$$Q = q_n A$$

where:

Q	=	flow capacity (cfs)
q_n	=	impingement (ft/s)
A	=	total area served by the drain (= L x DL) (ft^2)
DL	=	length of drain between outlet locations (ft).

Step 4:

After finding Q for each drain, the designer shall select the appropriate type and size of drain.

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SHEET: 3 / 3
JOB #: JOHNSTON-07-2
DATE: 2/28/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
Final Cover Drainage Layer Analysis

Input Parameters:

Side Slope Angle (β):	14.0 degrees	
Impingement (q_n):	0.0001 cm/sec	(= Permeability of Vegetative Soil Layer)
Drain Spacing (L):	140 ft	(= Horizontally Projected Distance Up & Down Slope)
Reduction Factors for Drainage Geocomposite:		(Per Richardson, Giroud, & Zhao Recommendations)
$RF_{intrusion}$:	1.2	
RF_{creep}:	1.4	
$RF_{chemical\ clogging}$:	1.2	
$RF_{biological\ clogging}$:	1.5	
Overall Factor of Safety:	2.0	
Reduction Factor for Drainage Geocomposite in Final Cover (RF_{dc}):	6.0	
Drain Length (DL):	200 ft	(= Distance Across Slope at Toe)
Final Cover: Thickness:	2.0 ft	
Unit Weight:	110 pcf	

Note: Spreadsheet Converts Units as Required.

Transmissivity Requirements:

Determine Minimum Transmissivity:

θ_{min} = 1.0E-03 m^3/m/sec = 5.0 gpm/ft

Determine Transmissivity Test Parameters:

Min. Normal Stress = 220.0 psf

Hydraulic Gradient = 0.25

Determine Required Drain Capacity:

Calculate Required Total Flow Capacity:

Q = 0.09 cfs *Based on 200 foot spacing between outlets.

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Filter Geotextile Analysis - FCS

JOB NO. JOHNSTON-07-2
DATE 3/15/07
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Objective To determine the maximum geotextile apparent opening size (AOS) to provide proper retention to protect drainage media from piping and clogging from adjacent soil. Additionally, to determine the minimum required geotextile permittivity to provide proper drainage from the adjacent soil. Geotextile filtration properties must be selected based on the up-gradient soil gradation and plasticity and site specific hydraulic conditions.

References

Bhatia, S.K. and Huang, Q. (1995), "Geotextile Filters for Internally Stable/Unstable Soils", *Geosynthetics International*, Vol. 2, No. 3, pp. 537-565.

Koerner, Robert M. (1999), Designing with Geosynthetics, 4th Ed., Prentice-Hall Inc., Englewood Cliffs, NJ, pp. 84-91.

Mirafi - Geotextile Filter Design, Application, and Product Selection Guide, Ten Cate Nicolon Corp. (www.mirafi.com).

Richardson, G.N., Giroud, J-P., and Zhao, A. (2000), Design of Lateral Drainage Systems for Landfills, Tenax Corp., Baltimore.

Assumption The design criteria given assume that the soil is "set" in intimate contact with the geotextile.

Background From Richardson et. al.:

For the purposes of filtration design, soils can be characterized as stable or unstable. Stable soils perform an internal filtration process that limits migration of fines within the soil. Typically, these soil types include well-graded soils. Unstable soils are those which cannot perform self-filtration (i.e. they have the potential to pipe internally). They may include gap-graded, broad-graded, and other highly erodible soils. In gap-graded soils, there exists a coarse and fine fraction, but very little medium fraction. If there is an insufficient quantity of soil particles in the medium fraction, fine soil particles pipe through the coarse fraction. In broad-graded soils, the gradation is distributed over a very wide range of particle sizes such that fine soil tends to pipe through coarser particles.

Analysis

1. **Define Application and Function of Geotextile:**

Define the application and function of the geotextile (i.e. where the geotextile is to be used and whether retention or permeability is the key function of the material) and also the confining stress (i.e. high - leachate collection system; low - final cover system) and flow conditions (i.e. steady-state - landfill drains; dynamic - shoreline protection).

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2. Evaluate Soils Information:

For representative soils, evaluate grain size and plasticity information. From the grain size curves determine the coefficients of uniformity and curvature as follows:

$$C_u = \frac{d_{60}}{d_{10}}$$

$$C_c = \frac{d_{30}^{\ 2}}{\left(d_{10} \times d_{60}\right)}$$

where: C_u = coefficient of uniformity (quantifies the distribution of particle sizes)
C_c = coefficient of curvature (identifies internal soil stability)
d_x = the diameter at which x percent of the soil is finer

For $C_u \leq 4$, the soil is uniformly-graded; for $4 < C_u \leq 20$, the soil is well-graded; and for $C_u > 20$, the soil is broad-graded. Uniformly-graded and broad-graded soils require careful analysis. Gap-graded soils which have a coarse and fine fraction, but limited medium fraction are of particular concern and should be avoided. Gap-graded soils are readily identified by the appearance of the grain size curve. For $1 \leq C_c \leq 3$, the soil should be internally stable (Bhatia and Huang state that soils having $C_c \leq 7$ are internally stable.).

Additionally, in general, particles do not move within soils having a plasticity index (PI) greater than 15% so there is no clogging potential (Richardson et. al.).

3. Selection of Soil Retention Requirements (Maximum AOS):

To determine the maximum AOS, use the method given in Koerner/Mirafi (after Luettich) and the method given in Bhatia and Huang. For the AOS determined by either method, the following shows the relationship between opening size and the corresponding U.S. sieve number (with typical non-woven geotextile information as shown).

Opening Size (mm)	U.S. Sieve
0.150	100 (most 8 to 16 oz/sy non-wovens)
0.180	80
0.212	70 (most 4 to 6 oz/sy non-wovens)
0.250	60
0.300	50
0.425	40
0.600	30

- Luettich Method:

For steady-state conditions, use the chart below.

- Bhatia and Huang Method:

Bhatia and Huang developed the following retention criteria:

For $n \geq 60\%$: $O_{95} < d_{85}(2.71 - 0.36C_c)$ $C_c \leq 7$

$O_{95} < d_{85}(0.65 - 0.05C_c)$ $C_c > 7$

For $n < 60\%$: $O_{95} < d_{85}$

where: O_{95} = apparent opening size
n = geotextile porosity (%) (for non-woven geotextiles this value is typically 70 to 90%)

4. Determine Geotextile Permittivity Requirements:

Determine the geotextile permittivity requirements:

$$\Psi = \frac{k_g}{t_g} \qquad (\text{sec}^{-1})$$

where: Ψ = minimum required geotextile permittivity (sec^{-1})
k_g = minimum allowable geotextile permeability (cm/sec)
$k_g \geq i_S k_S$
t_g = geotextile thickness under design load (cm)
i_S = hydraulic gradient (use 1.5 for landfills)
k_S = permeability of retained soil (cm/sec).

5. Other Considerations:

Other things to consider in the design of a filter geotextile include anti-clogging requirements and survivability/durability requirements. For anti-clogging, it is generally best to use the largest AOS that satisfies the retention criteria. For non-woven geotextiles used in landfill applications, an AOS of 0.21 mm (No. 70 sieve) is typically the largest AOS that is available. For survivability/durability concerns, generally an adequately UV stabilized geotextile made from polypropylene or polyester with an AASHTO M288 Strength Class of 2 is suitable for use in subsurface drainage applications.

PROJECT Johnston County MSWLF - Phase 4A - Cell 3

SUBJECT Filter Geotextile Analysis - FCS

JOB NO. JOHNSTON-07-2
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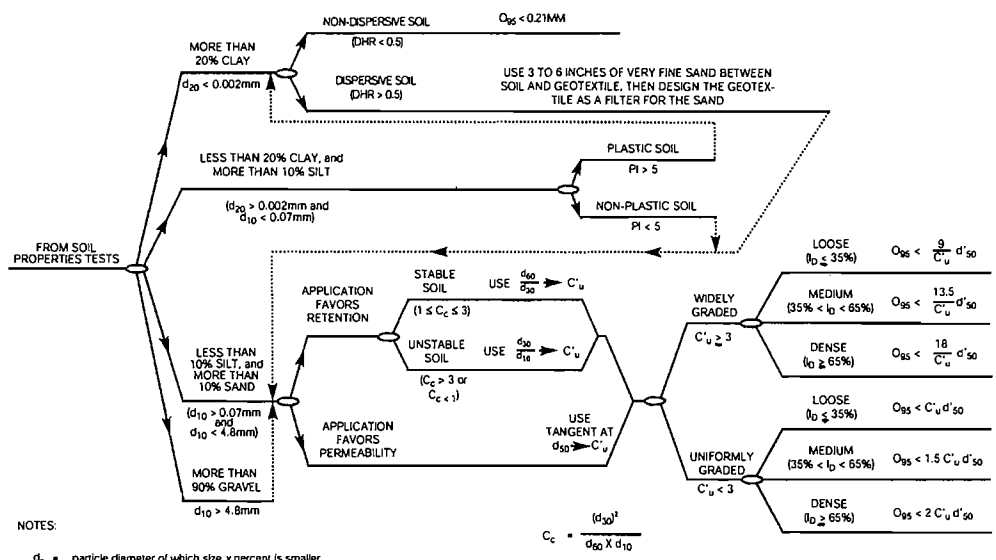
Chart 1. Soil Retention Criteria of Steady-State Flow Conditions



Ref: Mirafi (After Luettich)

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SHEET: 5 / 9
JOB #: JOHNSTON-07-2
DATE: 3/19/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A
Filter Geotextile Analysis (Final Cover System)

Application: Final Cover Drainage Geocomposite
Primary Function: Retention
Relative Confining Stress: Low
Flow Conditions: Steady-State

	Soil Evaluated			
	643-01-01	643-01-03	643-04-01	643-06-01
Soil Description:	Brown Sandy Silt	Brown Clayey Sand	Tan Clayey Sand	Reddish Tan Sand w/ Silt
Soil Type:	ML	SC	SC	SP-SM
Particle Size (mm) d_{85}:	0.700	0.600	1.000	0.850
d_{60}:	0.060	0.320	0.480	0.500
d_{50}:	0.020	0.270	0.370	0.400
d_{30}:	0.003	0.110	0.200	0.270
d_{20}:	0.001	0.010	0.120	0.160
d_{10}:	0.001	0.001	0.010	0.100
PI:	11	25	18	2
C_u:	120.00	320.00	48.00	5.00
	Use Caution - Soil is Broad Graded!	Use Caution - Soil is Broad Graded!	Use Caution - Soil is Broad Graded!	Soil is Well Graded.
C_c	0.30	37.81	8.33	1.46
Luettich Method:*	-----	-----	-----	-----
Soil Dispersion (When Applicable):	Is Soil Dispersive? (Y/N)	Is Soil Dispersive? (Y/N)	Is Soil Dispersive? (Y/N)	NA
	N	N	N	
Recommended Maximum AOS (mm) (When Applicable):	**0.210**	**0.210**	**0.210**	
	No. 70 Sieve	**No. 70 Sieve**	**No. 70 Sieve**	
Internal Soil Stability (When Applicable):	NA	NA	NA	Soil is Stable
				Draw straight line through d60 and d30 to obtain C'u.
Particle Size (mm) for Determining C'_u d'_{100}:				1.300
d'_{50}:				0.400
d'_0:				0.110
C'_u (When Applicable):				3.44
				Soil is Widely Graded.
Soil Relative Density (I_D) (Loose (L), Medium (M), Dense (D) (When Applicable):				M
Recommended Maximum AOS (mm) (When Applicable):				**1.571**
				No. 30 Sieve
Bhatia & Huang Method:	-----	-----	-----	-----
Internal Soil Stability:	Soil is Stable.	Soil is Unstable.	Soil is Unstable.	Soil is Stable.
Geotextile Porosity (%):	80	80	80	80
Recommended Max. AOS (mm):	**1.821**	**-0.744**	**0.233**	**1.857**
	No. 30 Sieve	**Check Available Geotextiles.**	**No. 70 Sieve**	**No. 30 Sieve**
Required Geotextile Properties:	-----	-----	-----	-----
Hydraulic Gradient (i_e):	1.5	1.5	1.5	1.5
Estimated Soil Permeability (k_s) (cm/sec):	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Min. Allowable Geotextile Permeability (k_g) (cm/sec):	1.5E-03	1.5E-03	1.5E-03	1.5E-03
Geotextile Thickness (t_g) (cm):	0.25	0.25	0.25	0.25
Min. Required Geotextile Permittivity (Ψ) (sec^{-1}):	**0.006**	**0.006**	**0.006**	**0.006**

***Note: Spreadsheet assumes retention application in using the Luettich Method.**

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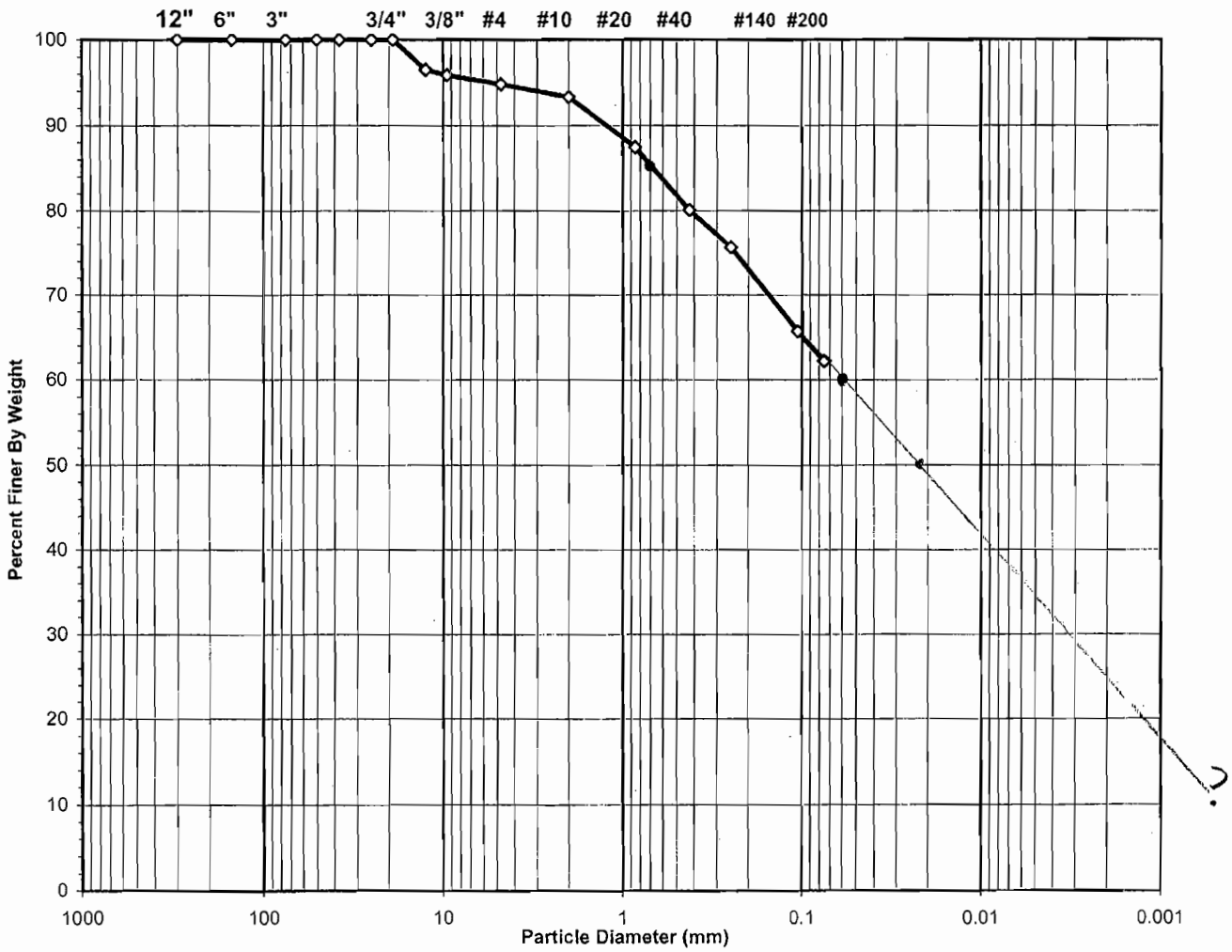
geotechnics
INTEGRITY IN TESTING

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

Client	GN RICHARDSON & ASSOC.	Boring No.	TP-01
Client Reference	JOHNSTON CO. C&D LF AREA 2 CELL 1	Depth (ft)	1-5'
Project No.	2006-643-01	Sample No.	SF-01
Lab ID	2006-643-01-01	Soil Color	**BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol ***ML, TESTED***

USCS Classification ***SANDY SILT***

Tested By JSC Date 10/24/2006 Checked By GRM Date 10-25-06

 DCN: CT-S3C DATE 6-25-98 REVISION: 2 *\\Lab1\c\2006 PROJECTS\2006-643 GNRA JOHNSTON CO\[2006-643-01-01 SIEVE.XLS]Sheet1*

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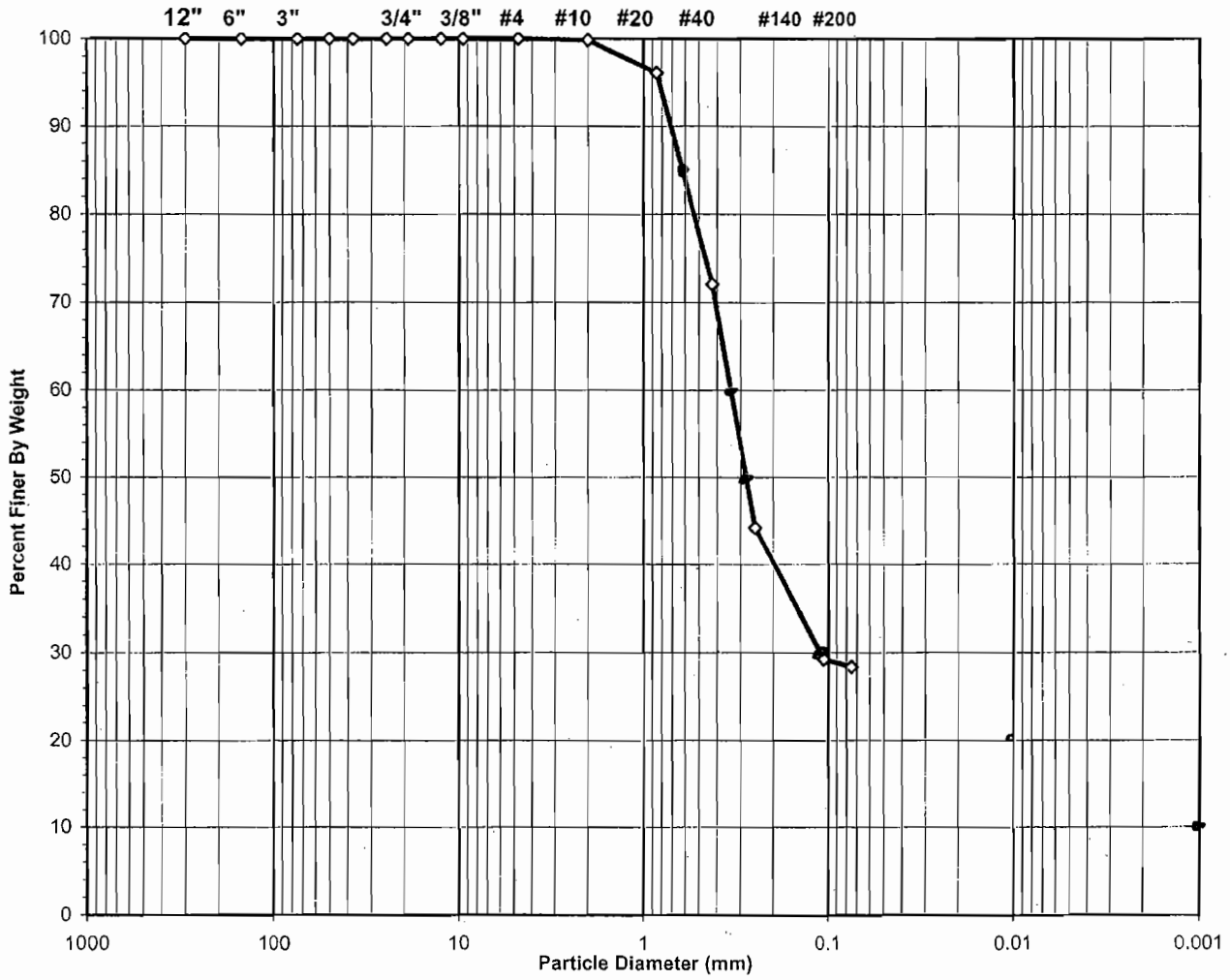
SIEVE ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	GN RICHARDSON & ASSOC.	Boring No.	TP-03
Client Reference	JOHNSTON CO. C&D LF AREA 2 CELL 1	Depth (ft)	0.5-3'
Project No.	2006-643-01	Sample No.	SF-03
Lab ID	2006-643-01-03	Soil Color	**BROWN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	**gravel**	**sand**	**silt and clay**



USCS Symbol ***SC, TESTED***

USCS Classification ***CLAYEY SAND***

Tested By JSC Date 10/24/2006 Checked By GEM Date 10-25-06

 DCN: CT-S3C DATE 6-25-98 REVISION: 2 *\\Lab1\c\2006 PROJECTS\2006-643 GNRA JOHNSTON CO\[2006-643-01-03 SIEVE.XLS]Sheet1*

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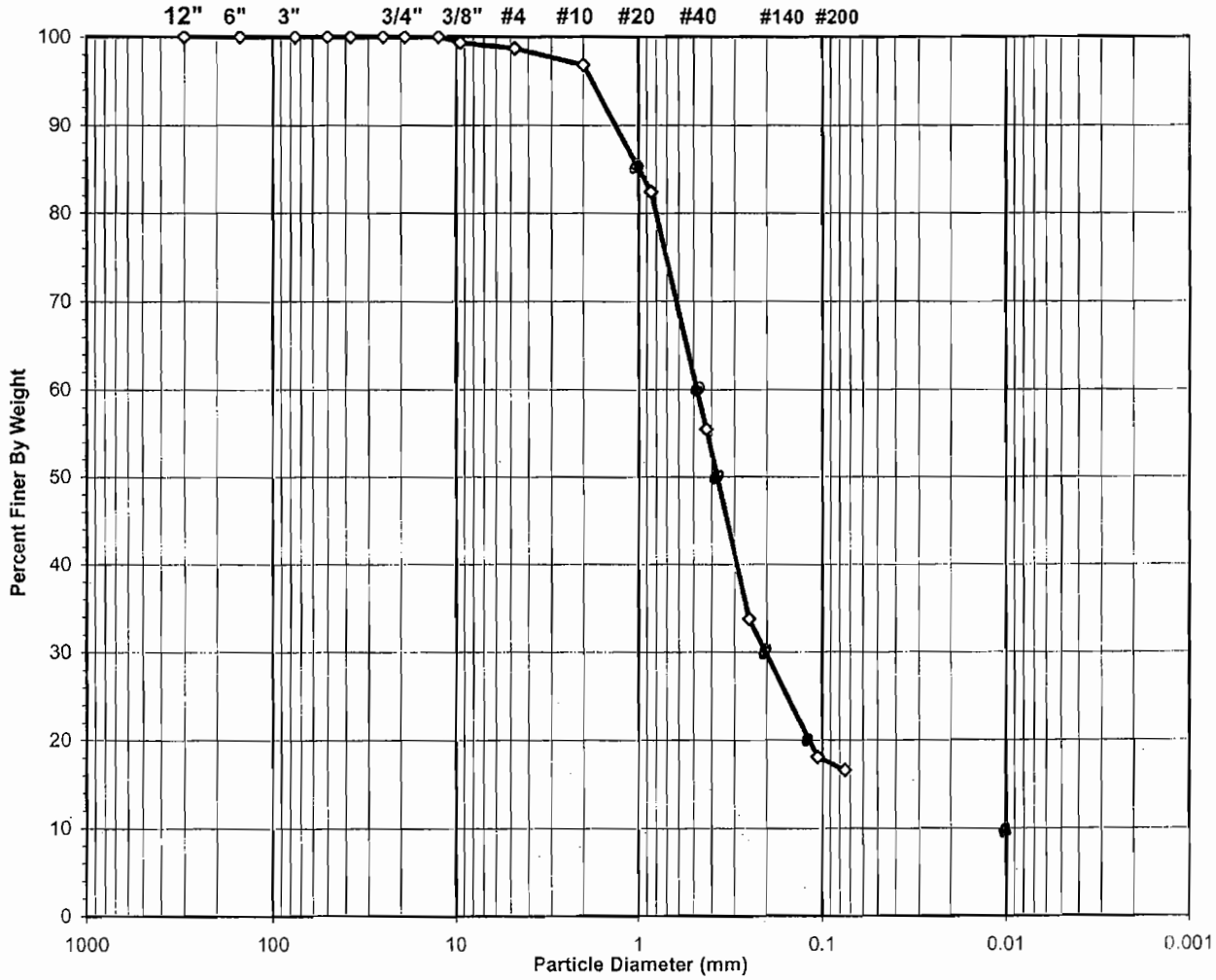
INTEGRITY IN TESTING

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

Client	G.N. RICHARDSON & ASSOC.	Boring No.	NA
Client Reference	JOHNSTON CO. C&D LF AREA 2 CELL 1	Depth (ft)	SURFACE
Project No.	2006-643-04	Sample No.	NA
Lab ID	2006-643-04-01	Soil Color	**TAN**

USCS	SIEVE ANALYSIS		HYDROMETER
	gravel	sand	silt and clay



USCS Symbol ***SC, TESTED***

USCS Classification ***CLAYEY SAND***

Tested By JBD Date 11/21/06 Checked By MCW Date 11/21/06

 DCN: CT-S3C DATE 6-25-98 REVISION: 2 *C:\2006 PROJECTS\2006-643 GNRA JOHNSTON CO\[2006-643-04-01 SIEVE.XLS]Sheet1*

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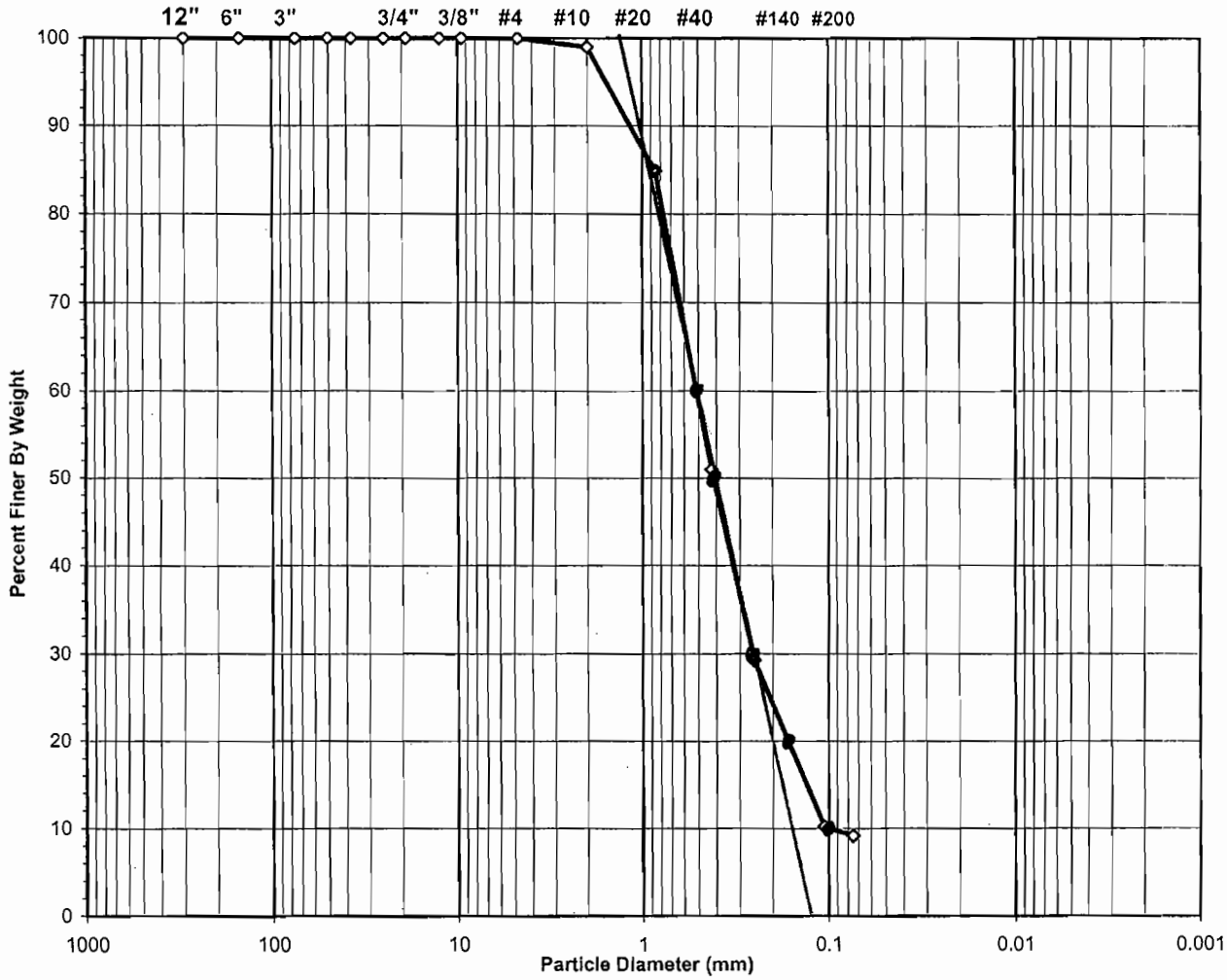
INTEGRITY IN TESTING

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

Client	GN RICHARDSON & ASSOC.	Boring No.	TP-10
Client Reference	JOHNSTON CO. C&D LF AREA 2 CELL 1	Depth (ft)	2-3
Project No.	2006-643-06	Sample No.	12-04-06
Lab ID	2006-643-06-01	Soil Color	**REDDISH TAN**

	SIEVE ANALYSIS		*HYDROMETER*
USCS	gravel	sand	silt and clay



USCS Symbol	***SP-SM, TESTED***	**D60 =**	**0.5**	**CC =**	**1.3**
USCS Classification	***POORLY GRADED SAND WITH SILT***	**D30 =**	**0.3**	**CU =**	**5.1**
		D10 =	**0.1**		

Tested By SGH Date 12/11/2006 Checked By GOM Date 12-12-06

 DCN: CT-S3C DATE 6-25-98 REVISION: 2 *\\Lab1\c\2006 PROJECTS\2006-643 GNRA JOHNSTON CO\[2006-643-06-01 SIEVE.XLS]Sheet1*

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Objective To design rain gutters and down pipes to handle the peak discharge from the design storm.

Reference Debo, T.N., and Reese, A.J. (1995), Municipal Storm Water Management, Lewis Publishers, Boca Raton, FL.

Malcom, H. Rooney (1989 & 2003 Supplement), Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC.

Analysis The following approach is used in the design of rain gutters and down pipes:

1. Determine the peak discharge from the design storm(s). Use the Rational Method.
2. For each pipe size, determine the maximum area (A), to handle the predicted peak discharge (Q) with an added factor of safety. Analyze rain gutters and down pipes based on partial flow to determine flow depth and velocity then compare the full flow capacity of each pipe size with the calculated peak flow rate to verify the desired factor of safety. Analyze rain gutter drop inlets (inlet to down pipes) as orifices.
3. Analyze rain gutter pipe perforations as orifice flow to ensure adequate flow capacity into rain gutters.

Calculations

- Rain Gutters & Down Pipes:

Determine Flow Capacity of Pipe:

$$Q_{\max} = \frac{0.463 D^{8/3} S^{1/2}}{n} \qquad \text{(D\&R Equation 8.24)}$$

where:
Q_{max} = flow capacity of pipe (cfs)
D = inside diameter of pipe (ft)
S = pipe slope (ft/ft)
n = Manning's roughness coefficient

FCS RAIN GUTTERS & DPIPES.WPD

Determine Factor of Safety (FS):

$$FS = \frac{Q_{max}}{Q}$$

Iterate the drainage area (A) to each drainage structure such that $Q_{max}/Q \geq$ the desired factor of safety.

Determine Flow Depth:

$$h = \frac{1}{2}\left(1 - \cos\left(\frac{\theta}{2}\right)\right)D \qquad \text{(D\&R Equation 8.29)}$$

where:
h = flow depth (inches)
θ = central angle

$$\theta = \frac{3\pi}{2}\left[1 - \left(1 - (\pi K)^{1/2}\right)^{1/2}\right]^{1/2} \qquad \text{(D\&R Equation 8.28)}$$

K = constant

$$K = 0.673QnD^{-8/3}S^{-1/2} \qquad \text{(D\&R Equation 8.27)}$$

Determine Flow Velocity:

$$V = \frac{Q}{A} = \frac{Q}{D^2\,\frac{(\theta - \sin\theta)}{8}} \qquad \text{(D\&R Equation 8.30 for "A")}$$

where:
V = flow velocity (ft/sec)
A = cross-sectional area of flow (ft^3)

- Down Pipe Drop Inlets and Rain Gutter Pipe Perforations:

Determine Q_{max}:

$$Q_{max} = C_d A\sqrt{2gh}$$ (Malcom Equation I-7)

where:
C_d = coefficient of discharge
A = cross-sectional area of flow (ft^3)
g = acceleration of gravity (32.2 ft/sec^2)
h = driving head - centroid of orifice to water surface (ft)

Determine Factor of Safety (FS):

$$FS = \frac{Q_{max}}{Q}$$

Iterate the drainage area (A) to each drainage structure such that $Q_{max}/Q \geq$ the desired factor of safety.

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SHEET: 4 / 4
JOB #: JOHNSTON-07-2
DATE: 2/28/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A - Cell 3
Rain Gutters & Down Pipe Sizing

Input Parameters:

Manning's Rougness Coefficient =	0.009	--> HDPE Pipe
Runoff Coefficient =	0.5	
Rainfall Intensity =	8.19	IN/HR --> 25 YR - 5 MIN STORM
Allowable Head (Down Pipe Drop Inlets) =	24	INCHES
Orifice Coef. Of Discharge (Down Pipe Drop Inlets) =	0.6	TYPICAL
Hole Diameter (Rain Gutter Pipe Bottom Perforations) =	0.5	INCHES
Allowable Head (Rain Gutter Pipe Bottom Perforations) =	12	INCHES
Orifice Coef. Of Discharge (Rain Gutter Pipe Perforations) =	0.6	TYPICAL

Rain Gutters

ID	Drainage Area (AC)	Runoff Volume (Q) (CFS)	Pipe I.D. (SDR 26) (IN)	Pipe Slope (%)	Flow Capacity (Q_{max}) (CFS)	Factor of Safety (>/= 1.10)	K (CONSTANT)	θ (< 265°)	Flow Depth (IN)	Flow Area (SF)	Flow Velocity (FPS)
Max. Area - 6"	0.32	1.31	6.1	3	1.47	1.12	0.278	233	4.41	0.16	8.33
Max. Area - 8"	0.67	2.74	8.0	3	3.02	1.10	0.283	235	5.86	0.27	10.01
Max. Area - 10"	1.18	4.83	9.9	3	5.33	1.10	0.282	235	7.24	0.42	11.53
Max. Area - 12"	1.89	7.74	11.8	3	8.52	1.10	0.283	236	8.65	0.60	12.97

Down Pipe Drop Inlets

ID	Drainage Area (AC)	Runoff Volume (Q) (CFS)	Pipe I.D. (SDR 26) (IN)	X-Sectional Area (SF)	Flow Capacity (Q_{max}) (CFS)	Factor of Safety (>/= 1.10)
Max. Area - 8"	0.52	2.13	8.0	0.35	2.38	1.12
Max. Area - 10"	0.80	3.28	9.9	0.53	3.64	1.11
Max. Area - 12"	1.14	4.67	11.8	0.76	5.17	1.11
Max. Area - 14"	1.37	5.61	12.9	0.91	6.18	1.10
Max. Area - 16"	1.80	7.37	14.8	1.19	8.14	1.10
Max. Area - 18"	2.27	9.30	16.6	1.50	10.23	1.10

Down Pipes

ID	Drainage Area (AC)	Runoff Volume (Q) (CFS)	Pipe I.D. (SDR 26) (IN)	Pipe Slope (%)	Flow Capacity (Q_{max}) (CFS)	Factor of Safety (>/= 1.10)	K (CONSTANT)	θ (< 265°)	Flow Depth (IN)	Flow Area (SF)	Flow Velocity (FPS)
Max. Area - 8"	1.02	4.18	8.0	7	4.62	1.11	0.282	235	5.85	0.27	15.28
Max. Area - 10"	1.80	7.37	9.9	7	8.15	1.11	0.282	235	7.23	0.42	17.61
Max. Area - 12"	2.88	11.79	11.8	7	13.01	1.10	0.282	235	8.63	0.60	19.81
Max. Area - 14"	3.65	14.95	12.9	7	16.51	1.10	0.282	235	9.43	0.71	21.02
Max. Area - 16"	5.27	21.58	14.8	7	23.81	1.10	0.282	235	10.83	0.94	23.04
Max. Area - 18"	7.15	29.28	16.6	7	32.34	1.10	0.282	235	12.14	1.18	24.86

Rain Gutter Pipe Perforations

ID	Max. Drainage Length (LF)	Runoff Volume/LF Pipe (CFS)	No. Holes/LF	X-Sectional Area (SF/Hole)	Flow Capacity (Q_{max}) (CFS/LF)	Factor of Safety (>/= 1.10)
2 Bottom Perfs. @ 4" O.C.	200	0.019	6	0.001	0.039	2.10

Note: Conservatively Neglects Upper Holes.

Pipe Dimensions

Standard Dimension Ratio (SDR) of Pipe = 26

Nominal Pipe Size (IN)	Pipe O.D. (IN)	Min. Wall Thickness (IN)	Pipe I.D. (IN)
6	6.625	0.255	6.1
8	8.625	0.332	8.0
10	10.75	0.413	9.9
12	12.75	0.490	11.8
14	14	0.538	12.9
16	16	0.615	14.8
18	18	0.692	16.6
24	24	0.923	22.2

RICHARDSON SMITH GARDNER & ASSOCIATES
Engineering and Geological Services
14 N. Boylan Avenue Tel: 919-828-0577
Raleigh, NC 27603 Fax: 919-828-3899

SHEET: 1 / 2
JOB #: JOHNSTON-07-2
DATE: 6/5/07
BY: PKS
CHKD BY:

Johnston County MSW Landfill - Phase 4A
Piggyback Liner Evaluation

Objective: To estimate the amount of strain in the piggyback liner system.

Given:
1. Results from analysis of original piggyback liner critical Cross Section B (**See Attached**).
2. Revised Critical Cross Section B.

Assumptions:
1. Conservatively assume that the increase in load at originally analyzed node results in a linear increase in Y displacement.
2. Ignore any X displacement. This was a very small number in the original analysis.
3. As in the original analysis, assume that there is zero displacement at Start, End, and Nodes 11 and 17.

Calculations:

Node *	X Base (ft)	Y Base (ft)	Segment Length (ft)	From Original Analysis (Load Step 4) Y Displacement (Primary) (ft)	Y Displacement (Secondary) (ft)	Y Displacement (Total) (ft)	Waste Thickness Over Liner (Original) (ft)	(Revised) (ft)	Increase in Load (%)	Assumed Y Displacement (Total) (ft)	Revised Segment Length (ft)	Strain Total (%)
Start	31.000	254.000		0.000	0.000	0.000	0	0	0.00	0.000		
73	350.000	212.000	321.753	-3.203	-0.572	-3.775	64	99	54.69	-5.839	322.567	0.25
11	431.000	186.000	85.071	0.000	0.000	0.000	97	132	36.08	0.000	83.471	-1.88
17	641.000	186.000		0.000	0.000	0.000	105	139	32.38	0.000	667.441	
88	773.000	220.500	136.434	-3.979	-0.616	-4.595	63	101	60.32	-7.367	134.760	-1.23
90-91	882.000	223.500	109.041	-3.802	-0.606	-4.408	60	90	50.00	-6.612	109.065	0.02
End	1063.000	271.500	187.257	0.000	0.000	0.000	0	0	0.00	0.000	189.059	0.96

→ MAX. O.K.

*— Ref. Fig 3-1 in Engineering Plan.

G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

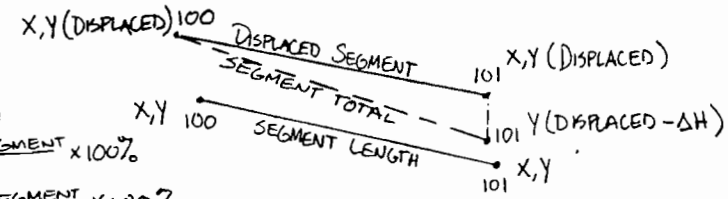
Johnston County Landfill
Johnston County, NC
Piggyback Liner Strains - Revised Waste Unit Weight

SHEET: 2/2
JOB #: Johnston-9
DATE STARTED: 10/20/99
DATE PRINTED: 10/29/99
BY: DTD
CHKD BY: PKS

Objective: To determine the amount of strain applied to the piggyback liner system.

Given:
C_C = 0.04
γ = 80 pcf - existing waste
γ = 70 pcf - proposed waste

$\Delta H = C_C H_O \log(P_F/P_O)$
ΔH = Settlement
P_O = Intial average vertical stre = 0.5 X Ex. Waste Ht. X γ_1
P_F = Final average vertical str = 0.5 X Prop. Waste Ht. X γ_2



Reference:
1) Section B-B
2) Johnston County Site Plan
3) Load Step 4 - Finite Element Analysis

$$\text{STRAIN (ELASTIC)} = \frac{\text{DISPLACED SEG.} - \text{SEGMENT}}{\text{SEGMENT}} \times 100\%$$

$$\text{STRAIN (TOTAL)} = \frac{\text{SEGMENT TOTAL} - \text{SEGMENT}}{\text{SEGMENT}} \times 100\%$$

Calculations:

Node	X Base (ft)	Y Base (ft)	X Displacement (ft)	Y Displacement (ft)	Segment Length (ft)	Displaced Segment (ft)	Strain (%)	Ex. Waste Height (ft)	Prop. Waste Height (ft)	P_O Stress (psf)	P_F Stress (psf)	ΔH (ft)	Segment Total (ft)	Strain Total (%)
100	99.995934	254.07133	8.447E-02	9.697E-02				74	0	2962.85	2962.85	0.00000		
101	140.10295	245.32902	9.249E-03	-1.099E+00	41.0488	41.2470	0.48	65	17	2613.16	3208.16	0.23281	41.3037	0.62
102	180.17428	236.85308	-8.913E-02	-2.477E+00	40.9579	41.1696	0.52	57	29	2274.12	3289.12	0.36446	41.2013	0.59
70	220.31863	228.81292	-1.294E-01	-2.980E+00	40.9416	41.0039	0.15	49	40	1952.52	3352.52	0.45840	41.0236	0.20
71	260.29230	220.49789	-5.117E-02	-3.175E+00	40.8293	40.9459	0.29	40	53	1619.92	3474.92	0.53692	40.9623	0.33
72	308.17599	211.09450	-1.421E-01	-2.893E+00	48.7983	48.6554	-0.29	31	66	1243.78	3553.78	0.56710	48.6611	-0.28
73	330.19894	211.02300	-2.011E-01	-3.203E+00	22.0231	21.9673	-0.25	31	67	1240.92	3585.92	0.57189	21.9674	-0.25
74	345.16376	203.73478	-1.835E-01	-2.540E+00	16.6452	16.3820	-1.58	24	78	949.39	3679.39	0.55856	16.3766	-1.61
41	360.07881	196.38848	-2.078E-01	-1.857E+00	16.6261	16.3136	-1.88	16	85	655.54	3630.54	0.48731	16.2847	-2.05
42	372.54187	190.66988	-1.223E-01	-9.847E-01	13.7124	13.4519	-1.90	11	85	426.80	3401.80	0.38475	13.4153	-2.17
11	385.00000	185.00000	0.000E+00	0.000E+00	13.6877	13.4245	-1.92	0	97	0.00	3395.00	0.00000	13.2952	-2.87
17	590.00000	185.00000	0.000E+00	0.000E+00				0	107	0.00	3745.00	0.00000		
50	605.00472	188.75805	7.452E-02	-8.627E-01	15.4682	15.3547	-0.73	9	103	350.32	3955.32	0.36879	15.2894	-1.16
51	619.99317	192.57837	1.185E-01	-1.628E+00	15.4677	15.3398	-0.83	13	99	503.13	3968.13	0.45126	15.3236	-0.93
84	639.90879	197.45355	8.593E-02	-2.192E+00	20.5036	20.3450	-0.77	17	92	698.14	3918.14	0.52300	20.3299	-0.85
85	659.82456	202.20224	3.109E-02	-2.813E+00	20.4741	20.2854	-0.92	22	86	888.09	3898.09	0.57050	20.2757	-0.97
87	699.83782	210.82952	-1.270E-02	-3.523E+00	40.9328	40.7461	-0.46	31	76	1233.18	3893.18	0.61570	40.7373	-0.48
88	736.89066	221.57476	-1.741E-01	-3.979E+00	38.5794	38.2994	-0.73	42	64	1662.99	3902.99	0.61615	38.2993	-0.73
89	779.94734	221.39990	3.929E-03	-3.763E+00	43.0570	43.2347	0.41	41	64	1656.00	3896.00	0.61530	43.2347	0.41
90	819.94947	222.16585	2.022E-02	-3.802E+00	40.0095	40.0250	0.04	42	62	1686.63	3856.63	0.60582	40.0252	0.04
91	859.96052	222.91228	6.655E-02	-3.791E+00	40.0180	40.0645	0.12	43	60	1716.49	3816.49	0.59566	40.0647	0.12
92	899.95651	223.65015	1.296E-01	-3.732E+00	40.0028	40.0670	0.16	44	60	1746.01	3846.01	0.59882	40.0669	0.16
93	939.93539	224.38966	1.995E-01	-3.597E+00	39.9857	40.0584	0.18	44	56	1775.59	3735.59	0.57354	40.0589	0.18
94	979.89604	225.17327	2.757E-01	-3.468E+00	39.9683	40.0472	0.20	45	52	1806.93	3626.93	0.54677	40.0478	0.20
95	1033.8250	225.07101	3.233E-01	-3.143E+00	53.9291	53.9770	0.09	45	48	1802.84	3482.84	0.51557	53.9772	0.09
129	1068.9224	232.29706	2.024E-01	-2.590E+00	35.8335	35.8313	-0.01	52	37	2091.88	3386.88	0.43775	35.8482	0.04
131	1087.8997	236.77086	1.700E-01	-2.134E+00	19.4975	19.5758	0.40	57	28	2270.83	3250.83	0.35382	19.5971	0.51
133	1139.9943	248.03772	-4.947E-02	-5.456E-01	53.2991	53.4441	0.27	68	0	2721.51	2721.51	0.00000	53.5304	0.43

Primary Finite Element

Secondary

Construction Quality Assurance Manual

Johnston County Landfill Facility
Smithfield, North Carolina

Prepared for:

Johnston County Department of Solid Waste Services
Smithfield, North Carolina

December 2013

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

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Johnston County Landfill Facility
Smithfield, North Carolina

Construction Quality Assurance Manual

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APPENDIX

Appendix A Reference List of Test Methods

1.0 GENERAL

This Construction Quality Assurance (CQA) Manual has been prepared to provide the Owner, (Design) Engineer, and CQA Engineer the means to govern the construction quality and to satisfy landfill certification requirements under current solid waste management regulations.

More specifically, this CQA Manual addresses the soils and geosynthetics components of the liner, the leachate management, and the final cover systems (as applicable) of the municipal solid waste (MSW) and construction and demolition debris (C&D) landfill units at the facility.

The CQA Manual is divided into the following sections:

- Section 1.0 General
- Section 2.0 CQA Documentation
- Section 3.0 Earthwork CQA
- Section 4.0 Soil Liner CQA
- Section 5.0 Geomembrane CQA
- Section 6.0 Leachate Management System CQA
- Section 7.0 Geotextile CQA
- Section 8.0 Drainage Geocomposite CQA
- Section 9.0 Geosynthetic Clay Liner CQA
- Section 10.0 Final Cover System CQA

1.1 Definitions Relating to Construction Quality

1.1.1 Construction Quality Assurance (CQA)

In the context of this Manual, Construction Quality Assurance is defined as a planned and systematic program employed by the Owner to assure conformity of the liner, leachate management, and final cover systems installation with the project drawings and the project specifications. CQA is provided by the CQA Engineer as a representative of the Owner and is independent from the Contractor and all manufacturers. The CQA program is designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

1.1.2 Construction Quality Control (CQC)

Construction Quality Control refers to actions taken by manufacturers, fabricators, installers, and/or the Contractor to ensure that the materials and the workmanship meet the requirements of the project drawings and the project specifications. The manufacturer's specifications and quality control (QC) requirements are included in this CQA Manual by reference only. A complete updated version of each geosynthetic component manufacturer's QC Plan shall be incorporated as part of the Contractor's CQC Plan.

1.1.3 CQA Certification Document

At the completion of construction, a certification document will be prepared by the CQA Engineer and submitted to State Solid Waste Regulators. The certification report will include documentation of all QC testing performed by the Geosynthetics Manufacturers, all CQC testing performed by the Geosynthetic Installers, and all CQA testing performed by the CQA Engineer.

1.1.4 Discrepancies Between Documents

The Contractor is instructed to bring discrepancies to the attention of the CQA Engineer who shall then notify the Engineer for resolution. The Engineer has the sole authority to determine resolution of discrepancies existing within the Contract Documents (this may also require the approval of State Solid Waste Regulators). Unless otherwise determined by the Engineer, the more stringent requirement shall be the controlling resolution.

1.2 Parties to Construction Quality Assurance

1.2.1 Description of the Parties

The parties to Construction Quality Assurance and Quality Control include the Owner, Engineer, Contractor, Geosynthetics Manufacturer, Geosynthetics Installer, CQA Engineer, Geosynthetics CQA Laboratory, and Soils CQA Laboratory.

1.2.1.1 Owner

The Owner is Johnston County, North Carolina, who owns and/or is responsible for the facility.

1.2.1.2 Engineer

The Engineer is responsible for the engineering design, drawings, and project specifications for the liner, leachate management, and final cover systems. The Engineer is an official representative of the Owner. The Engineer serves as communications coordinator for the project, initiating the meetings outlined in **Section 1.6**. The Engineer will also be responsible for proper resolution of all quality issues that arise during construction. The Engineer is Smith Gardner, Inc.

1.2.1.3 Contractor

The Contractor is responsible for the construction of the subgrade, earthwork, and for placement of the liner, leachate management, and final cover systems. The Contractor is responsible for the overall CQC on the project and coordination of submittals to the CQA Engineer. Additional responsibilities of the Contractor are defined by the project specifications.

1.2.1.4 Geosynthetics Manufacturer

The Geosynthetics Manufacturer(s) is (are) responsible for the production of the geosynthetic components used in landfill construction. The Manufacturer(s) is (are) responsible for Quality Control (QC) during manufacture of the geosynthetic components, certification of the properties of the geosynthetic components, and field installation criteria.

1.2.1.5 Geosynthetics Installer

The Geosynthetics Installer(s) is (are) routinely a subcontractor of the Contractor and is (are) responsible for field handling, storing, placing, seaming, protection of (against wind, etc.), and other aspects of the geosynthetics installations. The Installer may also be responsible for transportation of these materials to the site, and for the preparation and completion of anchor trenches.

1.2.1.6 CQA Engineer

The CQA Engineer is a representative of the Owner, is independent from the Contractor, and is responsible for observing, testing, and documenting activities related to the CQA of the earthworks at the site, and the installation of the soil and geosynthetic components of the liner, leachate management, and final cover systems. The CQA Engineer may make field observations and review submittals for the Engineer and is responsible for notifying the Owner and Engineer of all quality issues that arise during construction. The CQA Engineer is also responsible for issuing a facility certification report, sealed by a Professional Engineer registered in The State of North Carolina.

1.2.1.7 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory is a party, independent from the Owner, that is responsible for conducting tests on conformance samples of geosynthetics used in the liner, leachate management, and final cover systems. The Geosynthetics CQA Laboratory service cannot be provided

by any party involved with the manufacture, fabrication, or installation of any of the geosynthetic components. The services of the Geosynthetics CQA Laboratory are coordinated by the CQA Engineer and are paid for by the Owner.

1.2.1.8 Soils CQA Laboratory

The Soils CQA Laboratory is a party, independent from the Owner, that is responsible for conducting geotechnical tests on conformance samples of soils and aggregates used in structural fills and the liner, leachate management, and final cover systems. The services of the Soils CQA Laboratory are coordinated by the CQA Engineer and are paid for by the Owner.

1.2.2 Qualifications of the Parties

The following qualifications are required of all parties involved with the manufacture, fabrication, installation, transportation, and CQA of all materials for the liner, leachate management, and final cover systems. Where applicable, these qualifications must be submitted by the Contractor to the Owner and Engineer for review and approval.

1.2.2.1 Contractor

Qualifications of the Contractor are specific to the construction contract and independent of this CQA Manual.

1.2.2.2 Geosynthetics Manufacturers

Each Geosynthetics Manufacturer must satisfy the qualifications presented in the project specifications.

1.2.2.3 Geosynthetic Installer(s)

The Geosynthetic Installer(s) will be trained and qualified to install the geosynthetics components of the liner, leachate management, and final cover systems. Each Geosynthetics Installer must meet the requirements of the project specifications and be approved by the Engineer. The Geomembrane Installer must be approved by the Geomembrane Manufacturer.

1.2.2.4 CQA Engineer

The CQA Engineer will act as the Owner's Quality Assurance Representative. The CQA Engineer will perform CQA testing to satisfy the requirements of this CQA Manual and will prepare the CQA certification document. The CQA Engineer will have experience in the CQA aspects of the construction and testing of landfill liner, leachate management, and final cover systems, and be familiar with ASTM and other related industry standards. The activities of the CQA Engineer will be performed under the supervision of a Registered Professional Engineer.

1.2.2.5 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory should be certified by the Geosynthetics Accreditation Institute, will have experience in testing geosynthetics, and be familiar with ASTM, GRI, and other applicable test standards. The Geosynthetics CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples depending on the test(s) to be conducted, as agreed to at the outset of the project by affected parties, and will maintain that standard throughout the installation.

1.2.2.6 Soils CQA Laboratory

The Soils CQA Laboratory will have experience in testing structural fills, soil liners, and aggregates, and be familiar with ASTM and other applicable test standards. The Soils CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples depending on the test(s) to be conducted, as agreed to at the outset of the project by affected parties, and will maintain that standard throughout the installation.

1.3 Scope of Construction Quality Assurance Manual

The scope of this CQA Manual includes the CQA of the soils and geosynthetic components of the liner, leachate management, and final cover systems for the subject facility. The CQA for the selection, evaluation, and placement of the soils is included in the scope.

1.4 Units

In this CQA Manual, all properties and dimensions are expressed in U.S. units.

1.5 References

The CQA Manual includes references to the most recent version of the test procedures of the American Society of Testing and Materials (ASTM) and/or the Geosynthetic Research Institute (GRI). **Appendix A** contains a list of these procedures.

1.6 CQA Meetings

To facilitate the specified degree of quality during installation, clear, open channels of communication are essential. To that end, meetings are critical.

1.6.1 Soil Liner CQA Meeting

Prior to the start of the soil liner system construction a CQA Meeting will be held. This meeting will include all parties then involved, including the Engineer, the CQA Engineer, and the Contractor.

The purpose of this meeting is to begin planning for coordination of tasks, anticipate any problems which might cause difficulties and delays in construction, and, above all, review the CQA Manual to all of the parties involved. It is very important that the rules regarding testing, repair, etc., be known and accepted by all.

This meeting should include all of the activities referenced in the project specifications.

The meeting will be documented by the Engineer and minutes will be transmitted to all parties. The Soil Liner CQA Meeting and the Geosynthetics CQA Meeting may be held as one meeting or separate meetings, depending on the direction of the Engineer.

1.6.2 Geosynthetics CQA Meeting

A CQA Meeting will be held at the site prior to placement of the geosynthetics. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and the Geosynthetic Installation Superintendent(s).

The purpose of this meeting is to begin planning for coordination of tasks, anticipate any problems which might cause difficulties and delays in construction, and, above all, review the CQA Manual to all of the parties involved. It is very important that the rules regarding testing, repair, etc., be known and accepted by all.

This meeting should include all of the activities referenced in the project specifications.

The meeting will be documented by the Engineer and minutes will be transmitted to all parties. The Soil Liner CQA Meeting and the Geosynthetics CQA Meeting may be held as one meeting or separate meetings, depending on the direction of the Engineer.

1.6.3 CQA Progress Meetings

Progress meetings will be held between the Engineer, the CQA Engineer, the Contractor, the Geosynthetic Installation Superintendent(s), and representatives from any other involved parties at the frequency dictated in the project specifications or, at a minimum, once per month during active construction. These meetings will discuss current progress, planned activities for the next week, and any new business or revisions to the work. The CQA Engineer will log any problems, decisions, or questions arising at this meeting in his daily or periodic reports. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties. These meetings will be documented by the Engineer and minutes will be transmitted to affected parties.

1.6.4 Problem or Work Deficiency Meetings

A special meeting will be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and representatives from any other involved parties. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions; and
- implement an action plan to resolve the problem or deficiency.

The meeting will be documented by the Engineer and minutes will be transmitted to affected parties.

1.7 Control Versus Record Testing

1.7.1 Control Testing

In the context of this CQA Manual, Control Tests are those tests performed on a material prior to its actual use in construction to demonstrate that it can meet the requirements of the project plans and specifications. Control Test data may be used by the Engineer as the basis for approving alternative material sources.

1.7.2 Record Testing

Record Tests are those tests performed during the actual placement of a material to demonstrate that its in-place properties meet or exceed the requirements of the project drawings and specifications.

2.0 CQA DOCUMENTATION

An effective CQA plan depends largely on recognition of construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Engineer will document that quality assurance requirements have been addressed and satisfied.

The CQA Engineer will provide the Owner and Engineer with his daily and progress reports including signed descriptive remarks, data sheets, and logs to verify that required CQA activities have been carried out. These reports will also identify potential quality assurance problems. The CQA Engineer will also maintain at the job site a complete file of project drawings, reports, project specifications, a CQA Manual, checklists, test procedures, daily logs, and other pertinent documents.

2.1 Daily CQA Report

The CQA Engineer's reporting procedures will include preparation of a daily report which, at a minimum, will include the following information, where applicable:

- a unique identifying sheet number for cross referencing and document control;
- date, project name, location, and other identification;
- data on weather conditions;
- a reduced scale Site Plan showing all proposed work areas and test locations;
- descriptions and location of ongoing construction;
- descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- locations where tests and samples were taken;
- a summary of test results;
- calibrations or recalibrations of test equipment, and actions taken as a result of recalibration;
- off-site materials received, including quality verification documentation;
- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality;

- summaries of pertinent discussions with the Contractor and/or Geosynthetic Installers; and

- the CQA Engineer's signature.

The daily report must be completed at the end of each day. This information will be submitted to the Engineer for review on a routine basis and to the Owner upon request.

2.2 CQA Progress Reports

The CQA Engineer will prepare summary progress reports at time intervals as requested by the Engineer or Owner or upon a total project shutdown. As a minimum, this report will include the following information for the reporting period, where applicable:

- a summary of work activities performed;

- a summary of construction situations, deficiencies, and/or defects;

- a summary of all test results, failures, and retests;

- a compilation of daily CQA reports; and

- the CQA Engineer's signature.

Critical problems that occur will be communicated verbally to the Engineer immediately as well as being included in the progress reports.

2.3 CQA Photographic Reporting

Photographs will be taken by the CQA Engineer at regular intervals during the construction process and in all areas deemed critical by the CQA Engineer. These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. Videotaping may be used to supplement photographs in the documentation of work progress, problems, and/or mitigation activities. These records will be presented to the Engineer upon completion of the project.

2.4 Deficiencies

The Owner and Engineer will be made aware of any significant recurring non-conformance with the project specifications. The Engineer will then determine the cause of the non-conformance and recommend appropriate changes in procedures or specification. When this type of evaluation is made, the results will be documented, and any revision to procedures or project specifications will be approved by the Owner and Engineer.

2.5 Design and/or Project Technical Specification Changes

Design and/or project specification changes may be required during construction. In such cases, the CQA Engineer will notify the Engineer. The Engineer will then notify the appropriate agency, if necessary.

Design and/or project specification changes will be made only with the written agreement of the Engineer, and will take the form of an addendum to the project specifications. All design changes will include a detail (if necessary) and state which detail it replaces in the plans.

2.6 Final CQA Report

At the completion of each major construction activity, the CQA Engineer will certify all required forms, observation logs, field and laboratory testing data sheets including sample location plans, etc. The CQA Engineer will also provide a final report which will certify that the work has been performed in compliance with the plans and project technical specifications, and that the supporting documents provide the necessary information.

The CQA Engineer will also provide summaries of all the data listed above with the report. The Record Drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). All surveying and base maps required for development of the Record Drawings will be done by the Contractor's Construction Surveyor. These documents will be certified by the Contractor and delivered to the CQA Engineer and included as part of the final CQA (Certification) report.

It may be necessary to prepare interim certifications, as allowed by the regulatory agency, to expedite completion and review.

At a minimum, the items shown in **Table 2.1** will be included in the Final CQA Report. Note that some items may not be applicable to all projects.

2.7 Storage of Records

All handwritten data sheet originals, especially those containing signatures, will be stored by the CQA Engineer in a safe repository on site. Other reports may be stored by any standard method which will allow for easy access. All written documents will become property of the Owner.

Table 2.1A Final CQA Report General Outline (Liner System)

1. Introduction
2. Project Description
3. CQA Program
    a. Scope of Services
    b. Personnel
4. Earthwork CQA
5. Soil Liner CQA
6. GCL CQA
7. Geomembrane CQA
8. Leachate Management System CQA
9. Geotextile CQA
10. Drainage Geocomposite CQA
11. Summary and Conclusions
12. Project Certification

Appendices

- Appendix A Design Clarifications and Modifications
- Appendix B Piezometer Abandonment (if applicable)
- Appendix C Photographic Documentation
- Appendix D CQA Reporting
    - E1. CQA Reports
    - E2. CQA Meeting Minutes
- Appendix F Earthwork CQA Data
    - F1. CQA Test Results - Control Tests
    - F2. CQA Test Results - Record Tests
- Appendix G Soil Liner CQA Data
    - G1. CQA Test Results - Control Tests
    - G2. CQA Test Results - Record Tests
- Appendix H Interface Shear Strength Test Data
- Appendix I GCL CQA Data
    - I1. Manufacturer's Product Data Submittals and Quality Control Certificates
    - I2. Geosynthetics Inventory - GCL
    - I3. CQA Test Results - Material Control Tests
    - I4. GCL Installation Certification
- Appendix J Geomembrane CQA Data
    - J1. Manufacturer's Product Data Submittals and Quality Control Certificates
    - J2. Geosynthetics Inventory - Geomembrane(s)
    - J3. CQA Test Results - Material Control Tests
    - J4. Subgrade Acceptance Certificates
    - J5. Trial Seam Logs
    - J6. Panel Placement Logs
    - J7. Panel Seaming Logs

Table 2.1A (Continued):

J8.	CQC Test Results - Nondestructive Seam Testing Report Forms
J9.	CQC Test Results - Destructive Seam Testing Report Forms (Field)
J10.	CQA Test Results - Destructive Seam Testing Report Forms (Laboratory)
J11.	Repair Logs
J12.	Geomembrane Installation Certification
Appendix K	Leachate Management System CQA Data
K1.	Manufacturer's Product Data Submittals and Quality Control Certificates
K2.	CQA Test Results - Drainage Aggregate
K3.	CQA Test Results - Protective Cover
K4.	CQC Test Results - Pressure Testing of HDPE Transmission Piping
K5.	CQC Test Results - Leak Testing of Precast Concrete Structures
K6.	Documentation of Pump Start Up
Appendix L	Geotextile CQA Data
L1.	Manufacturer's Product Data Submittals and Quality Control Certificates
L2.	Geosynthetics Inventory - Geotextiles
L3.	CQA Test Results - Material Control Tests
Appendix M	Drainage Geocomposite CQA Data
M1.	Manufacturer's Product Data Submittals and Quality Control Certificates
M2.	Geosynthetics Inventory - Drainage Geocomposite
M3.	CQA Test Results - Material Control Tests
Appendix N	Record Drawings
N1.	Subgrade As-Built
N2.	Soil Liner As-Built
N3.	Geomembrane As-Built(s)
N4.	Leachate Collection Media As-Built
N5.	HDPE Pipe As-Built
N6.	Protective Cover As-Built

Table 2.1B Final CQA Report General Outline (Final Cover System)

1. Introduction
2. Project Description
3. CQA Program
    a. Scope of Services
    b. Personnel
4. Earthwork CQA
5. Final Cover System CQA
6. Geomembrane CQA
7. Geotextile CQA
8. Drainage Geocomposite CQA
9. Summary and Conclusions
10. Project Certification

Appendices

- Appendix A Design Clarifications/Modifications
- Appendix B Photographic Documentation
- Appendix C CQA Reporting
    - C1. CQA Reports
    - C2. CQA Meeting Minutes
- Appendix D Earthwork CQA Data
    - D1. CQA Test Results - Control Tests
    - D2. CQA Test Results - Record Tests
- Appendix E Final Cover System CQA Data
    - E1. Manufacturer's Product Data Submittals and Quality Control Certificates
    - E2. CQA Test Results - Drainage Aggregate
    - E3. CQA Test Results - Vegetative Soil Layer
    - E4. CQC Test Results - Pressure Testing of HDPE Piping
- Appendix F Interface Shear Strength Test Data
- Appendix G Geomembrane CQA Data
    - G1. Manufacturer's Product Data Submittals and Quality Control Certificates
    - G2. Geosynthetics Inventory - Geomembrane
    - G3. CQA Test Results - Material Control Tests
    - G4. Subgrade Acceptance Certificates
    - G5. Trial Seam Logs
    - G6. Panel Placement Logs
    - G7. Panel Seaming Logs
    - G8. CQC Test Results - Nondestructive Seam Testing Report Forms
    - G9. CQC Test Results - Destructive Seam Testing Report Forms (Field)
    - G10. CQA Test Results - Destructive Seam Testing Report Forms (Laboratory)
    - G11. Repair Logs
    - G12. Geomembrane Installation Certification

Table 2.1B (Continued):

Appendix H	Geotextile CQA Data
H1.	Manufacturer's Product Data Submittals and Quality Control Certificates
H2.	Geosynthetics Inventory - Geotextiles
H3.	CQA Test Results - Material Control Tests
Appendix I	Drainage Geocomposite CQA Data
I1.	Manufacturer's Product Data Submittals and Quality Control Certificates
I2.	Geosynthetics Inventory - Drainage Geocomposite
I3.	CQA Test Results - Material Control Tests
Appendix J	Record Drawings
J1.	Subgrade As-Built
J2.	Geomembrane As-Built
J3.	HDPE Pipe As-Built
J4.	Vegetative Soil Layer As-Built

3.0 EARTHWORK CQA

This section of the CQA Manual addresses earthwork (excavation and embankment) and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, field control and record tests, and resolution of problems.

3.1 Embankment Material Approval

All material to be used as compacted embankment shall be approved in advance by the CQA Engineer. Approval is based upon successful completion of CQA control testing outlined below. Such testing can be performed either during excavation and stockpiling or from existing stockpiles prior to use.

3.1.1 Control Tests

The procedure for CQA testing during excavation and stockpiling (including existing stockpiles) is outlined below.

Each load of soil will be examined either at the borrow source or the stockpile area. Any unsuitable material will be rejected or routed to separate stockpiles consistent with its end use. Appropriate entries will be made in the daily log.

During stockpiling operations, control tests, as shown on **Table 3.1**, will be performed by the CQA Engineer prior to placement of any compacted embankment.

3.2 Subgrade Approval

The CQA Engineer will verify that the compacted embankment subgrade is constructed in accordance with the project specifications.

3.3 Earthwork Construction

3.3.1 Construction Monitoring

A. Earthwork shall be performed as described in the project specifications.

B. Only soil previously approved by the CQA Engineer (see **Section 3.1**) shall be used in construction of the compacted embankment. Unsuitable material will be removed prior to acceptance by the CQA Engineer.

C. All required field density and moisture content tests shall be completed before the overlying lift of soil is placed. The surface preparation (e.g.

wetting, drying, scarification, etc.) shall be completed before the CQA Engineer will allow placement of subsequent lifts.

D. The CQA Engineer will monitor protection of the earthwork during and after construction.

3.3.2 Control Tests

The control tests, as shown on **Table 3.2**, will be performed by the CQA Engineer prior to placement of compacted embankment.

3.3.3 Record Tests

The record tests, as shown on **Table 3.2**, will be performed by the CQA Engineer during placement of compacted embankment.

3.3.3.1 Record Test Failure

Recompaction of the failed area shall be performed and retested until the area meets or exceeds requirements outlined in the specifications.

3.3.4 Judgmental Testing

During construction, the frequency of control and/or record testing may be increased at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- the rollers slip during rolling operation;
- the lift thickness is greater than specified;
- the fill material is at an improper moisture content;
- fewer than the specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- the rollers may not have used optimum ballast;
- the fill materials differ substantially from those specified; or
- the degree of compaction is doubtful.

3.4 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 3.1 CQA Testing Program for Embankment Material Approval

Property	Test Method	Minimum Test Frequency
Control Tests:		
Visual Classification	ASTM D 2488	Each Soil
Moisture-Density Relationship	ASTM D 698	5,000 CY per Each Soil

Table 3.2 CQA Testing Program for Compacted Embankment

Property	Test Method	Minimum Test Frequency
Control Tests: (See **Table 3.1**)		
Record Tests:		
Lift Thickness	-----	Each Lift
In-Place Density	ASTM D 6938[1]	20,000 ft^2 per lift & 1 per 500 LF/lift of Berms (< 200 ft. base width)
Moisture Content	ASTM D 6938[2]	20,000 ft^2 per lift & 1 per 500 LF/lift of Berms (< 200 ft. base width)

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform, at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.

2. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every 10 nuclear moisture tests, perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.

4.0 SOIL LINER CQA

This section of the CQA Manual addresses the soil liner component of the liner system and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, test fill construction, field and laboratory control and record tests, and resolution of problems.

4.1 Soil Liner Material Approval

All material to be used as soil liner shall be approved in advance by the CQA Engineer. Approval is based upon successful completion of CQA control testing outlined below. Such testing can be performed either during excavation and stockpiling or from existing stockpiles prior to use.

4.1.1 Control Tests

The procedure for CQA testing during excavation and stockpiling (including existing stockpiles) is outlined below.

Each load of soil will be examined either at the borrow source or the stockpile area. Any unsuitable material will be rejected or routed to separate stockpiles consistent with its end use. Appropriate entries will be made in the daily log.

During stockpiling operations, control tests, as shown on **Table 4.1**, will be performed by the CQA Engineer prior to placement of any soil liner material.

4.2 Subgrade Approval

The CQA Engineer will verify that the soil liner subgrade is constructed in accordance with the project specifications.

4.3 Test Fill Construction

A test fill meeting the requirements of the project specifications will be constructed using the same construction methods, equipment, and material to be used for the soil liner component. The test fill construction will be conducted prior to or coincide with the beginning of construction of the soil liner component.

Construction equipment and methods will be reviewed by the CQA Engineer prior to test fill placement.

4.3.1 Control Tests

The control tests, as shown on **Table 4.2**, will be performed by the CQA Engineer prior to placement of soil liner material in the test fill.

4.3.2 Record Tests

The record tests, as shown on **Table 4.2**, will be performed by the CQA Engineer during placement of soil liner material in the test fill.

4.3.3 Test Fill Completion

The test fill program is completed when the Contractor has shown that the soil liner constructed using the same construction methods, equipment, and material to be used in construction of the soil liner will satisfy project specifications. No soil liner can be placed until the test fill program is completed.

4.4 Soil Liner Construction

4.4.1 Construction Monitoring

A. Soil liner shall be placed as described in the applicable section(s) of the project specifications using the construction methods, equipment, and material demonstrated in the test fill construction.

B. Only soil previously approved by the CQA Engineer (see **Section 4.1**) shall be used in construction of the soil liner. Unsuitable material will be removed prior to acceptance by the CQA Engineer.

C. All required field density and moisture content tests shall be completed before the overlying lift of soil is placed. The surface preparation (e.g. wetting, drying, scarification, etc.) shall be completed before the CQA Engineer will allow placement of subsequent lifts.

D. The CQA Engineer will monitor protection of the soil liner during and after construction.

E. The liner surface shall be sprinkled with water as needed to prevent desiccation. Should desiccation occur, the last lift shall be reconstructed in accordance with the project specifications. Standing water should not be present on the soil liner.

F. Frost heave or other damage due to freezing shall require lift reconstruction in accordance with the project specifications.

G. The CQA Engineer will inspect the soil liner and certify that it is in accordance with the project specifications and approved plans prior to the Contractor beginning installation of overlying geosynthetics.

H. The finished soil liner shall be free of all rock protrusions. All cracks and voids shall be filled and the surface made uniform. This shall be accomplished by final dressing of the soil liner with smooth-drum rollers and hand raking. No rubber tired vehicles are permitted on the final dressed surface unless authorized by the CQA Engineer.

I. The surface on which the overlying geosynthetics are to be placed shall be maintained in a firm, clean, and smooth condition and shall be within the acceptable moisture range before and during the geosynthetics installation.

4.4.2 Control Tests

The control tests, as shown on **Table 4.3**, will be performed by the CQA Engineer prior to placement of soil liner material.

4.4.3 Record Tests

The record tests, as shown on **Table 4.3** and as described below, will be performed by the CQA Engineer during placement of soil liner material.

A. Each lift will be checked visually for soil clods, rocks, debris, plant materials and other foreign material. Any such material which does not meet specified requirements shall be identified and removed prior to and during the compaction process.

B. The thickness of the loose lift will be measured at random locations after spreading and leveling is completed. Loose lift thickness should not exceed the depth of penetration of the compaction feet.

C. Moisture content will be monitored by the CQA Engineer prior to compaction. If the soil is drier than the specified minimum moisture content, water will be added and the lift will be disced to distribute the moisture evenly.

Results of testing will be certified within 7 days of soil liner placement.

4.4.3.1 Record Test Failure

The following procedures shall be used in the event of density or hydraulic conductivity test failure:

A. Failed Density Test: Recompaction of the failed area shall be performed and retested until the area meets or exceeds requirements outlined in the specifications.

B. Failed Hydraulic Conductivity Test: The area of failure shall be localized and reconstructed in accordance with the project specifications. This area will be retested as outlined within the plan by the CQA Engineer. Optionally, at least five replicate samples shall be obtained and tested by the Contractor in the immediate vicinity of the failed test. If all five samples pass, then the initial failing test will be discounted. However, should the replicate samples confirm the failure of the soil liner to meet specifications, the area of failure shall be localized, reconstructed, and retested as described above.

4.4.4 Judgmental Testing

During construction, the frequency of control and/or record testing may be increased at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- the rollers slip during rolling operation;
- the lift thickness is greater than specified;
- the fill material is at an improper moisture content;
- fewer than the specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- the rollers may not have used optimum ballast;
- the fill materials differ substantially from those specified; or
- the degree of compaction is doubtful.

4.4.5 Perforations In Soil Liner

All holes shall be patched with compacted soil liner (if allowed by the project specifications) or sodium bentonite compacted and hydrated in the holes.

4.5 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 4.1 CQA Testing Program for Soil Liner Material Approval

Property	Test Method	Minimum Test Frequency
Control Tests:		
Visual Classification	ASTM D 2488	Each Soil
Moisture Content	ASTM D 2216	2,000 CY per Each Soil
Grain Size Analysis	ASTM D 422	2,000 CY per Each Soil
Atterberg Limits	ASTM D 4318	2,000 CY per Each Soil
Moisture-Density Relationship	ASTM D 698	5,000 CY per Each Soil
Hydraulic Conductivity - Lab Remolded	ASTM D 5084[3]	10,000 CY per Each Soil

Table 4.2 CQA Testing Program for Soil Liner Test Fill

Property	Test Method	Minimum Test Frequency
Control Tests: (See **Table 4.1**)		
Moisture-Density Relationship	ASTM D 698[4]	1 per lift
Hydraulic Conductivity - Lab Remolded	ASTM D 5084[3,4]	1 per lift
Record Tests:		
Lift Thickness	-----	Each Lift
Atterberg Limits	ASTM D 4318	1 per lift
Grain Size Analysis	ASTM D 422	1 per lift
In-Place Density	ASTM D 2922[1]	3 per lift
Moisture Content	ASTM D 6938[2]	3 per lift
Hydraulic Conductivity - Undisturbed (Shelby Tube)	ASTM D 5084[3]	1 per lift

Table 4.3 CQA Testing Program for Soil Liner

Property	Test Method	Minimum Test Frequency
Control Tests: (See **Table 4.1**)		
Record Tests:		
Lift Thickness	-----	Each Lift
In-Place Density	ASTM D 6938[1]	10,000 ft^2 per lift
Moisture Content	ASTM D 6938[2]	10,000 ft^2 per lift
Hydraulic Conductivity - Undisturbed (Shelby Tube)	ASTM D 5084[3]	80,000 ft^2 per lift

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests, perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.

2. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every 10 nuclear moisture tests ,perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.

3. Maximum effective confining pressure and hydraulic gradient as required by the project specifications. Backpressure as recommended by ASTM D 5084.

4. These tests performed on the test fill may count toward the minimum frequencies established in **Table 4.1**.

5.0 GEOMEMBRANE CQA

This section of the CQA Manual addresses the geomembrane components of the liner and final cover systems and outlines the CQA program to be implemented with regard to manufacturer and installer approval, material approval, subgrade approval, field and laboratory control and record tests, repairs, and resolution of problems.

5.1 Geomembrane Manufacturer and Installer Approval

The Contractor shall submit the qualifications of the Geomembrane Manufacturer and the Geomembrane Installer, as described in the specifications, to the CQA Engineer for approval.

5.2 Geomembrane Material Approval

5.2.1 Geomembrane Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

5.2.2 Shipment And Storage

During shipment and storage, all geomembrane will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

5.2.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls or sheets related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications

5.2.4 Material Control Tests

Samples for material control tests, as shown on **Table 5.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the geomembrane. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be three (3) feet long by the roll or sheet width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All control test results must be available at the site prior to the deployment of all geomembrane. The CQA Engineer will examine all results from laboratory conformance testing.

5.2.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geomembrane Installer will replace the roll or sheet of geomembrane that is in nonconformance with the project specifications with a roll or sheet that meets project specifications.

B. The Geomembrane Installer will remove conformance samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll or sheet on both sides of the failed roll or sheet. These two samples must both conform to project specifications. If either of these samples fails, then the next numerical roll or sheet will be tested until a passing roll or sheet is found. This additional conformance testing will be at the expense of the Geomembrane Installer. If either of the two closest rolls or sheets fails, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

5.3 Geomembrane Installation

5.3.1 Handling

The Geosynthetic Installer will handle all geomembrane in such a manner as required by the project specifications.

5.3.2 Earthwork

5.3.2.1 Surface Preparation

The Geomembrane Installer will certify in writing that the surface on which the geomembrane will be installed meets line and grade, and the surface preparation requirements of the project specifications. The certificate of acceptance will be given to the CQA Engineer prior to commencement of geomembrane installation in the area under consideration. The CQA Engineer will give a copy of this certificate to the Engineer.

To ensure a timely covering of the subgrade (or soil liner) surface, the Engineer may allow subgrade acceptance in areas as small as one acre. After the supporting soil has been accepted by the Geomembrane Installer, it will be the Geomembrane Installer's responsibility to indicate to the Engineer and CQA Engineer any change in the supporting soil condition that may require repair work. If the CQA Engineer concurs with the Geomembrane Installer, then the Engineer will ensure that the supporting soil is repaired.

5.3.2.2 Anchorage System

The CQA Engineer will verify that anchor trenches have been constructed and backfilled according to project specifications and design drawings.

5.3.3 Geomembrane Placement

5.3.3.1 Field Panel Identification

The CQA Engineer will document that the Geomembrane Installer labels each field panel with an "identification code" (number or letter-number consistent with the layout plan) agreed upon by the Geomembrane Installer and CQA Engineer at the Geosynthetics CQA Meeting (see **Section 1.6.2**).

The Geomembrane Installer will establish a table or chart showing correspondence between roll or sheet numbers and field panel identification codes. This documentation shall be submitted to the CQA Engineer weekly for review and verification. The field panel identification code will be used for all quality control and quality assurance records.

5.3.3.2 Field Panel Placement

Location: The CQA Engineer will verify that field panels are installed at the location indicated in the Geomembrane Installer's layout plan, as approved or modified in **Section 5.3.3.1**.

Installation Schedule: The CQA Engineer will evaluate every change in the schedule proposed by the Geomembrane Installer and advise the Engineer on the acceptability of that change.

The CQA Engineer will record the identification code, location, and date of installation of each field panel.

Placement of Geomembrane: The CQA Engineer will verify that project specification related restrictions on placement of geomembrane are fulfilled. Additionally, the CQA Engineer will verify that the supporting soil has not been damaged by weather conditions.

Damage: The CQA Engineer will visually observe each panel, after placement and prior to seaming, for damage. The CQA Engineer will advise the Engineer which panels, or portion of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the CQA Engineer. Repairs will be made according to procedures described in this section.

As a minimum, the CQA Engineer will document that:

- the panel is placed in such a manner that it is unlikely to be damaged; and
- any tears, punctures, holes, thin spots, etc. are either marked by the Geomembrane Installer for repair or the panel is rejected.

5.3.4 Field Seaming

5.3.4.1 Seam Layout

The Geomembrane Installer will provide the CQA Engineer with a seam layout drawing, i.e., a drawing of the area to be lined showing all expected seams. The CQA Engineer and Engineer will review the seam layout drawing and verify that it is consistent with the accepted state of practice and this CQA Manual.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Geosynthetics CQA Meeting (see **Section 1.6.2**). An on-going written record of the seams and repair areas shall be maintained by the Geomembrane Installer with weekly review by the CQA Engineer.

5.3.4.2 Requirements of Personnel

The Geomembrane Installer will provide the CQA Engineer with a list of proposed seaming personnel and their experience records. This document will be reviewed by the CQA Engineer for compliance with project specifications.

5.3.4.3 Seaming Equipment and Products

Field seaming processes must comply with project specifications. Proposed alternate processes will be documented and submitted to the Engineer and CQA Engineer for their approval. Only seaming apparatus which have been specifically approved by make and model will be used. The CQA Engineer will submit all documentation to the Engineer for his concurrence.

5.3.5 Field Seam Control Tests

5.3.5.1 Trial Seams

A. Prior to production seaming, after four (4) hours of continuous seaming, and/or when significant changes in geomembrane or ambient temperature occurs, the Geomembrane Installer shall perform trial seams to verify that seaming conditions and procedures are adequate. Trial seams shall be performed by each operator of extrusion welders and by the primary operator of each wedge welder using seaming equipment to be used in production seaming.

B. Trial seams shall be made on appropriate sized pieces of identical or equivalent geomembrane material.

C. Hot wedge trial seams shall be approximately 72" x 12" with the seam centered lengthwise. Extrusion fillet trial seams shall be approximately 36" x 12" with the seam centered lengthwise. A minimum of four coupons shall be tested in peel and shear (two each) (ASTM D 6392) by the Geomembrane Installer using a field tensiometer. All coupons shall meet the minimum seam strength requirements as shown in the project specifications.

D. Each trial seam shall be assigned a number and the test results recorded in the appropriate log by the Geomembrane Installer. The CQA Engineer will observe all trial seams and compile all trial seam logs.

5.3.6 Field Seam Record Tests

5.3.6.1 Nondestructive Seam Continuity Testing

The Geomembrane Installer shall test and document all seams continuously over their full length using one of the following nondestructive seam tests. This testing shall be performed simultaneously with geomembrane deployment as the work progresses and not at the completion of all field seaming.

A. Vacuum Testing shall conform to ASTM D 5641 requirements.

B. Air Pressure Testing (for double seam with an enclosed space) shall conform to ASTM D 5820 requirements and the requirements listed in **Table 5.2**.

The CQA Engineer will observe the nondestructive testing on a full time basis to ensure conformance with this CQA Manual and the project specifications.

5.3.6.2 Field Destructive Seam Testing

A. The Geomembrane Installer shall obtain 12" x 30" (or longer as needed) samples of field seams with the seam centered lengthwise, suitable for testing, at an average frequency of one sample per 500 linear feet of seam. The sample shall be cut into two equal-length pieces, one for field destructive seam testing by the Geosynthetics Installer and one given to the CQA Engineer as an archive sample. The date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the CQA Engineer.

B. The Geomembrane Installer shall perform and document field destructive seam testing using a field tensiometer which has been calibrated within the prior 6 months (calibration information shall be provided to the CQA Engineer). A minimum of three (3) coupons each will be tested in peel and shear (ASTM D 6392). Coupons shall meet the minimum seam strength requirements as shown in the project specifications.

C. The CQA Engineer or the Owner may require additional random samples to be taken for testing in areas which visually appear defective and not in accordance with the project requirements.

D. All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in this manual.

5.3.6.3 Geosynthetics CQA Laboratory Destructive Testing

A. The Geomembrane Installer shall obtain 12" x 30" (or longer as needed) samples of field seams with the seam centered lengthwise, suitable for testing, at an average frequency of one sample per day to confirm field destructive seam tests. The sample shall be cut into two equal-length pieces, both to be given to the CQA Engineer for laboratory destructive seam testing and as an archive sample. The date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the CQA Engineer.

B. Laboratory destructive test samples will be packaged and shipped to the Geosynthetics CQA Laboratory by the CQA Engineer in a manner that will not damage the test sample.

C. A minimum of five (5) coupons each will be tested in peel and shear (ASTM D 6392) by the Geosynthetics CQA Laboratory. Coupons shall meet the minimum seam strength requirements as shown in the project specifications.

D. All geomembrane destructive test samples that fail to meet project specifications will be saved and sent to the CQA Engineer for observation.

E. The CQA Engineer will review laboratory test results as soon as they become available.

5.3.6.4 Field Seam Record Test Failure

For noncomplying tests, the CQA Engineer will:

- observe continuity testing of the repaired areas performed by the Geomembrane Installer;

- confirm the record location, date, test unit number, name of tester, and compile the record of testing provided by the Geomembrane Installer;

- provide a walk-through inspection of all impacted seam areas and verify that the areas have been tested in accordance with the CQA Manual and project specifications; and

- verify that the Geomembrane Installer has marked repair areas with the appropriate color-coded marking pencil.

5.3.6.5 Defining Extent of Field Seam Record Test Failure

All defective seam test failures must be bounded by acceptable destructive tests. The CQA Engineer will document repair actions taken in conjunction with all seam test failures.

5.3.7 Repairs & Verification

5.3.7.1 Repair Procedures

A. All repair procedures shall be in accordance with the project specifications. The CQA Engineer will observe all repair procedures.

B. All surfaces shall be clean and dry at the time of the repair.

C. After an extrusion seam is made, no more than ¼ inch of abrasion shall be visible beyond the weld.

5.3.7.2 Repair Verification

A. Each repair shall be numbered and logged by the Geomembrane Installer.

B. Each repair shall be non-destructively tested by the Geomembrane Installer using the methods described above. Repairs which pass non-destructive testing shall be taken as an indication of an adequate repair.

C. Repairs more than 150 feet long may be of sufficient length to require destructive test sampling, at the discretion of the CQA Engineer. A failed test indicates that the repair shall be redone and retested until passing test results are achieved.

5.4 Liner System Acceptance

The geomembrane component of the liner system will be accepted by the Owner when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- CQA Engineer provides the Engineer with a final copy of the nondestructive test documentation, repair information, and as-built drawings, as submitted by the Geomembrane Installer;
- CQA Engineer provides the Engineer with a certification, submitted by the Geomembrane Installer that the geomembrane was installed in accordance with the Geomembrane Manufacturer's recommendations as well as the project drawings and project specifications; and
- all documentation of the installation is completed including the CQA Engineer's final report.

5.5 Materials in Contact with Geomembranes

The quality assurance procedures indicated in this subsection are only intended to assure that the installation of these materials does not damage the geomembrane. All reasonable measures to protect the geomembrane and provide additional quality assurance procedures are necessary to assure that systems built with these materials will be constructed to ensure proper performance.

5.5.1 Soils

Prior to placement, the CQA Engineer will visually confirm that all soil materials to be placed against the geomembrane comply with project specifications. The Geomembrane Installer will provide the CQA Engineer a written surface acceptance certificate in accordance with **Section 5.3.2**. All soil materials shall be placed and compacted in accordance with project specifications.

5.5.2 Sumps and Appurtenances

The CQA Engineer will verify that:

- installation of the geomembrane in appurtenance areas, and connection of the geomembrane to appurtenances have been made according to the project specifications;

- extreme care is taken while seaming around appurtenances since neither nondestructive nor destructive testing may be feasible in these areas; and

- the geomembrane or appurtenances have not been visibly damaged while making connections to appurtenances.

5.6 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 5.1 CQA Testing Program for Geomembrane Material Approval

Property	Test Method	Test Frequency
Thickness	ASTM D 5199/D 5994	100,000 ft^2 or 1 per Lot[1]
Density	ASTM D 1505/D 792	100,000 ft^2 or 1 per Lot[1]
Carbon Black Content	ASTM D 1603	100,000 ft^2 or 1 per Lot[1]
Carbon Black Dispersion	ASTM D 5596	100,000 ft^2 or 1 per Lot[1]
Tensile Properties:	ASTM D 6693 (Type IV)	
Tensile Strength at Yield		100,000 ft^2 or 1 per Lot[1]
Tensile Strength at Break		100,000 ft^2 or 1 per Lot[1]
Elongation at Yield		100,000 ft^2 or 1 per Lot[1]
Elongation at Break		100,000 ft^2 or 1 per Lot[1]
Tear Resistance	ASTM D 1004	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.

Table 5.2 Air Pressure Test Requirements

Material	Minimum Pressure (PSI)	Maximum Pressure Drop (PSI) After 5 Minutes
30 Mil LLDPE 40 Mil LLDPE ≥ 60 Mil HDPE	25	3

6.0 LEACHATE MANAGEMENT SYSTEM CQA

This section of the CQA Manual addresses the components of the leachate management system including components of the leachate collection system (LCS) (drainage aggregate, collection pipe, protective cover, and geosynthetic rain cover) and the leachate transmission and storage system (sumps, transmission piping, manholes, valves, etc.). By reference to **Sections 7.0 and 8.0** of this CQA Manual, this section also addresses the geotextiles and drainage geocomposite that are components of the LCS. This section outlines the CQA program to be implemented with regard to material approval, construction monitoring, and resolution of problems.

6.1 Leachate Management System Material Approval

The CQA Engineer will verify that the following are provided and installed in accordance with the project drawings, specifications, and this CQA Manual.

6.1.1 Coarse Aggregate (Drainage Aggregate)

A. Receipt of Contractor's submittals on coarse aggregate.

B. Review of submittals for coarse aggregate for conformity to the project specifications.

C. Verify that coarse aggregate in stockpiles or at borrow sources conforms to the project specifications.

D. Conduct material control tests in accordance with **Table 6.1**.

6.1.2 Leachate Collection Media (Drainage Aggregate)

A. Receipt of Contractor's submittals on leachate collection media.

B. Review of submittals for leachate collection media for conformity to the project specifications.

C. Verify that collection media in stockpiles or at borrow sources conforms to the project specifications.

D. Conduct material control tests in accordance with **Table 6.1**.

6.1.3 High Density Polyethylene (HDPE) Pipe

A. Receipt of Contractor's submittals on HDPE pipe.

B. Review of submittals for HDPE pipe for conformity to the project specifications.

6.1.4 Geotextiles (Verify for each type of Geotextile)

The CQA program for geotextiles is presented in **Section 7.0** of this CQA Manual.

6.1.5 Drainage Geocomposite

The CQA program for drainage geocomposite is presented in **Section 8.0** of this CQA Manual.

6.1.6 Protective Cover

A. Review the proposed source of protective cover for conformance with the project specifications.

B. Conduct material control tests in accordance with **Table 6.1**.

6.1.7 Geosynthetic Rain Cover

A. Receipt of Contractor's submittals on Geosynthetic Rain Cover.

B. Review of submittals for Geosynthetic Rain Cover for conformity to the project specifications.

6.1.8 Sumps/Manholes/Leachate Storage

A. Receipt of Contractor's submittals on sumps/manholes/leachate storage components.

B. Review of submittals for sumps/manholes/leachate storage components for conformity to the project specifications.

6.1.9 Valves

A. Receipt of Contractor's submittals on valves.

B. Review of submittals for valves for conformity to the project specifications.

6.2 Leachate Management System Installation

6.2.1 Leachate Collection System (LCS)

The CQA Engineer will allow installation of the LCS to proceed only after he has been provided certification of the installed HDPE geomembrane.

The CQA Engineer will monitor and document the construction of all LCS components for compliance with the project specifications. Monitoring the construction work includes the following:

- monitoring the minimum vertical buffer maintained between field equipment and the geomembrane;
- monitoring that the placement of the LCS components does not fold or damage the geomembrane or other underlying layers;
- witness and verify the installation of collection piping and gravel columns.

6.2.2 Leachate Transmission and Storage System

The CQA Engineer will monitor and document the construction of all leachate transmission and storage system components for compliance with the project specifications. Monitoring the construction work includes the following:

- witness and verify the installation of transmission piping; and
- witness and verify the leak testing of transmission piping; and
- witness and verify the leak testing of manholes and storage tanks (where applicable).

6.3 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 6.1 CQA Testing Program for Leachate Management System

Component	Property	Test Method	Minimum Test Frequency
Control Tests:			
Coarse Aggregate:	Gradation	ASTM C 136	5,000 CY
	Carbonate Content	ASTM D 3042	1 per source
Leachate Collection Media:	Gradation	ASTM C 136	5,000 CY
	Permeability[1]	ASTM D 2434	10,000 CY
	Carbonate Content	ASTM D 3042	1 per source
Protective Cover: (Soil Only - See Note 2)	Visual Classification	ASTM D 2488	Each Load
	Grain Size Analysis	ASTM D 422	5,000 CY per Each Soil

Notes:

1. Option for Failed Permeability Test:
   In the case of a failed permeability test value within 20% of the specified value, an additional three tests may be run on the proposed material. If all three tests pass, then the results from the first test can be discounted. Otherwise a different material or material from a different source shall be submitted. The cost for additional testing shall be borne solely by the Contractor.
2. If protective cover consists of additional leachate collection media, perform control tests in accordance with the requirements for leachate collection media.

7.0 GEOTEXTILE CQA

This section of the CQA Manual addresses geotextiles and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

7.1 Geotextile Material Approval

7.1.1 Geotextile Product Data

For each type of geotextile to be used, the CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

7.1.2 Shipment And Storage

During shipment and storage, all geotextiles will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

7.1.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

7.1.4 Geotextile Material Control Tests

Samples for material control tests, as shown on **Table 7.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the geotextiles. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be three (3) feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all geotextiles. The CQA Engineer will examine all results from laboratory testing.

7.1.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of geotextile that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fails, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fails, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

7.2 Geotextile Installation

7.2.1 Handling And Placement

The Geosynthetic Installer will handle and place all geotextiles in such a manner as required by the project specifications.

7.2.2 Seams And Overlaps

All geotextiles will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer.

7.2.3 Repairs

Any holes or tears in the geotextile will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

7.2.4 Placement Of Overlying Materials

All soil materials located on top of a geotextile shall be placed in accordance with the project specifications.

7.3 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 7.1 CQA Testing Program for Geotextile Material Approval

Property	Test Method	Test Frequency
Control Tests:		
Tensile Properties	ASTM D 4632	100,000 ft^2 or 1 per Lot[1]
Puncture Resistance	ASTM D 6241	100,000 ft^2 or 1 per Lot[1]
Trapezoidal Tear Strength	ASTM D 4533	100,000 ft^2 or 1 per Lot[1]
Mass Per Unit Area (Type GT- C Geotextile Only)	ASTM D 5261	100,000 ft^2 or 1 per Lot[1]
Apparent Opening Size (AOS) (Type GT-S Geotextile Only)	ASTM D 4751	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.

2. CQA testing is not required for geotextiles placed outside of the containment area.

8.0 DRAINAGE GEOCOMPOSITE CQA

This section of the CQA Manual addresses drainage geocomposite (DGC) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

8.1 DGC Material Approval

8.1.1 DGC Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

8.1.2 Shipment And Storage

During shipment and storage, all DGC will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

8.1.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

8.1.4 DGC Material Control Tests

Samples for material control tests, as shown on **Table 8.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the DGC. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be three (3) feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all DGC. The CQA Engineer will examine all results from laboratory testing.

8.1.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of DGC that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fails, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fails, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

8.2 DGC Installation

8.2.1 Handling And Placement

The Geosynthetic Installer will handle and place all DGC in such a manner as required by the project specifications.

8.2.2 Stacking And Joining

When several layers of DGC are stacked, care should be taken to ensure that stacked DGC are placed in the same direction. Stacked DGC will never be laid in perpendicular directions to the underlying DGC (unless otherwise specified by the Engineer). The CQA Engineer will observe the stacking of DGC.

Adjacent rolls of DGC will be joined according to construction drawings and project specifications.

8.2.3 Repairs

Any holes or tears in the DGC will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

8.2.4 Placement Of Overlying Materials

All soil materials located on top of DGC shall be placed in accordance with the project specifications.

8.3 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 8.1 CQA Testing Program for Drainage Geocomposite Material Approval

Property	Test Method	Test Frequency
Control Tests:		
Thickness (geonet only)	ASTM D 5199	100,000 ft^2 or 1 per Lot[1]
Density (geonet only)	ASTM D 1505	100,000 ft^2 or 1 per Lot[1]
Ply Adhesion	ASTM D 7005	100,000 ft^2 or 1 per Lot[1]
Transmissivity	ASTM D 4716[2]	1 per Resin Lot

Notes:

1. Whichever provides the larger number of tests.

2. Conduct tests for transmissivity in accordance with the conditions given in the project specifications.

9.0 GEOSYNTHETIC CLAY LINER (GCL) CQA

This section of the CQA Manual addresses geosynthetic clay liner (GCL) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

9.1 GCL Manufacturer and Installer Approval

The Contractor shall submit the qualifications of the GCL Manufacturer and the GCL Installer, as described in the specifications, to the CQA Engineer for approval.

9.2 GCL Material Approval

9.2.1 GCL Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

9.2.2 Shipment And Storage

During shipment and storage, GCL will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

9.2.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

9.2.4 GCL Material Control Tests

Samples for material control tests, as shown on **Table 9.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the GCL. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be three (3) feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all GCL. The CQA Engineer will examine all results from laboratory testing.

9.2.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of GCL that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fails, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fails, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

9.3 GCL Installation

9.3.1 Handling And Placement

The Geosynthetic Installer will handle and place all GCL in such a manner as required by the project specifications.

9.3.2 Seams And Overlaps

All GCL will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer.

9.3.3 Repairs

Any holes or tears in the GCL will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

9.3.4 Placement Of Overlying Materials

All soil materials located on top of the GCL shall be placed in accordance with the project specifications.

9.4 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 9.1 CQA Testing Program for GCL Material Approval

Property	Test Method	Test Frequency
Control Tests:		
Hydraulic Conductivity	ASTM D 5084/D 5887	100,000 ft^2 or 1 per Lot[1]
Bentonite Content	ASTM D 5993 (@ 0% moisture)	100,000 ft^2 or 1 per Lot[1]
Peel Strength	ASTM D 6496	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.

10.0 FINAL COVER SYSTEM CQA

This section of the CQA Manual addresses the landfill gas (LFG) system, drainage aggregate and piping, and the vegetative soil layer of the final cover system. By reference to **Sections 5.0, 7.0, and 8.0** of this CQA Manual, this section also addresses the geomembrane, geotextiles, and drainage geocomposite that are included in the final cover system. This section outlines the CQA program to be implemented with regard to material approval, construction monitoring, and resolution of problems.

10.1 Final Cover System Material Approval

The CQA Engineer shall verify that the following are provided and installed in accordance with the project drawings, specifications, and this CQA Manual.

10.1.1 High Density Polyethylene (HDPE) Pipe

A. Receipt of Contractor's submittals on HDPE pipe.

B. Review of submittals for HDPE pipe for conformity to the project specifications.

10.1.2 Polyvinyl Chloride (PVC) Pipe

A. Receipt of Contractor's submittals on PVC pipe.

B. Review of submittals for PVC pipe for conformity to the project specifications.

10.1.3 Corrugated Polyethylene (CPE) Pipe

A. Receipt of Contractor's submittals on CPE pipe.

B. Review of submittals for CPE pipe for conformity to the project specifications.

10.1.4 LFG System Components

A. Receipt of Contractor's submittals on LFG system components.

B. Review of submittals for LFG system components for conformity to the project specifications.

10.1.5 Aggregates (Verify for each type of aggregate)

A. Receipt of Contractor's submittals on aggregates.

B. Review of submittals for aggregates for conformity to the project specifications.

C. Verify that aggregates in stockpiles or at borrow sources conform to the project specifications.

D. Conduct material control tests in accordance with **Table 10.1**.

10.1.6 Geomembrane

The CQA program for geomembranes is presented in **Section 5.0** of this CQA Manual.

10.1.7 Geotextiles

The CQA program for geotextiles is presented in **Section 7.0** of this CQA Manual.

10.1.8 Drainage Geocomposite

The CQA program for drainage geocomposite is presented in **Section 8.0** of this CQA Manual.

10.1.9 Vegetative Soil Layer

A. Review the proposed source of vegetative soil layer for conformance with the project specifications.

B. Conduct material control tests in accordance with **Table 10.1**.

10.2 Final Cover System Installation

The CQA Engineer will monitor and document the construction of all final cover system components for compliance with the project specifications. Monitoring the construction work for the components of the final cover system includes the following:

- verify location and depth of LFG wells;
- verify location of all piping;
- monitoring the minimum vertical buffer maintained between field equipment and geosynthetics/piping; and
- monitoring that the placement of the final cover system components does not fold or damage the geosynthetics or other underlying layers.

10.3 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 10.1 CQA Testing Program for Final Cover System

Component	Property	Test Method	Minimum Test Frequency
Control Tests:			
Coarse Aggregate:	Gradation	ASTM C 136	5,000 CY
Vegetative Soil Layer:	Visual Classification	ASTM D 2488	Each Load
	Grain Size Analysis	ASTM D 422	5,000 CY
	Atterberg Limits	ASTM D 4318	5,000 CY

Appendix A

Reference List of Test Methods

Construction Quality Assurance Manual
Johnston County Landfill Facility
Smithfield, North Carolina

Construction Quality Assurance Manual
Appendix A: Reference List of Test Methods

American Society American Society of Testing and Materials (ASTM):

ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM D 422	Standard Test Method for Particle Size Analysis of Soils.
ASTM D 698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
ASTM D 792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
ASTM D 1004	Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.
ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head).
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.

ASTM D 3042	Standard Test Method for Insoluble Residue in Carbonate Aggregates.
ASTM D 4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
ASTM D 4716	Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4959	Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.
ASTM D 5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
ASTM D 5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
ASTM D 5641	Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
ASTM D 5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.

ASTM D 5887	Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.
ASTM D 5993	Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners.
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
ASTM D 6241	Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile Related Products Using a 50 mm Probe.
ASTM D 6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
ASTM D 6496	Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.
ASTM D 6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Flexible Polyethylene and Nonreinforced Polypropylene Geomembranes.
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
ASTM D 7005	Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites.

Operations Manual

Johnston County Landfill Facility
Smithfield, North Carolina

Prepared for:

Johnston County Department of Solid Waste Services
Smithfield, North Carolina

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Johnston County Landfill Facility
Smithfield, North Carolina

Operations Manual

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1.0 GENERAL FACILITY OPERATIONS

This Operations Manual was prepared for operations of the Johnston County Landfill facility (Permit No. 51-03) located off of Highway 210 on County Home Road near Smithfield. This document discusses the operation of the following landfill units and other solid waste management activities:

- Lined Subtitle D MSW Landfill Units (Phase 5 (Inactive); Phase 4A (Active));
- Lined C&D Landfill (Area 2);
- Yard Waste Processing Area; and
- Convenience Center (including white goods and tire handling areas).

Refer to **Figure 1** for the location of existing and proposed landfill units and other solid waste management activities.

The information contained herein was prepared to provide facility personnel with a clear understanding of how the Design Engineer assumed that the completed facility would be operated and how regulatory operations criteria will be met. While deviations from the operations procedures outlined herein may be acceptable, they must be reviewed and approved by the NC Department of Environment and Natural Resources (DENR) Division of Waste Management (DWM) prior to implementation. Additionally, the Design Engineer should be consulted regarding any changes which may affect the design of the facility. Please refer to the appropriate permit application for a detailed discussion and calculations for the individual components of each landfill unit, including phasing plans.

1.1 Contact Information

All correspondence and questions concerning the operation of the Johnston County Landfill facility should be directed to the appropriate County and State personnel listed below. For fire or police emergencies dial 911.

1.1.1 Johnston County (County)

Johnston County Department of Solid Waste Services
680 County Home Road
P.O. Box 2263
Smithfield, NC 27577
Phone: (919) 938-4750
Fax: (919) 989-7152

Director: Rick Proctor

1.1.2 North Carolina Department of Environment and Natural Resources

North Carolina DENR - Raleigh Central Office (RCO)
217 W. Jones Street
Raleigh, NC 27603
1646 Mail Service Center
Raleigh, NC 27699-1646
Phone/Fax: (919) 707-8200

North Carolina DENR - Raleigh Regional Office (RRO)
3800 Barrett Drive
Raleigh, NC 27609
Phone: (919) 571-4700
Fax: (919) 571-4718

North Carolina DENR - Fayetteville Regional Office (FRO)
225 Green Street, Suite 714
Fayetteville, NC 28301
Phone: (910) 486-1541
Fax: (910) 486-0707

Division of Waste Management (DWM) - Solid Waste Section:

Field Operations Branch Head:	Mark Poindexter (RCO)
Eastern District Supervisor:	Dennis Shackelford (FRO)
Waste Management Specialist:	Mary Whaley ((919) 693-5023)

Division of Land Resources - Land Quality Section:

Regional Engineer:	John Holley, P.E. (RRO)

1.2 Facility Operating Hours

Normal hours of operation are 8:00 A.M. to 4:45 P.M. Monday through Friday and 8:00 A.M. to 3:30 P.M. on Saturday. The facility is closed on Sundays and on holidays as designated by the County.

The County may elect to modify these hours from time to time.

1.3 Site Access

The site will be accessed by the existing entrance on County Home Road. A scale and scale house are located near the entrance. All waste will have been weighed prior to being placed in the landfill.

1.3.1 Physical Restraints

Limiting access to the landfill facility is important for the following reasons:

- Unauthorized and illegal dumping of waste materials is prevented.
- Trespassing, and injury resulting therefrom, is discouraged.
- The risk of vandalism is greatly reduced.

Access to active areas of the landfill will be controlled by a combination of fences and natural barriers, and strictly enforced operating hours. A landfill attendant will be on duty at all times when the facility is open for public use to enforce access restrictions (see also **Section 1.2**). The entrance has a gate which will be securely locked during non-operating hours.

1.3.2 Security

Frequent inspections of gates and fences will be performed by landfill personnel. The County also has security cameras around facility buildings and at the main entrance gate. The County will arrange for a random security patrol of the landfill entrance to further discourage trespassing. Evidence of trespassing, vandalism, or illegal operation will be reported to the County Solid Waste Director.

1.4 Signage

A prominent sign(s) containing the information required by the DWM will be placed at the main landfill entrance. This sign(s) will provide information on operating hours, operating procedures, and acceptable wastes. Additional signage will be provided as necessary within the landfill complex to distinctly distinguish the roadway to the active landfill unit(s). Service and maintenance roads for use by facility staff will be clearly marked and barriers (e.g., traffic cones, barrels, etc.) will be provided as required.

1.4.1 Waste Limit Markers

During construction or closure of landfill units, waste limit markers will be used to identify the permitted limits of waste. The waste markers will be constructed of non-degradable material and will state "Waste Limits" or "Edge of Liner" (or similar wording) in bold lettering. Offsets are acceptable such that all wording is clear to the DWM and operational staff. The waste markers will be maintained and replaced when damaged.

1.5 Communications

Two-way radio communication will be maintained between the active landfill unit(s), the landfill scale house, and the office. The scale house and office have telephones in case of emergency and for the conduct of day-to-day business. Emergency telephone numbers are displayed in these locations. Most staff also have cellular phones.

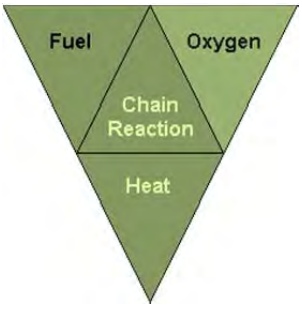
1.6 Fire Control

The possibility of fire within the landfill or a piece of equipment must be anticipated in the daily operation of the facility. Potential fire hazards include both surface conditions and subsurface conditions. Surface conditions include equipment operations and newly placed waste. Subsurface conditions include existing waste previously landfilled.

1.6.1 Open Burning

With the exception of the controlled burning of land clearing debris generated on-site or from emergency clean-up operations, no opening burning is allowed at the facility. Controlled burning will occur only if permitted or approved by the DWM, the Division of Air Quality (DAQ), and the local fire department.

1.6.2 Fire Tetrahedron[1]



To better understand the properties of fire, the fundamental methods to extinguish it must be understood. The fire "tetrahedron" illustrates the rule that in order to ignite and burn, each component of the tetrahedron (fuel, oxygen, heat, and chemical chain reaction) represents a property of flaming fire. A fire is prevented or extinguished by "removing" any one of them. A fire naturally occurs when the elements are combined in the right mixture (e.g., more heat needed for igniting some fuels, unless there is concentrated oxygen). The fire tetrahedron is a more modern adaptation of the traditional fire "triangle" recognizing the chemical reactions that may occur as a component - "the uninhibited chain reaction". This chain reaction is the feedback of heat to the fuel to produce the gaseous fuel used in the flame. In other words, the chain reaction provides the heat necessary to maintain the fire. These principles are integral in the prevention and management of potential fire situations. *Please note this information is considered as a basis of understanding which may be superseded by the direction and skill of the local Fire Marshal.*

[1] National Fire Protection Association (www.nfpa.org).

1.6.3 Equipment

A combination of factory installed fire suppression systems and/or portable fire extinguishers will be operational on all pieces of heavy equipment at all times. Potential fire hazards are created from the build-up of fine, dry dust particles on and around operational motors and control panels. The presence of these build-ups can cause overheating and potential fire if periodic equipment cleaning and maintenance are not practiced. Portable fire extinguishers should be maintained in a state of readiness on each piece of moving equipment and equipment should be cleaned periodically.

1.6.4 General Fire Management Strategies

Each fire situation is site specific; however, general strategies for active fire management include the following (in no particular order):

- Accelerated high temperature combustion (displacing fuel);
- Covering of burning material with soil (reduce oxygen);
- Covering of burning material with foams (reduce oxygen);
- Flooding of burning material with water (reduce heat);
- Injecting an inert gas such as CO_2 (reduce oxygen);
- Excavating the burning material (displacing fuel) and then extinguishing it in small controlled areas; and
- Applying extinguishing agents that will interfere with and inhibit the combustion process at the molecular level (break the chemical reaction).

1.6.5 Fires Within Disposal Areas

Fires within the landfill disposal areas will be limited by the use of daily/periodic cover as a fire break and control of "hot" loads entering the landfill. Landfill personnel at the scale house will turn away all trucks containing waste that is suspected to be hot. If a hot load is placed on the working face, then the load will be spread as thin as possible and daily cover soil will be immediately placed on the waste to extinguish the fire.

In general, fires that break out close to the surface of the disposal area should be excavated and smothered with cover material. Deep fires should be smothered out by placing moist soil on the surface and by constructing soil barriers around the fire. Where the smothering technique fails, the burning material must be excavated and smothered or quenched with water once the burning material is brought to the surface. Water is usually not effective unless it can be directly applied to the burning material.

For the lined landfill unit(s), in the event a fire occurs in the first lift of waste immediately above the protective cover layer, the possibility of damage to

geosynthetics and collection piping exists. Once the fire is extinguished, the residue must be removed to allow limited inspection of the geosynthetics and piping. Damaged sections of geosynthetics, piping, etc. must be removed and replaced with new items of the same or equal material. The new materials must be placed in accordance with the technical specifications and construction quality assurance (CQA) documents prepared for this facility.

1.6.6 Notification

The County will verbally notify the DWM (see **Section 1.1.2**) within 24 hours of discovery of a fire within any landfill disposal area. In addition, written documentation describing the fire, the actions carried out to extinguish the fire, and a strategy for preventing future occurrences will be provided to the DWM within 15 days following any such occurrence using the DWM's Fire Occurrence Notification Form (see **Appendix A**).

1.6.7 Coordination With Local Fire Department

A copy of this Operations Manual will be filed with the local fire department including all contact information for the facility.

1.7 Severe Weather Conditions

Unusual weather conditions can directly affect the operation of the landfill facility. Some of these weather conditions and recommended operational responses are as follows.

1.7.1 Ice Storms

An ice storm can make access to the facility dangerous, prevent movement or placement of cover soil, and, thus, may require closure of the facility until the ice is removed or has melted.

1.7.2 Heavy Rains

Exposed soil surfaces can create a muddy situation in some portions of the facility during rainy periods. The control of drainage and use of crushed stone on unpaved roads should provide all-weather access for the site and promote drainage away from critical areas. In areas where the aggregate surface is washed away or otherwise damaged, new aggregate should be used for repair.

Intense rains can affect newly constructed drainage structures such as swales, diversions, cover soils, and vegetation. After such a rain event, inspection by facility personnel will be initiated and corrective measures taken to repair any damage found before the next rainfall.

1.7.3 Electrical Storms

The open area of the facility is susceptible to the hazards of an electrical storm. If necessary, activities will be temporarily suspended during such an event. Refuge will be taken as necessary in the on-site buildings or in rubber-tired vehicles.

1.7.4 Windy Conditions

Facility operations during a particularly windy period may require that the working face be temporarily shifted to a more sheltered area. When this is done, the previously exposed face will be immediately covered with cover soil.

1.7.5 Violent Storms

In the event of hurricane, tornado, or severe winter storm warning issued by the National Weather Service, facility operations may be temporarily suspended until the warning is lifted. Cover soil will be placed on exposed waste and buildings and equipment will be properly secured to the extent deemed safe.

1.8 Equipment Requirements

The County will maintain on-site equipment required to perform the necessary site activities. Periodic maintenance of all equipment and minor and major repair work will be performed at designated maintenance zones.

The anticipated equipment requirements for operation and maintenance of the site are listed in the following table. These may vary based upon incoming tonnages.

Table 1 Equipment Requirements

Description	Primary Function (Allocation)
1) Compactors (3)	Waste placement and compaction
2) Dozers (2)	Stripping and grading of borrow areas, fine grading, slope work, and site cleanup
3) Rubber-Tired Loader	General site work, sediment control, and site cleanup
4) Water Truck	Dust control
5) Excavators (2)	Loading and placement of cover soils
6) Articulating Dump Trucks (2)	Loading and hauling of cover soils
7) Service Truck	Equipment maintenance and site management

1.9 Personnel Requirements

At least one member of the facility supervisory staff will be certified as a Manager of Landfill Operations (MOLO) by the Solid Waste Association of North America (SWANA) (or other DWM-approved program) and operations staff will go through appropriate training. At least one certified (SWANA Landfill Operations Specialist or other DWM-approved program) operator will be present on-site during times when the landfill is receiving or disposing of waste. As part of this training, personnel learn to recognize loads which may contain prohibited wastes.

1.10 Health and Safety

All aspects of the facility operations were developed with the health and safety of the operating staff, customers, and neighbors in mind. Prior to commencement of operations of the facility, a member of the operating staff will be designated site safety officer. This individual, together with the facility's management will modify the site safety and emergency response program to remain consistent with SWANA and Occupational Safety and Health Administration (OSHA) guidance.

Safety equipment provided includes equipment rollover protective cabs, seat belts, audible reverse warning devices, hard hats, safety shoes, and first aid kits. Facility personnel will be encouraged to complete the American Red Cross Basic First Aid Course. Other safety requirements as designated by the County will also be implemented.

Facility employees will be routinely trained in health and safety by supervisory staff. All training will be documented. The following are some general recommendations for the health and safety of workers:

1.10.1 Personal Hygiene

The following items are recommended as a minimum of practice:

- Wash hands before eating, drinking, or smoking.
- Wear personal protective equipment as described in Section 1.10.2.
- Wash, disinfect, and bandage ANY cut, no matter how small it is. Any break in the skin can become a source of infection.
- Keep fingernails closely trimmed and clean (dirty nails can harbor pathogens).

1.10.2 Personal Protective Equipment

Personal Protective Equipment (PPE) must be evaluated as to the level of protection necessary for particular operating conditions and then made available

to facility employees. The list below includes the PPE typically used and/or required in a solid waste management facility workplace.

- Safety shoes with steel toes.
- Noise reduction protection should be used in areas where extended exposure to continuous high decibel levels are expected.
- Disposable rubber latex or chemical resistant gloves for handling and/or sampling of waste materials.
- Dust filter masks (voluntary).
- Hard hats (in designated areas).

Following use, PPE's should be disposed of or adequately cleaned, dried, or readied for reuse.

1.10.3 Mechanical Equipment Hazard Prevention

All equipment should be operated with care and caution. All safety equipment such as horns, backup alarms, and lights should be functional. A Lockout-Tagout program will be used to identify equipment in need or under repair and insure that operation is "off-limits" prior to maintenance or repair. All operators will be trained in the proper operation of equipment.

1.10.4 Employee Health and Safety

Some general safety rules are:

- Consider safety first when planning and conducting activities.
- Review the equipment O&M manual(s) prior to attempting repairs/changes.
- Remember the buddy system for repair of mechanical equipment.
- Post emergency contact phone numbers.
- Provide easy and visible access to the Right to Know materials.
- Provide easy and visible access to first aid kits and fire extinguishers.

1.10.5 Physical Exposure

Facility personnel may come in contact with the fluids, solids, and airborne constituents found at the facility. Routine training should be conducted regarding the individual and collective materials used at the facility and their associated hazards. Training concerning safe work practices around these potential exposures should cover the use of equipment and proper disposal procedures.

1.10.6 Safety Data Sheets

Safety Data Sheets (SDS) will be made available for all chemicals stored on site for use at the facility. SDS will be stored in a location with all other Right to Know information for the site.

1.11 Utilities

Electrical power, water, telephone, and restrooms are provided at the scale house and/or office.

1.12 Record Keeping Program

The County will maintain the following records in an operating record at the facility:

A. Current permit(s) (Permit to Construct, Permit to Operate, etc.);
B. Current operations manual/plan(s) and engineering plan for each landfill unit;
C. Inspection reports;
D. Audit and compliance records;
E. Annual reports (including survey and other documentation related to airspace usage in landfill units);
F. Waste inspection records (see **Section 2.3.1**);
G. Daily tonnage records - including source of generation;
H. Waste determination records (if applicable);
I. Quantity, location of disposal, generator, and special handling procedures for all special wastes disposed of at the site;
J. List of generators and haulers that have attempted to dispose of restricted wastes;
K. Employee training procedures and records of training completed;
L. All ground water monitoring and surface water quality information (See the current **Water Quality Monitoring Plan**) including:
    1. Monitoring well construction records;
    2. Sampling dates and results;
    3. Statistical analyses (if applicable); and
    4. Results of inspections, repairs, etc.
M. LFG monitoring results and remedial measures as required (see the current **LFG Monitoring Plan**);
N. All closure and post-closure information, where applicable, including:
    1. Notification of intent to close;
    2. Testing;
    3. Certification; and
    4. Recording.
O. Cost estimates or financial assurance documentation;
P. A notation of the date of cover placement;

Q. Documentation of approval for controlled burning (Date of Approval/Name of Approving DWM personnel) (see **Section 1.6.1**);
R. Documentation of cell activation (see **Section 2.4.3.2**);
S. NPDES records (see **Section 3.1.6**);
T. Documentation of cleaning and inspection activities for leachate collection piping (see **Section 3.2.1.2**); and
U. Leachate records (see **Section 3.2.4**).

The operating record will be kept up to date by the Solid Waste Director or his designee. It will be presented upon request to the DWM for inspection. A copy of this Operations Manual will be kept at the landfill and will be available for use at all times.

2.0 WASTE HANDLING OPERATIONS

This section describes the required waste handling operations for the Johnston County Landfill facility. In addition to the MSW and C&D waste disposed of at this facility, the County also processes wood/yard waste, recyclables, scrap tires, and white goods. These materials are stored at the landfill facility until there are sufficient quantities for pick up by various recycling contractors.

2.1 Acceptable Wastes

2.1.1 MSW Landfill Unit

Non-hazardous solid waste as defined by NCGS 130A-290(a)(35) generated within the approved service area may be disposed of in the MSW landfill unit. In addition, the special wastes described in **Section 2.4.4** may also be disposed of in the MSW landfill unit.

2.1.2 C&D Landfill Unit

Only the following wastes generated within the approved service area may be disposed of in the C&D landfill unit:

- Construction and Demolition (C&D) Solid Waste: as defined in 15A NCAC 13B.0532(8) means solid waste resulting solely from construction, remodeling, repair, or demolition operations on pavement and buildings or structures. C&D waste does not include municipal and industrial wastes that may be generated by the on-going operations at buildings or structures.
- Inert Debris: as defined in 15A NCAC 13B.0101(22) means concrete, brick, concrete block, uncontaminated soil, gravel and rock, and untreated and unpainted wood.
- Land Clearing Waste: as defined in 15A NCAC 13B.0101(23) means solid waste which is generated solely from land-clearing activities, limited to stumps, trees, limbs, brush, grass, and other naturally occurring vegetative material.
- Asphalt: in accordance with NCGS 130A-294(m).
- Industrial solid waste that is generated by mobile or modular home manufacturers and asphalt shingle manufacturers. The waste must be separated at the manufacturing site to exclude municipal solid waste, hazardous waste, and other waste prohibited from disposal in a Construction and Demolition Landfill.
- Other Wastes as Approved by the Solid Waste Section of the Division of Waste Management.

In addition, the special wastes (asbestos only) described in **Section 2.4.4** may also be disposed of in the C&D landfill unit.

2.2 Prohibited Wastes

2.2.1 MSW Landfill Unit

The following wastes are prohibited from disposal within the MSW landfill unit:

- Used Oil and Motor Vehicle Oil Filters;
- Yard Waste;
- White Goods;
- Antifreeze (ethylene glycol);
- Aluminum Cans;
- Whole Scrap Tires;
- Lead Acid Batteries;
- Certain Recyclable Rigid Plastic Containers (per NCGS 130A-309.10(f)(11));
- Wooden Pallets;
- Oyster Shells;
- Discarded Computer Equipment and Televisions;
- Construction and Demolition Debris (C&D) (Except when allowed by the County).

In addition, operating criteria prohibit other materials from disposal within the MSW landfill unit. These materials include:

- Hazardous waste as defined by NCGS 130A-290(a)(8), including hazardous waste from conditionally exempt small quantity generators.
- Polychlorinated biphenyls (PCB) wastes as defined in 40 CFR 761 with the exception of trace amounts found in materials such as consumer electronics.
- Bulk or non-containerized liquid wastes unless the waste is household waste other than septic waste and waste oil; or the waste is leachate or gas condensate derived from the MSW landfill unit. A liquid determination will be performed by the paint filter test (see **Appendix B** for apparatus and procedure).
- Containers holding liquid wastes unless the waste is household waste.

2.2.2 C&D Landfill Unit

Only wastes as defined in **Section 2.1.2** above may be accepted for disposal in the C&D landfill unit. Prohibited wastes include waste exclusions listed in 15A NCAC 13B 0.0542 as follows:

- Wastewater treatment sludge. Wastewater treatment sludge may be accepted, with the approval of the DWM, for utilization as a soil conditioner and incorporated into or applied onto the vegetative soil layer component of the final cover system. In this case, the sludge will be applied at no greater than agronomic rates and to a maximum depth of six inches.
- Containers such as tubes, drums, barrels, tanks, cans, and bottles unless they are empty and perforated to ensure that no liquid, hazardous, or municipal solid waste is contained therein;
- Garbage as defined in G.S. 130A-290(a)(7);
- Hazardous waste as defined in G.S. 130A-290(a)(8), to also include hazardous waste from conditionally exempt small quantity generators;
- Industrial solid waste unless a demonstration has been made and approved by the DWM that the landfill meets the requirements of Rule .0503(2)(d)(ii)(A);
- Liquid wastes;
- Medical waste as defined in G.S. 130A-290(a)(18);
- Municipal solid waste as defined in G.S. 130A-290(a)(18a);
- Polychlorinated biphenyls (PCB) wastes as defined in 40 CFR 761;
- Radioactive waste as defined in G.S. 104E-5(14);
- Septage as defined in G.S. 130A-290(a)(32);
- Sludge as defined in G.S. 130A-290(a)(34);
- Special wastes as defined in G.S. 130A-290(a)(40);
- White goods as defined in G.S. 130A-290(a)(44); and
- Yard trash as defined in G.S. 130A-290(a)(45).

The following wastes cannot be received if separate from C&D waste:

- Lamps or bulbs including but not limited to halogen, incandescent, neon or fluorescent;
- Lighting ballast or fixtures;
- Thermostats and light switches;
- Batteries including but not limited to those from exit and emergency lights and smoke detectors;
- Lead pipes;
- Lead roof flashing;
- Transformers;
- Capacitors;
- Copper chrome arsenate (CCA) and creosote treated woods; and
- Pallets.

Waste accepted for disposal in the C&D landfill unit must be readily identifiable as C&D waste and must not have been shredded, pulverized, or processed to such an extent that the composition of the original waste cannot be readily ascertained except as specified as follows:

- C&D waste that has been shredded, pulverized, or otherwise processed may be accepted for disposal from a facility that has received a permit from an authorized regulatory authority which specifies such activities are inspected by the authority, and whose primary purpose is recycling and reuse of the C&D material. For this case, a waste screening plan and waste acceptance plan will be prepared and made available to the DWM upon request.

The County will not dispose of C&D waste that is known to be generated within the boundaries of a unit of local government that by ordinance:

(A) Prohibits generators or collectors of C&D waste from disposing that type or form of C&D waste.
(B) Requires generators or collectors of C&D waste to recycle that type or form of C&D waste.

2.3 Waste Screening Programs

In order to assure that prohibited wastes are not entering the landfill facility, screening programs have been implemented. Waste received at both the scale house and waste taken to the active landfill units is inspected by trained personnel. These individuals have been trained to spot indications of suspicious wastes, including: hazardous placarding or markings, liquids, powders or dusts, sludges, bright or unusual colors, drums or commercial size containers, and "chemical" odors. Screening programs for visual and olfactory characteristics of prohibited wastes are an ongoing part of the facility operation.

Records of information gathered as part of the waste screening programs will be maintained at the facility during its active life and as long as required by the County and the DWM.

2.3.1 Waste Receiving and Inspection

All vehicles must stop at the scale house located near the entrance of the facility and visitors are required to sign-in. All waste transportation vehicles are weighed and the content of the load assessed. The scale attendant(s) requests from the driver of the vehicle a description of the waste it is carrying to ensure that unacceptable waste is not allowed into the facility. The attendant(s) then visually checks the vehicle as it crosses the scale. Signs informing users of the acceptable and unacceptable types of waste are posted at the scale house. Once passing the scales, the vehicles are routed to the appropriate landfill unit or other area (convenience center, etc.) as appropriate.

Vehicles are randomly selected for screening on a regular basis, depending on personnel available. Approximately 1% by weight of the waste stream entering

the facility will be randomly selected by inspection personnel. The number of loads inspected is determined by the total vehicle count based on scale tickets for the prior year (For example, for 2001, 1% was equal to 252 vehicles; 264 vehicles were actually inspected). However, if something suspicious is spotted in any waste load, that load is inspected further.

Vehicles selected for inspection are directed to an area of intermediate cover adjacent to the working face where the vehicle will be unloaded. Waste is carefully spread using suitable equipment. An attendant trained to identify wastes that are unacceptable inspects the waste discharged at the screening site. If unacceptable waste is found, including wastes generated from outside of the service area, the load will be isolated and secured by berming off the area. For unacceptable wastes that are non-hazardous, the Solid Waste Director will then notify officials of the DWM (see **Section 1.1.2**) within 24 hours of attempted disposal of any waste the landfill is not permitted to receive in order to determine the proper course of action. For unacceptable wastes that are thought to be hazardous, the Hazardous Waste Contingency Plan outlined in **Section 2.3.2** will be followed. The hauler is responsible for removing unacceptable waste from the facility property.

If no unacceptable waste is found, the load will be pushed to the working face and incorporated into the daily waste cell. All random waste inspections will be documented by facility staff using the waste screening form provided in **Appendix C**.

In addition to random waste screening described above, waste unloaded on the active face will be inspected by the equipment operators, trained to spot unacceptable wastes, before and during spreading and compaction. Any suspicious looking waste is reported immediately to the designated primary inspector for further evaluation.

2.3.2 Hazardous Waste Contingency Plan

In the event that identifiable hazardous waste or waste of questionable character is detected at the facility, appropriate equipment, protective gear, personnel, and materials as necessary will be employed to isolate the wastes. The DWM will be notified immediately (see **Section 1.1.2**) that an attempt was made to dispose of hazardous waste at the landfill. If the vehicle attempting disposal of such waste is known, all attempts will be made to prevent that vehicle from leaving the site or, if the vehicle has left the site, immediate notice will be served on the owner of the vehicle that hazardous waste, for which they have responsibility, has been disposed of at the facility.

The County will assist the DWM as necessary and appropriate in the removal and disposition of the hazardous waste and in the prosecution of responsible parties.

If needed, the hazardous waste will be covered with either on-site soils or other tarping material until such time when an appropriate method can be implemented to properly handle the waste. The cost of the removal and disposing of the hazardous waste will be charged to the owner of the vehicle involved. Any vehicle owner or operator who knowingly dumps hazardous waste in the landfill may be barred from using the facility.

Should an incident where hazardous waste is found at the facility occur, the event will be documented by facility staff using the waste screening form provided in Appendix C.

2.4 Waste Disposal

2.4.1 Access

Traffic will be clearly directed to the appropriate active access road. For the active lined landfill unit(s), all vehicles entering the unit will use the active ramp to avoid damaging the liner system. Traffic speed on the ramp should be less than 10 MPH. Rutting of gravel roadway surfaces must be repaired by placement of additional gravel on the roadway and not solely by grading the rut. This will maintain the separator geotextile placed below most gravel roadway surfaces.

The location of access roads during waste placement will be determined by facility staff in order to reflect waste placement strategy. Additionally, access will be maintained for site monitoring locations.

2.4.2 General Procedures

For each active landfill unit, waste transportation vehicles will arrive at the working face at random intervals. There may be a number of vehicles unloading waste at the same time, while other vehicles are waiting. In order to maintain control over the unloading of waste, a certain number of vehicles will be allowed on the working face at a time. The actual number will be determined by the spotter (the spotter is typically the compactor operator). This procedure will be used in order to minimize the potential of unloading un-acceptable waste and to control disposal activity. Operations at the working face will be conducted in a manner which will encourage the efficient movement of transportation vehicles to and from the working face, and to expedite the unloading of waste.

The approach to the working face will be maintained such that two or more vehicles may safely unload side by side (A minimum separation distance of 10 feet is encouraged.). A vehicle turn-around area large enough to enable vehicles to arrive and turn around safely with reasonable speed will be provided adjacent to the unloading area. The vehicles will back to a vacant area near the working face to unload. Upon completion of the unloading operation, the transportation

vehicles will immediately leave the working face area. Personnel will direct traffic as necessary to expedite safe movement of vehicles.

Waste unloading at the landfill will be controlled to prevent disposal in locations other than those specified by site management. Such control will also be used to confine the working face to a minimum width, yet allow safe and efficient operations. The width and length of the working face will be maintained as small as practical in order to maintain the appearance of the site, control windblown waste, and minimize the amount of cover required each day. Normally, only one working face will be active on any given day, with all deposited waste in other areas covered by either daily/periodic, intermediate, or final cover, as appropriate.

The procedures for placement and compaction of solid waste include: unloading of vehicles, spreading of waste into 2 foot lifts (thicker lifts may be necessary at the operators discretion depending on waste type and location of waste placement), and compaction on relatively flat slopes (i.e. 5H:1V max.) using a landfill compactor and a minimum number of three full passes.

Caution will be used in wet conditions such that no waste will be placed into ponded water. Likewise, surface water will not be allowed to be impounded over waste.

Wind screens adjacent to active areas may be used as practical to control windblown waste.

The use of portable signs with directional arrows and portable traffic barricades will facilitate the unloading of wastes to the designated disposal locations. These signs and barricades will be placed along the access route to the working face of the landfill or other designated areas which may be established.

The removal of solid waste from any landfill unit is prohibited except upon notification of the DWM (see **Section 1.1.2**). Regardless, the general public is prohibited from any waste removal activities from any landfill unit.

2.4.3 Lined Landfill Units

2.4.3.1 Cell Operations and Phasing

Each lined landfill unit is divided into cells. Each cell will be filled in sequence until the entire footprint is covered with waste. Phasing drawings are presented in the appropriate permit application for each landfill unit.

It is advantageous to begin to establish final cover grades along the perimeter berms as soon as is possible. This will allow earlier construction of intermediate or final cover to promote "clean" runoff and to spread out final cover construction costs.

2.4.3.2 Cell Activation

Before placing waste in a particular area of any cell, that area must be connected to the leachate collection system (LCS) by removing (or suitably perforating) the geosynthetic rain cover (if any) and/or making any required piping connections such that all liquid collected in that area will flow to the sump. Next, just ahead of waste placement operations, the Type GT-S geotextile placed over the gravel columns is to be cut and removed such that waste will be placed in direct contact with the coarse aggregate.

Once an area has reached its effective capacity, operations will move to the next scheduled area. Prior to placing waste in a new area, it must be connected to the LCS as described above.

See **Appendix D** for cell activation form(s) to be used in the documentation of cell activation activities.

2.4.3.3 Placement of Initial Lift

During waste placement operations, the landfill liner system is most vulnerable during the placement of the first lift of waste. The first lift of waste should be comprised of select loads spread on top of the protective cover layer. These select loads must be free of long or large pieces of waste that may push through the protective cover layer and damage the liner system. Workers will be positioned near the working face to check for any waste which could possibly penetrate the protective cover layer. The first lift should be a minimum of four (4) feet thick and provide sufficient area for at least one day's operation without placing other areas of the liner in jeopardy.

The side slopes of the liner system are also vulnerable during placement of the first lift of waste. As with the bottom slopes, the first lift of waste against the side slopes should be comprised of select loads.

In the event that the facility staff identifies any damage to any part of the landfill's liner system, they should immediately initiate its repair. Additionally, they should document the damage and the repair as a part of the operating record.

2.4.3.4 Equipment Operations Within the Landfill

Both the facility's operational vehicles and waste transportation vehicles must be restricted as follows within the lined landfill:

- Equipment operation directly on the protective cover will be limited to rubber-tired vehicles having a maximum ground contact, i.e., tire pressure, of less than 32 pounds per square inch (psi).
- A minimum vertical separation of 3 feet will be maintained between the geomembrane liner and all waste transportation vehicles.
- A minimum vertical separation of 5 feet will be maintained between the geomembrane liner and waste compactors.

The operation of vehicles within those portions of the landfill not actively receiving waste should be restricted to activities associated with erosion and sedimentation control.

2.4.3.5 Tipper Operations (If Applicable)

The following guidelines will be used when using a tipper for dumping larger waste transportation vehicles.

- The tipper must only be used per the manufacturer's recommendations and instructions;
- The tipper must be level from side to side (both at the front and the back);
- All outrigger cylinders must contact their respective floats and the base under the floats must be capable of withstanding the necessary loadings;
- Be sure deck is cleared of all equipment and personnel;
- Never exceed the rated capacity of the tipper;
- It is important to maintain good housekeeping on, around, and under the tipper. An accumulation of material or debris may obstruct the freedom of operation of the tipper deck and related components;
- The trailer must be designed for tipper use;
- Use caution when lowering the deck - watch out for personnel in the immediate area;
- The deck must be safely supported before any maintenance or service work is performed underneath;
- Tippers may not operate correctly when wind speeds exceed 40 mph.

2.4.4 Special Waste Management

2.4.4.1 Asbestos Management (MSW or C&D Landfill Units)

The County may dispose of asbestos within either the MSW or C&D landfill units. Asbestos will only be accepted if it has been processed and packaged in accordance with State and Federal (40 CFR 61) regulations. Asbestos will arrive at the site in vehicles that contain only the asbestos waste and only after advance notification by the generator.

Once the hauler brings the asbestos to the landfill, the hauler will be directed to the designated asbestos disposal area by facility staff. The designated disposal area will be prepared by facility staff by leveling a small area using a dozer or loader. Prior to disposal, the landfill operators will stockpile cover soil near the designated asbestos disposal area. The volume of soil stockpiled will be sufficient to cover the waste and to provide any berms, etc. to maintain temporary separation from other landfill traffic.

Once placed in the prepared area, the asbestos waste will be covered with a minimum of 18 inches of cover soil placed in a single lift. The surface of the cover soil will be compacted and graded using a tracked dozer or loader. The landfill compactor will be prohibited from operating over asbestos disposal areas until at least 18 inches of cover is in-place.

The facility staff will record the approximate location and elevation of the asbestos waste once cover is in-place (typically using a GPS device). The Solid Waste Director will then review pertinent disposal and location information to assure compliance with regulatory requirements and enter the information into the Operating Record.

Once disposal and recording for asbestos waste is completed, the disposal area may be covered with waste. No excavation into designated asbestos disposal areas will be permitted.

In general, for the lined landfill unit(s), no asbestos will be stored over gravel columns or over sump areas in order to minimize the potential for future disturbance.

2.4.4.2 Sewage Sludge Management (MSW Landfill Unit)

Sewage sludge may be accepted for disposal within the MSW landfill unit in accordance with Federal and State requirements. Sewage sludge will be co-disposed along with other wastes if the sludge passes the liquids restriction criteria (i.e., the Paint Filter Test) and has an acceptable

Toxicity Characteristic Leaching Procedure (TCLP) test. Such testing will be the responsibility of the generator, but facility staff may conduct spot testing.

In order to minimize the potential for clogging of the leachate collection and removal system, sewage sludge will not be placed within the first lift of waste. Sewage sludge may also be used as a soil conditioner incorporated into the vegetative soil layer of the final cover.

2.4.4.3 Spoiled Food and Animal Waste (MSW Landfill Unit)

The disposal of spoiled foods, animal carcasses, and other animal wastes within the MSW landfill unit will be handled as follows:

- The generator of the material must call in advance to the landfill, and a determination will be made as to whether or not the waste will be accepted.
- If the waste is approved, the generator will present the waste at a predetermined time.
- An area for disposal will already have been prepared and the waste will be covered immediately.

2.4.5 Daily or Periodic Cover

2.4.5.1 MSW Landfill Unit

At the completion of waste placement each day, a 6 inch layer of earthen material or approved alternate daily cover (see **Section 2.4.6**) will be placed over the working face. This daily cover is intended to control vectors, fire, odors, and blowing litter.

2.4.5.2 C&D Landfill Unit

At the completion of waste placement each week, or sooner if the area of exposed waste exceeds one-half acre in size, a 6-inch layer of earthen material or other material as approved by the DWM will be placed over the exposed waste. Cover must be placed at more frequent intervals if necessary to control disease vectors, fires, odors, blowing litter, and scavenging.

2.4.6 Alternate Daily Cover

The following alternate daily cover (ADC) materials may be used within the lined landfill units at this facility using the general operations methods described below:

- Tarps (Tarpomatic);
- Auto shredder residue/fluff (ASR); and/or
- Other materials/methods approved by the DWM.

2.4.6.1 Tarps (Tarpomatic)

The Tarpomatic apparatus consists of a 60-foot wide x 8-foot deep x 10-foot tall tubular steel support frame, a diesel engine, a hydraulic pump, stationary and remote control boxes, and a detachable 50-foot tarp spool. The frame has two carrier arms at the top that will latch over the blade of a compactor (or dozer) allowing the apparatus to become mobile when needed. Each spool may carry three 40-foot x 100-foot tarps which provide up to 12,000 square feet of coverage. Tarps are made from a woven high density polyethylene fire retardant material with reinforced seams and edges and connecting straps on each end. Heavy steel chains are installed in pockets throughout the tarp to provide ballast to prevent wind uplift. Carrier arm adjustment, tarp spool drive, and spool locking levers are hydraulically controlled and are activated by the remote control box located inside the compactor cab.

To operate the Tarpomatic, the operator will drive the compactor up to the apparatus and align the blade with the carrier arms. The blade is then lifted upward into the carrier arms, raising the frame off the ground. Once the operator has positioned the compactor and Tarpomatic over the area of waste to be covered, each tarp is applied to the surface while backing over the waste. The tarp is unrolled at the same rate as the compactor movement so that it may be applied to the surface without pulling the tarp through the waste. Once the tarp is completely applied, the operator will detach the tarp straps and set the frame to the side. Tarps are rolled back onto the spool in the reverse order.

Typically, the Tarpomatic is used to cover over the daily working face only. As migration occurs throughout cell development, all traffic areas and side slopes are covered with daily or intermediate cover soil. Severe thunderstorms, high winds, or freezing precipitation may prohibit the use of the Tarpomatic. Daily or intermediate cover soil is used as cover every Friday or whenever inclement weather is forecasted.

Tarps that become damaged will be repaired or replaced as necessary.

2.4.6.2 Auto Shredder Residue (ASR)

Auto shredder residue (ASR) may be used as an alternate daily cover as long as site (weather) conditions allow. Significant rainfall and/or high winds may restrict the use of ASR. In general, the following procedures will be employed when using ASR:

- ASR will be placed, spread, and compacted (tracked-in) to achieve a minimum thickness of 6-inches.
- ASR will be mixed with soil when utilized in windy conditions to control blowing litter.
- Soil cover will be applied at a minimum of one time per week.
- ASR will not be used on any outside slopes or as intermediate cover.
- ASR may be stockpiled within the limits of the disposal area. ASR stockpiles remaining in-place will be covered with soil if weather conditions dictate.

For the lined Area 2 C&D landfill unit, the County will use ASR on a trial basis for up to one year following approval of this document. The quantity of ASR will not exceed approximately 10 percent of the total volume utilized for waste disposal. Based on a review of the volume used over the past 3 years (6/12/2010 to 6/14/2013), the County has used an average of approximately 48,700 cubic yards (CY) for disposal each year. Assuming 10 percent of this volume (4,870 CY) and a density of compacted ASR of 0.7 tons/CY (based on a field trial by the County), the County will use no more than 3,400 tons of ASR as ADC in the Area 2 C&D landfill unit in one year. Additionally, the quantity of any stockpiled ASR in the C&D landfill unit will not exceed that which can be used for ADC in approximately 3 months (approximately 850 tons). At the end of the one-year trial period, the County will provide the DWM with a brief report documenting the use of ASR in the C&D landfill during the trial period. The report will note how much ASR material has been used and what, if any, operational issues and/or modifications have been made. Upon successful documentation, ASR may be used thereafter using the methods employed during the trial period.

2.4.6.3 Other Materials/Methods

Other ADC materials/methods may be used upon approval by the DWM. Materials and corresponding methods that have been approved for use at other facilities may be used upon notification of the DWM (see **Section 1.1.2**). Materials/methods which have not been approved for use at other facilities will require a demonstration period prior to approval.

2.4.7 Intermediate Cover

A 12 inch layer of soil cover should be placed on all waste surfaces that have not received waste in 30 days but are below final elevation. This intermediate cover should be seeded immediately and graded such that all precipitation run-off is channeled to the surface water systems. The County will periodically mow the surface of the intermediate cover.

Note that the inactive Phase 5 MSW landfill unit currently has a minimum of 12-inches of intermediate cover in-place and is well-vegetated. Maintenance includes routine mowing and visual inspection.

2.4.8 Height Monitoring

Periodically the facility staff will monitor landfill top and side slope elevations with a level. When such elevations approach design grades, the final top-of-waste grades will be staked to limit over-placement of waste.

2.5 Yard Waste Processing Area Operations

A yard waste processing area is located at the southeast end of the facility (see **Figure 1**). The operation of the yard waste processing area is as follows:

- Acceptable wood and yard wastes are stockpiled in separate windrows with a target height of 10 feet (maximum height of 15 feet) and width of 50 feet. Sufficient space is provided between windrows to allow equipment access in case of fire and the windrows are kept a minimum of 50 feet from the property line.

- Once sufficient material is accumulated at the site, a contractor is brought in to grind the waste. This typically occurs 4 times per year.

- Once the waste is ground and becomes mulch, it is used either around the site, primarily for surface stabilization, used for stabilization of sludges brought to the facility for disposal, or placed in windrows (with similar maximum dimensions to pre-processed materials) to be given to the public or otherwise used in the future. Typically, approximately 6,000 tons of material is ground each year.

- For ground wood/yard waste provided to the public, the County will follow the requirements for a Small Type 1 Compost facility (under 15A NCAC 13B.1402 (g)(3)) including operation in accordance with requirements of 15A NCAC 13B.1406. These requirements include:

    - Composting at or above 55 degrees Celsius (131 degrees F) for 3 days and piles will be aerated to maintain elevated temperatures.

A full time attendant looks over both the yard waste processing area and the convenience center operations.

Unacceptable wastes found in this area, if not otherwise prohibited, will be routed to either the MSW or C&D landfill unit as appropriate.

Adjacent to the yard waste processing area, there are approximately 14 acres available within two (2) former borrow areas that are designated for use in the handling of debris from a natural disaster.

2.6 Convenience Center Operations

The operation of the citizen's convenience center is as follows:

The convenience center is set up with up to eight 40 yard roll-off containers and other facilities for the collection and temporary storage of MSW (small loads) and recyclables. The County currently typically collects the following materials for recycling in co-mingled containers:

- Fiber (Newspaper, Cardboard, Paperboard, Mixed Residential Paper, and Office Paper);
- Glass Beverage Containers (Clear, Brown, and Green);
- Aluminum and Steel Food and Beverage Containers;
- Recyclable Rigid Plastic (#1 through #7);

The convenience center also includes collections facilities for:

- Automotive Batteries;
- Used Motor Oil and Oil Filters;
- Antifreeze;
- Consumer Electronics;
- White Goods and Scrap Metal;
- Used Tires; and
- Oyster Shells.

The list of accepted materials may change from time to time at the discretion of the County and depending on available recycling markets.

The operation of the white goods handling area (approximate size of 50-feet by 100-feet) is as follows:

- County personnel segregate materials suspected of containing chloroflourocarbon (CFC) refrigerants (i.e. refrigerators, freezers, and air conditioners containing Freon), and set aside to minimize the potential for

damage prior to CFC removal. CFC refrigerants are removed prior to loading these materials in roll-off containers.

- Other white goods and scrap metal are stockpiled or loaded directly in roll-off containers.

- Periodically the County hauls the full roll-off containers to a local salvage yard, where the white goods and scrap metal can be recycled.

Used tires are collected at the convenience center in up to three (3) tire trailers. Once one (1) or more trailers are full, the used tires are picked up by a tire recycler for recycling.

Automotive batteries are stored on pallets above a limestone pad (approximate dimensions of 15-feet by 20-feet by 1.5 to 2.0-feet thick). Typically there are at most 20 batteries stored at the site at one time.

A full time attendant looks over the both the convenience center and yard waste processing area operations. See **Figure 2** for a site plan of the convenience center.

3.0 ENVIRONMENTAL MANAGEMENT

This section reviews the overall environmental management tasks required for the successful operation of the facility. Emphasis is given to the supplemental tasks required for the lined landfill units.

3.1 Surface Water Control

As used herein, the definition of "surface water" is water which results from precipitation or site run-on that has not contacted the waste.

Proper control of surface water at the facility will accomplish the following goals:

- Minimize the potential for the discharge of pollutants to waters of the United States, including wetlands (point or non-point sources);
- Prevent the run-on of surface water into the landfill unit(s) or the active face(s);
- Prevent the run-off of surface water that has come into contact with the waste (i.e. leachate);
- Limit the erosion caused by surface waters;
- Limit sediments carried off-site by surface waters; and
- Maximize the SEPARATION of SURFACE water from LEACHATE.

Separate erosion and sedimentation control plans have been provided for the various landfill units and other site activities. These plans describe both short and long term engineered features and practices for preventing erosion and controlling sedimentation at this site. The following is a brief discussion of some of these features and practices, focusing more on the landfill units.

3.1.1 Surface Water Run-On Control

The perimeter berms and/or perimeter channels around the landfill unit(s) are designed to prevent the run-on of surface water from adjacent land into the landfill. Additional structures such as diversion berms, channels, down pipes, etc. carry surface water away from the landfill.

3.1.2 Active Face Run-Off Control

Particular care is required to ensure that surface water coming from the active face, e.g. having potential contact with the waste, is captured by the leachate collection system (LCS) and/or is allowed to percolate into the underlying waste. Only run-off from waste surfaces that have received adequate cover is not considered leachate and should be directed to the stormwater drainage system where practical.

3.1.3 Separation of Stormwater/Leachate - Lined Landfill Units

The stormwater separation system is accomplished by dividing the lined landfill unit into separate cells (or by utilizing geosynthetic rain cover) to reduce the volume of leachate generated and minimize the impoundment of stormwater within the landfill. The separation system allows stormwater in cells which have not yet received waste to be pumped out of the landfill to perimeter drainage features. During activation of a cell, the Owner will connect the cell to the LCS as discussed in **Section 2.4.3.2**.

3.1.4 Erosion Control

The serviceability of the landfill relies heavily on soil berms, barrier layers, and agricultural layers that are readily eroded by flowing water. Erosion control provisions incorporated in the landfill include the following:

- The slope of the working face should typically be no steeper than 5H:1V where practical to limit erosion of the daily/periodic cover.
- Intermediate cover that has been exposed for more than 30 days must be seeded immediately and repaired when erosion features are identified.
- Drainage breaks (diversion berms, rain gutters, etc.) are provided on the final cover to limit the flow length of run-off.
- Water collected by each drainage break is routed to stormwater drainage channels or down pipes so that the run-off volume does not accumulate going down the slope.
- The vegetative soil layer placed over the final cover must be seeded immediately.

Additional erosion control measures have been taken within the drainage channels and at points of stormwater discharge. All final cover should be inspected regularly for erosion damage and promptly repaired. Revegetation should be performed in accordance with the requirements of the applicable erosion and sedimentation control plan and/or the NC Erosion and Sedimentation Control Planning and Design Manual[2].

3.1.5 Sedimentation Control

Stormwater run-off from the landfill unit(s) is conveyed to one of the on site sediment basins and/or traps. These basins and/or traps should be inspected regularly for sediment build-up or erosion damage. The basins and/or traps should be cleaned out when sediment fills the lower half of the basin.

[2] NC Division of Land Resources (Current Update), North Carolina Erosion and Sediment Control Planning and Design Manual, NCDENR - Division of Land Resources - Land Quality Section, Raleigh, NC.

3.1.6 NPDES Requirements

The County will follow the requirements of applicable National Pollutant Discharge Elimination System (NPDES) permit requirements for the site. Requirements include periodic inspections, qualitative monitoring, and sampling of stormwater discharge points. The County will keep records of all inspections, monitoring, and sampling activities (including any test results) in the operating record.

3.2 Leachate Management - Lined Landfill Units

The leachate management system for the lined landfill units consists of the leachate collection system (LCS), the leachate transmission piping, pumps, valve boxes, valves, and the existing leachate storage lagoon.

Leachate from each lined landfill unit is collected in the leachate sumps at the low end(s) of each unit. Leachate collected in each sump is pumped to the leachate storage lagoon via a HDPE force main (except for the Phase 5 MSW landfill unit which drains via a gravity penetration and HDPE gravity main). From the storage lagoon, the leachate is pumped via force main to a County-owned wastewater treatment plant (WWTP). Refer to the appropriate permit application for a detailed discussion and details of the leachate management system for each lined landfill unit.

The County previously modified the existing leachate storage lagoon for use as an equalization basin for raw wastewater. The operation of the leachate storage lagoon/wastewater equalization basin are as described in **Section 3.2.6**.

3.2.1 Leachate Collection System (LCS)

A blanket drainage layer (either natural and/or geosynthetic drainage media) covers the liner system to collect and remove leachate draining from the waste. In addition, a large flow capacity network of perforated pipe and gravel drains is constructed in the blanket drain. The LCS is designed to remove inflow from a 25-year, 24-hour rainstorm. As such, its capacity is very large compared to that required to accommodate routine leachate generation rates once waste covers the landfill footprint.

The LCS has been designed to minimize the impact of long-term biological clogging as follows:

- Cleanouts are provided on the major perforated leachate collection pipes;
- No geotextiles will be used between the waste and the gravel columns; and
- The use of coarse aggregate around collection pipes (gravel columns)

allows hydro-washing of the pipe and aggregate to remove biological growth.

3.2.1.1 Drainage Aggregate Maintenance

The exposed surface of the drainage aggregate should be inspected monthly and after each large rain storm to check for buildup of sediment on the aggregate. Sediment buildup must be periodically removed carefully with a backhoe. Aggregate that is removed must be replaced with new clean material. Per **Section 2.4.3.2**, the Type GT-S geotextile overlying the gravel column must be removed just prior to the placement of waste over that portion of gravel column.

3.2.1.2 Collection Pipe Cleanout

Flushing and remote camera inspection of all leachate collection piping accessible with a cleanout port will be performed at time of construction and every five (5) years or earlier if an abnormal reduction in leachate production is observed. An abnormal reduction is defined as a drop in monthly leachate production of 30% or more as compared to the monthly average over the prior six (6) month period and which does not appear to be the result of a reduction in rainfall, the covering of new cell areas, etc.

The location of existing leachate collection pipe cleanout locations are shown on **Figures 3A (MSW Phase 4A), 3B (MSW Phase 5), and 3C (C&D Area 2)**. Documentation of cleaning and inspection activities for leachate collection piping will be placed in the operating record (see **Section 1.12**).

Leachate collection pipes were previously cleaned and inspected at the facility on the following dates:

- July 2009
- August 2012

No blockages or damaged piping was discovered.

3.2.1.3 Leachate Removal

As constructed, leachate is collected in one or more sumps at the low points of the landfill and is removed from the landfill via a side riser pump or through a gravity penetration. The leachate is routed to the leachate storage lagoon via a force main or gravity main.

Under normal conditions, the County will remove (via force main) leachate from the storage lagoon at a rate to maintain a water elevation having 3 feet, or greater, of freeboard (see also **Section 3.2.6**). This allows ample volume in the lagoon to handle the anticipated "surge" event caused by a design storm and minimizes the potential for ponding within the landfill. Additional draw-down of the lagoon will be performed in advance of predicted heavy rainfall (tropical storm, hurricane, etc.).

3.2.1.4 O&M of Leachate Pumps and Storage Lagoon

Operation and maintenance of leachate pumps will be in accordance with the appropriate manufacturer's recommendations. If required, the leachate storage lagoon may require cleanout of sediment and/or maintenance of aerators. The County Solid Waste Director or his designee will be responsible for following and documenting, as required, these activities.

3.2.2 Leak Detection System - Phase 4A MSW Landfill Unit

A leak detection system (LDS) has been incorporated into the design of the Phase 4A MSW landfill unit. The purpose of the LDS is to provide rapid detection of a major breach in the primary liner system and to limit the head on the secondary liner to less than the thickness of the LDS.

For Phase 4A, the LDS consists of a layer of drainage geocomposite directly overlying the secondary LLDPE geomembrane and a series of four leak detection trenches. Flow that is collected in the leak detection trenches is routed through 4 inch diameter HDPE piping to a pump station. The LDS pump station consists of a prefabricated HDPE manhole, valves, and submersible pumps. Leachate collected in the LDS pump station will be pumped to the existing leachate storage lagoon via the same force main as leachate collected in the LCS described above.

The LDS has been designed with an Action Leakage Rate (ALR) of 3,000 gallons per day. Should leakage collected in the LDS exceed the ALR based on routine flowmeter readings from the LDS pump station, the County will take steps (placement of soil cover, tarps, etc.) to limit leachate generation from in-place waste.

3.2.3 Leachate Quality Sampling

Semi-annual leachate quality sampling and analysis will be performed during operation of the lined landfill units. Samples will be recovered as grab samples from the following locations:

- MSW Phase 5: Sample from existing gravity line in leachate manhole;
- MSW Phase 4A (Leachate Collection System): Sample from side risers;
- MSW Phase 4A (Leak Detection System): Sample from leak detection pump station; and
- C&D Area 2: Sample from side risers.

The parameters to be analyzed will be as required by the current water quality monitoring plan(s).

3.2.4 Record Keeping

Accurate records for the following will be maintained at the landfill in accordance with **Section 1.12**.

Leachate Generation (Monthly):

MSW Phase 5 (Flowmeter along gravity main);
MSW Phase 4A (Leachate collection system flowmeter);
MSW Phase 4A (Leak detection system pump station flowmeter); and
C&D Area 2 (Leachate collection system flowmeter).

Leachate Quality (Semi-Annual):

MSW Phase 5;
MSW Phase 4A (Leachate Collection System);
MSW Phase 4A (Leak Detection System); and
C&D Area 2.

3.2.5 Leachate Contingency Plan

In the unlikely event that leachate levels within the existing leachate storage lagoon approach the freeboard capacity, due to unforeseen events, the DWM will be verbally notified (see **Section 1.1.2**) and the leachate flow will be valved off and temporarily stored in the landfill until the level of leachate in the lagoon can be lowered by pumping to the WWTP. Written documentation describing the unforeseen events, the actions carried out to remove the stored leachate, and a strategy for preventing future occurrences will be provided to the DWM within 30 days following any such occurrence.

3.2.6 Operation of Leachate Lagoon/Wastewater Equalization Basin

The existing leachate storage lagoon (pond) has an approximate capacity of 4.2M gallons with 2 feet of freeboard. Due to the large size of the pond relative to typical leachate generation at the site (between 1.26M and 3.05M gallons per year

based on 2004 and 2005 data), the County previously modified the storage lagoon for use as an equalization basin for raw wastewater.

Under normal conditions, the County will remove (via force main) leachate/wastewater from the storage lagoon at a rate to maintain a water elevation having 3 feet, or greater, of freeboard. This will provide a volume of at least 1 foot (approximately 650,000 gallons) below the required 2 feet of freeboard under typical conditions. This capacity is much greater than the anticipated surge volume from a newly operational landfill unit. Additionally, considering the very large pumping capacity (two 1,300 GPM pumps) of the existing raw sewage pump station which is connected to the lagoon, the ability to handle leachate generation at the site is very high.

The operation of the leachate storage lagoon as an equalization basin will not affect the County's ability to draw-down the basin in advance of predicted heavy rainfall (tropical storm, hurricane, etc.).

3.3 Water Quality Monitoring

The monitoring program and procedures outlined in the current water quality monitoring plan(s) will be followed for the monitoring of site groundwater monitoring wells and surface water monitoring locations. Documentation of the water quality monitoring program will be placed in the facility operating record as described in Section 1.12.

3.4 Landfill Gas (LFG) Management

3.4.1 MSW Landfill Units

A landfill gas (LFG) management system is included as part of the design of the MSW landfill units. Refer to the appropriate permit application for a detailed discussion and details of the LFG management system for each landfill unit.

In general, the existing active LFG collection system consists of vertical extraction wells, horizontal collectors, and connections to leachate cleanouts, header piping, a blower/flare station, and an electrical generation facility. The system is owned and operated by Carbon Infrastructure Investment Methane Management IV, LLC. under agreement with the County.

As the operation and maintenance of this system involves contact with explosive gases, operational staff involved with the operation and maintenance of this system should be specifically trained in the management and response for situations such as fire or explosion, confined space, drilling, and overhead hazards, or any other mechanical hazards addressed by the equipment Manufacturer's literature. Although this manual does not address the operation

of the LFG management system, reference is made to the Landfill Gas Operation and Maintenance Manual of Practice prepared by the Solid Waste Association of North America (SWANA)[3], which provides a general body of knowledge concerning the operation and maintenance of these systems.

3.4.2 C&D Landfill Unit

Landfill gas (LFG) generated from the C&D landfill unit will be vented using passive vents placed at the time of closure. Refer to the appropriate permit application for details of these vents.

3.5 Landfill Gas (LFG) Monitoring Plan

The County will implement a routine landfill gas (LFG) monitoring program to ensure that methane concentrations do not exceed 25 percent of the lower explosive limit (LEL) (1.25% methane (CH_4)) in facility structures, or 100 percent of the LEL (5% CH_4) at property boundaries. LFG monitoring activities and remedial actions for concentrations exceeding these requirements will be in accordance with the current landfill gas monitoring plan(s) for the facility.

3.5.1 Record Keeping

Results of LFG monitoring and description of any remedial measures will be placed in the facility operating record as described in **Section 1.12**.

3.6 Vector Control

3.6.1 MSW Landfill Units

Control of insects, rodents, and birds will be accomplished by compaction of the waste and the use of daily cover. If vector control becomes a problem, additional measures will be taken to ensure the protection of human health.

3.6.2 C&D Landfill Unit

Due to the nature of the waste disposed in this landfill unit, vector control is not anticipated to be of concern. Note that the use of periodic cover will discourage animals from nesting in the waste.

[3] SWANA (1997), Landfill Gas Operation and Maintenance Manual of Practice, SR-430-23070, Solid Waste Association of North America, Silver Spring, MD, March 1997.

3.7 Litter Control

The vegetative trees/bushes act as a barrier to keep litter contained within the site and a litter control crew will pick up litter around the site and on access roads daily as necessary. Wind screens adjacent to active areas may be used as practical to control windblown waste. Additionally, facility staff will make operational changes as practical based on wind conditions that may spread litter.

3.8 Odor Control

3.8.1 MSW Landfill Units

Odorous or potentially odorous materials will be covered as soon as possible to avoid odor problems. If odor control becomes a problem, additional measures will be taken to ensure odor control.

3.8.2 C&D Landfill Unit

Due to the nature of the waste disposed in this landfill unit, odor control is not anticipated to be of concern. However, if odor control becomes a problem, additional measures (such as additional cover over wastes such as drywall) will be taken to ensure odor control.

3.9 Dust Control

Dust related to waste hauler traffic on the access roads will be minimized by using a water truck to limit dust on the gravel portions of site roads. The County has approval for use of reclaimed wastewater for this purpose (see **Appendix E** for County training information related to the use of reclaimed wastewater). Dust generated by excavation of cover soil will be limited by watering the cut soil areas if accessible to the water truck.

3.10 Air Quality

The County will follow all air quality requirements which are applicable to the landfill facility.

3.11 Leachate Seeps

Leachate seeps can occur due to a variety of circumstances. The goal in dealing with leachate seeps is to prevent seepage from leaving the limits of waste disposal areas and to minimize the potential for reoccurrence. If evidence of leachate seeps is observed, the County will take the following actions. Depending on the circumstances, various combinations of actions may be appropriate.

1. If leachate is observed outside of the limits of waste disposal areas, notify the DWM (see **Section 1.1.2**).
2. Contain the flow of leachate using soil berms and/or excavation.
3. Excavate the area of seepage to attempt to allow flow into the underlying waste (i.e. break-up soil layers that may be causing the seep.).
4. For contained leachate that will not flow into underlying waste, a pump may be required to route the leachate to an existing leachate collection system cleanout pipe (lined landfill units) or to a tanker truck.
5. For lined landfill units, french drains may be utilized for routing the seepage to the leachate collection system (via cleanout pipes).
6. The use of soil (particularly clay) to plug the seepage may also be successful in the case where flows are minor.
7. Remove and dispose of impacted cover soils accordingly.
8. Repair landfill cover as necessary.

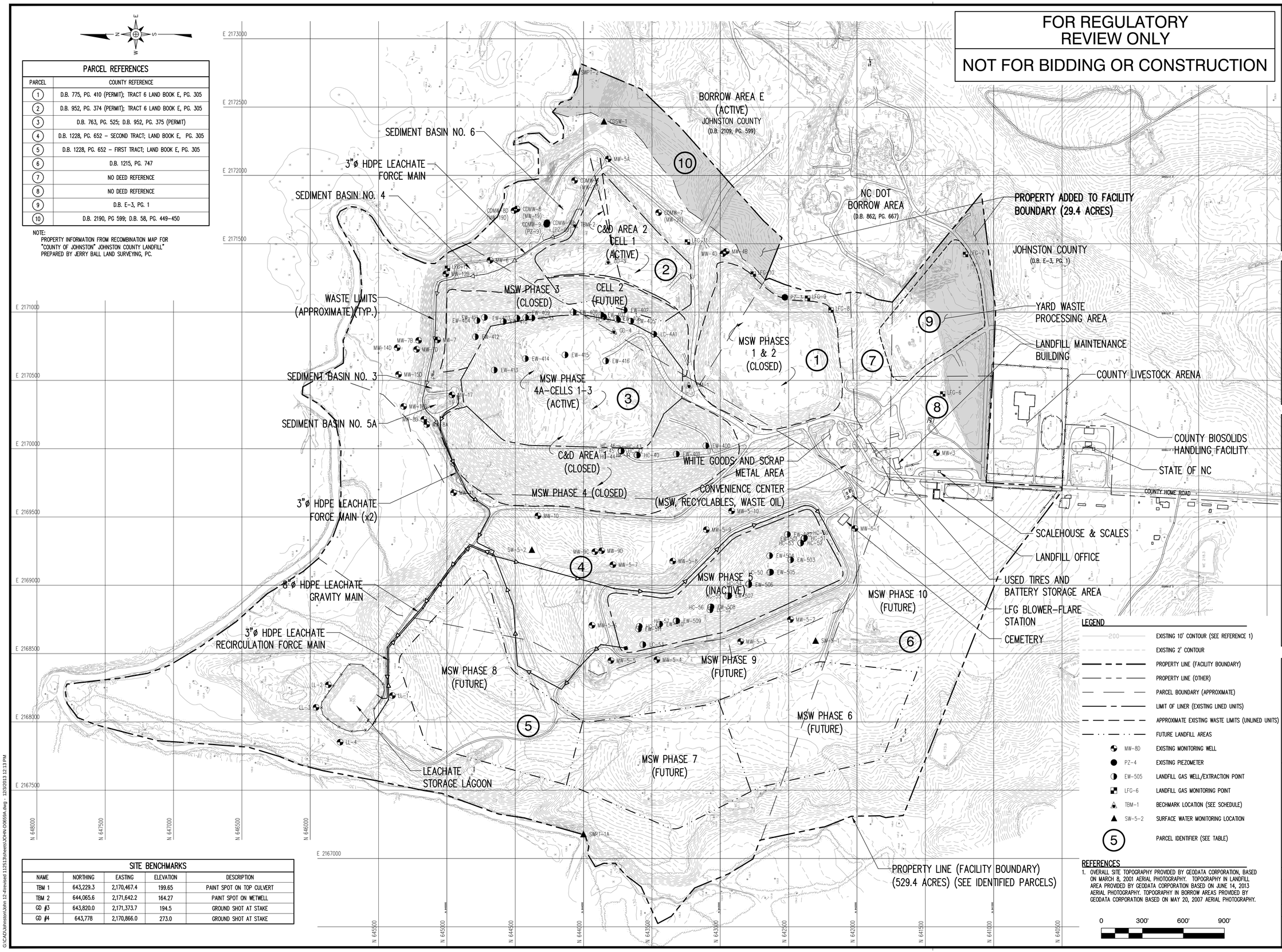
French drains have been installed previously on the northern slope of the active Phase 4A MSW landfill unit and the northeast slope of the inactive Phase 5 MSW landfill unit (both are lined units). These drains are connected to existing leachate cleanout pipes. Additionally, there is a seep collection system and pump station located at the north end of the closed unlined Phase 4 MSW landfill unit which includes collection drains located near Sediment Basins 2 and 5A. Flow from leachate seeps captured by the system is pumped to the leachate storage lagoon.

FOR REGULATORY REVIEW ONLY

NOT FOR BIDDING OR CONSTRUCTION

PARCEL REFERENCES	
PARCEL	COUNTY REFERENCE
1	D.B. 775, PG. 410 (PERMIT); TRACT 6 LAND BOOK E, PG. 305
2	D.B. 952, PG. 374 (PERMIT); TRACT 6 LAND BOOK E, PG. 305
3	D.B. 763, PG. 525; D.B. 952, PG. 375 (PERMIT)
4	D.B. 1228, PG. 652 – SECOND TRACT; LAND BOOK E, PG. 305
5	D.B. 1228, PG. 652 – FIRST TRACT; LAND BOOK E, PG. 305
6	D.B. 1215, PG. 747
7	NO DEED REFERENCE
8	NO DEED REFERENCE
9	D.B. E-3, PG. 1
10	D.B. 2190, PG 599; D.B. 58, PG. 449-450

NOTE:
PROPERTY INFORMATION FROM RECOMBINATION MAP FOR "COUNTY OF JOHNSTON" JOHNSTON COUNTY LANDFILL" PREPARED BY JERRY BALL LAND SURVEYING, PC.



SITE BENCHMARKS				
NAME	NORTHING	EASTING	ELEVATION	DESCRIPTION
TBM 1	643,229.3	2,170,467.4	199.65	PAINT SPOT ON TOP CULVERT
TBM 2	644,065.6	2,171,642.2	164.27	PAINT SPOT ON WETWELL
GD #3	643,820.0	2,171,373.7	194.5	GROUND SHOT AT STAKE
GD #4	643,778	2,170,866.0	273.0	GROUND SHOT AT STAKE

PREPARED FOR:

JOHNSTON COUNTY NORTH CAROLINA DEPARTMENT OF PUBLIC UTILITIES

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+ GARDNER ENGINEERS

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

SEAL

SEAL

REV.	DATE	DESCRIPTION
1	12/4/13	NEW PROPERTY SURVEY

PROJECT TITLE:

JOHNSTON COUNTY LANDFILL

DRAWING TITLE:

EXISTING AND PROPOSED LANDFILL UNITS AND SOLID WASTE MANAGEMENT ACTIVITIES

DESIGNED: P.K.S.	PROJECT NO: JOHN 12-4
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED:	DATE: AUG. 2012
FILENAME: JOHN-D0659A	
SHEET NUMBER:	DRAWING NUMBER: FIG.1

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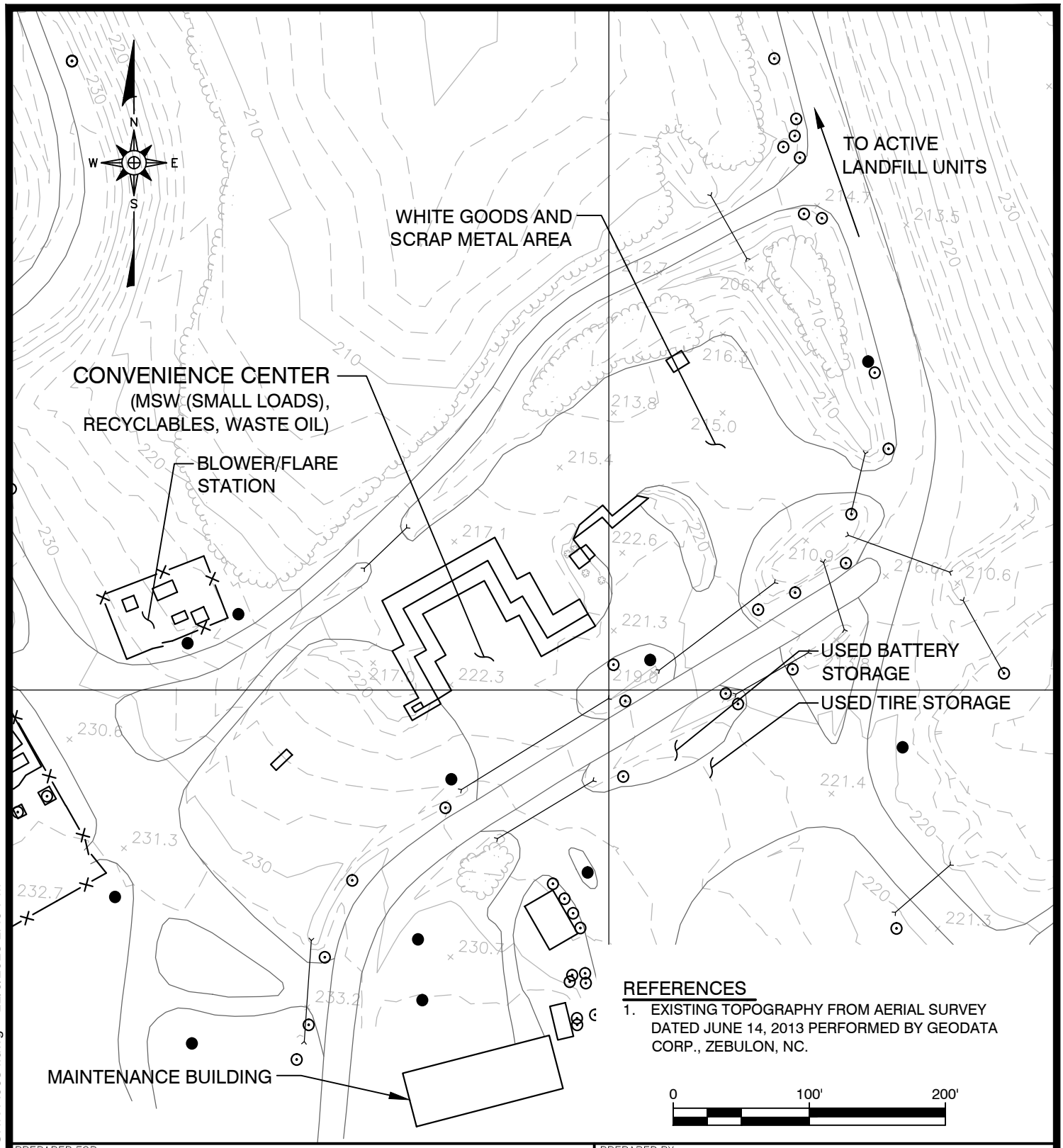

REFERENCES

1. EXISTING TOPOGRAPHY FROM AERIAL SURVEY DATED JUNE 14, 2013 PERFORMED BY GEODATA CORP., ZEBULON, NC.

PREPARED FOR:

CONVENIENCE CENTER SITE PLAN

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

DRAWN:	APPROVED:	SCALE:	DATE:	PROJECT NO.:	FIGURE NO.:	FILE NAME:
J.A.L.	P.K.S.	AS SHOWN	Dec 2013	JOHN13-4	2	JOHN-A0684

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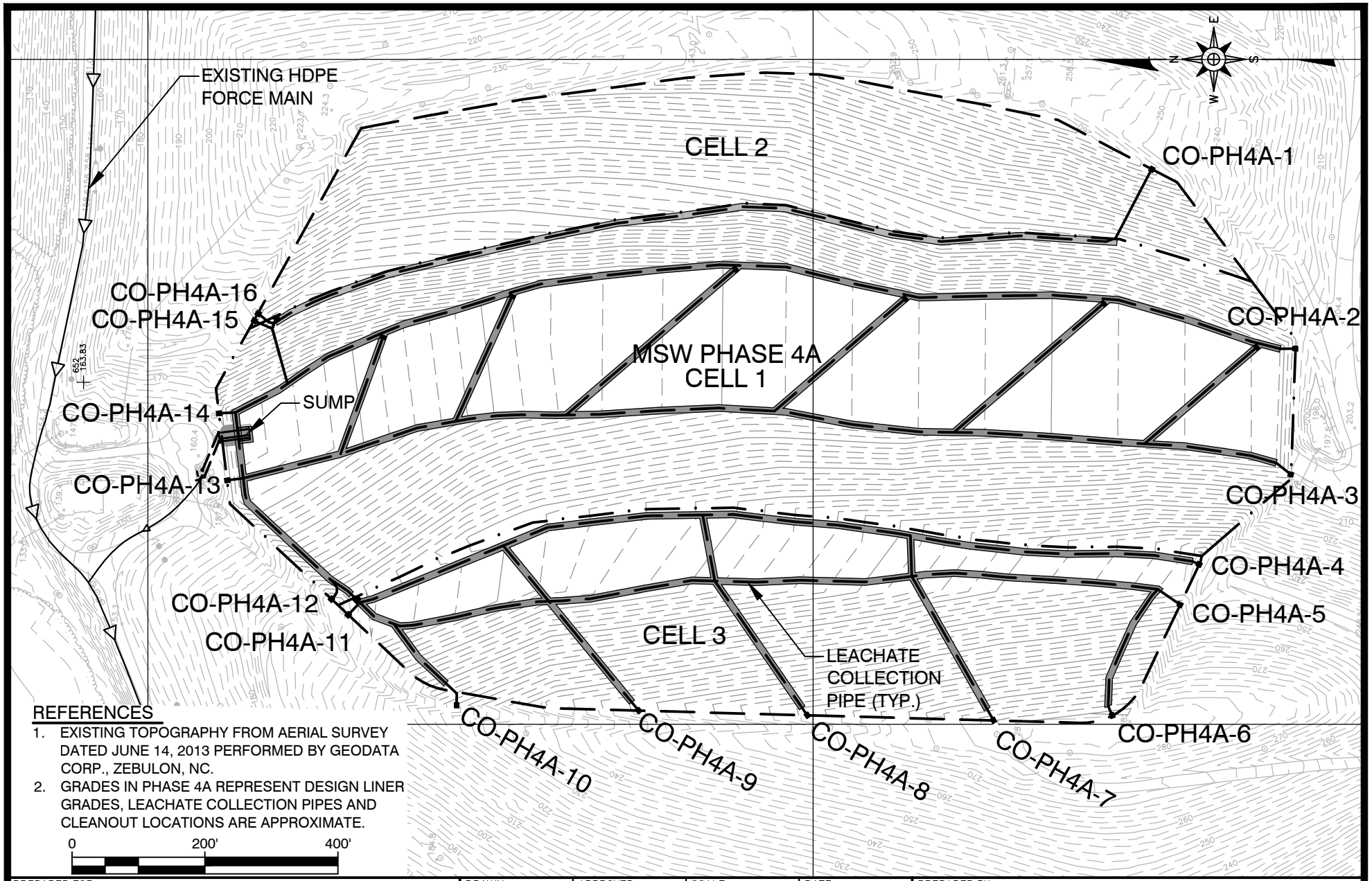

REFERENCES

1. EXISTING TOPOGRAPHY FROM AERIAL SURVEY DATED JUNE 14, 2013 PERFORMED BY GEODATA CORP., ZEBULON, NC.
2. GRADES IN PHASE 4A REPRESENT DESIGN LINER GRADES, LEACHATE COLLECTION PIPES AND CLEANOUT LOCATIONS ARE APPROXIMATE.

0 200' 400'

PREPARED FOR:

LEACHATE COLLECTION PIPE CLEANOUT LOCATIONS
MSW PHASE 4A

DRAWN:	APPROVED:	SCALE:	DATE:
J.A.L.	P.K.S.	AS SHOWN	Dec 2013

PROJECT NO.:	FIGURE NO.:	FILENAME:
JOHN 13-4	3A	JOHN-A0682

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

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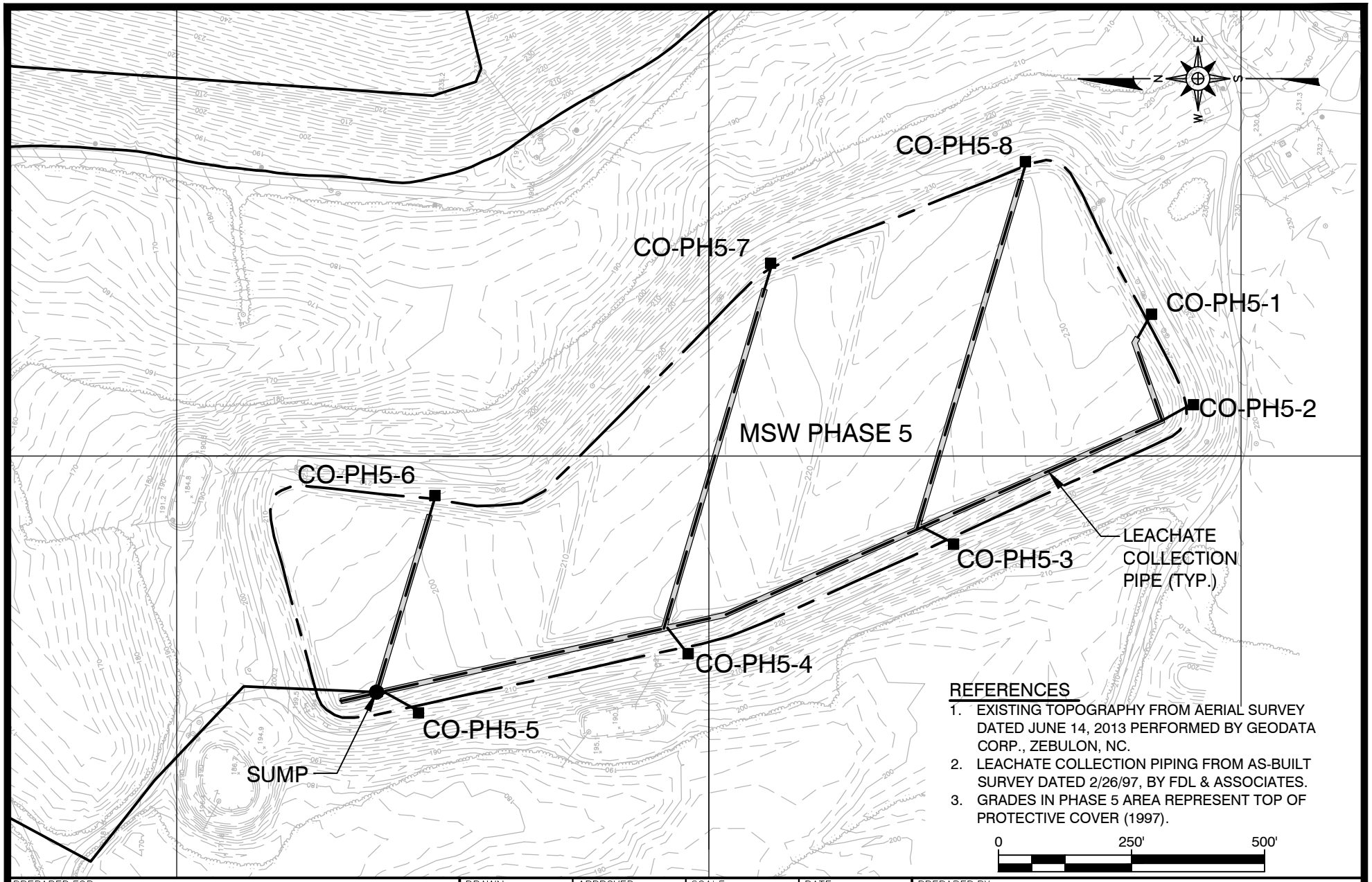

REFERENCES

1. EXISTING TOPOGRAPHY FROM AERIAL SURVEY DATED JUNE 14, 2013 PERFORMED BY GEODATA CORP., ZEBULON, NC.
2. LEACHATE COLLECTION PIPING FROM AS-BUILT SURVEY DATED 2/26/97, BY FDL & ASSOCIATES.
3. GRADES IN PHASE 5 AREA REPRESENT TOP OF PROTECTIVE COVER (1997).

PREPARED FOR:

LEACHATE COLLECTION PIPE CLEANOUT LOCATIONS
MSW PHASE 5

DRAWN:	APPROVED:	SCALE:	DATE:
J.A.L.	P.K.S.	AS SHOWN	Dec 2013

PROJECT NO.:	FIGURE NO.:	FILENAME:
JOHN 13-4	3B	JOHN-A0683

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

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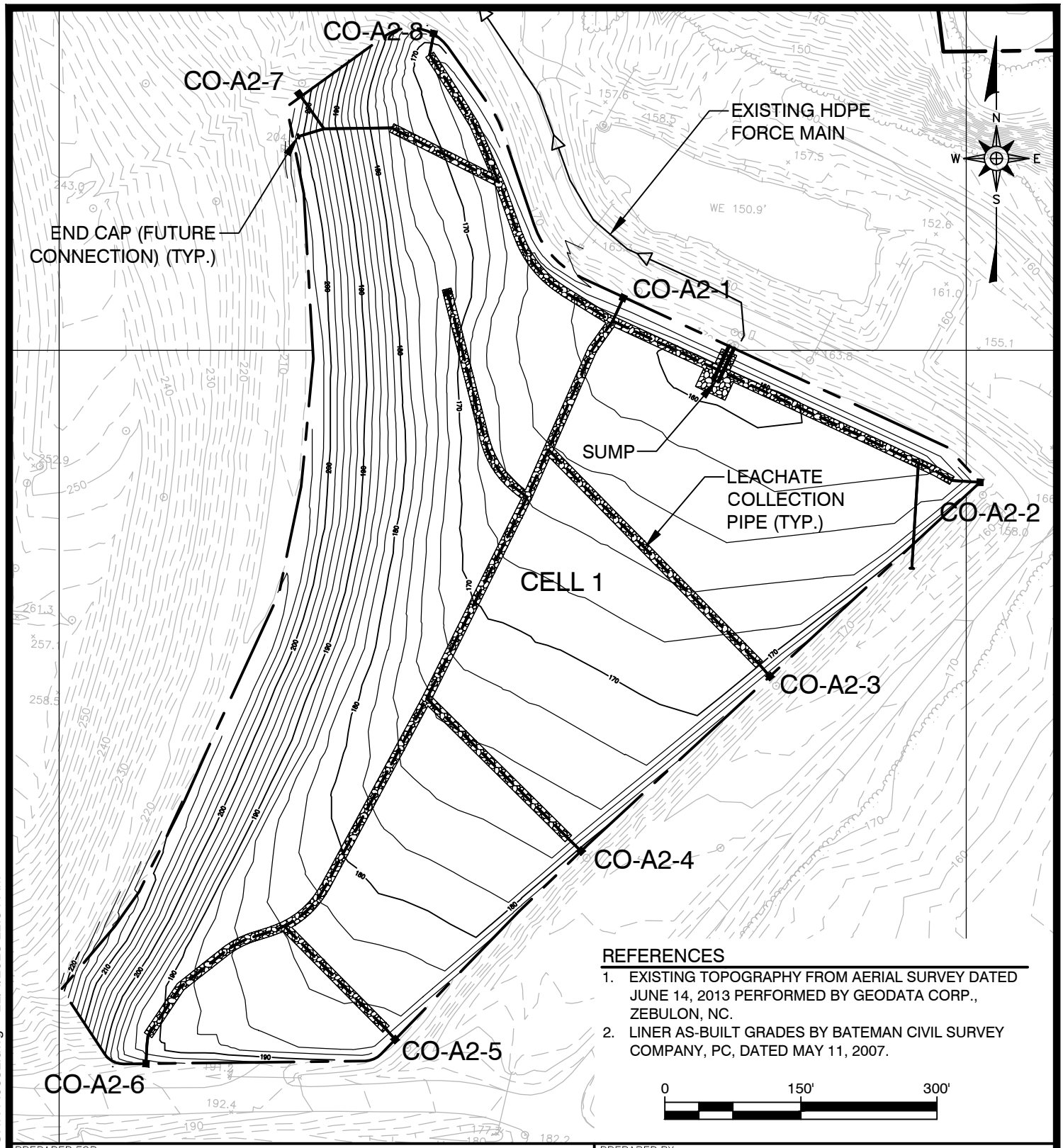

REFERENCES

1. EXISTING TOPOGRAPHY FROM AERIAL SURVEY DATED JUNE 14, 2013 PERFORMED BY GEODATA CORP., ZEBULON, NC.
2. LINER AS-BUILT GRADES BY BATEMAN CIVIL SURVEY COMPANY, PC, DATED MAY 11, 2007.

0 150' 300'

PREPARED FOR:

LEACHATE COLLECTION PIPE CLEANOUT LOCATIONS
C&D AREA 2

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

DRAWN:	APPROVED:	SCALE:	DATE:	PROJECT NO.:	FIGURE NO.:	FILE NAME:
J.A.L.	P.K.S.	AS SHOWN	Dec 2013	JOHN 13-4	3C	JOHN-A0681

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Appendix A

Fire Occurrence Notification Form

Operations Manual
Johnston County Landfill Facility
Smithfield, North Carolina

SOLID WASTE MANAGEMENT FACILITY
FIRE OCCURRENCE NOTIFICATION
NC DENR Division of Waste Management
Solid Waste Section

Notify the Section verbally within 24 hours and submit written notification within 15 days of the occurrence.
(If additional space is needed, use back of this form.)

NAME OF FACILITY: _____ PERMIT # _____

DATE AND TIME OF FIRE: _____ @ _____

HOW WAS THE FIRE REPORTED AND BY WHOM:

LIST ACTIONS TAKEN:

WHAT WAS THE CAUSE OF THE FIRE:

DESCRIBE AREA, TYPE, AND AMOUNT OF WASTE INVOLVED:

WHAT COULD HAVE BEEN DONE TO PREVENT THIS FIRE:

DESCRIBE PLAN OF ACTIONS TO PREVENT FUTURE INCIDENTS:

NAME: _____ TITLE: _____ DATE: _____

****

THIS SECTION TO BE COMPLETED BY SOLID WASTE SECTION REGIONAL STAFF

DATE RECEIVED _____

List any factors not listed that might have contributed to the fire or that might prevent occurrence of future fires:

_____

FOLLOW-UP REQUIRED:

☐ NO ☐ PHONE CALL ☐ SUBMITTAL ☐ MEETING ☐ RETURN VISIT BY:_____ (DATE)

ACTIONS TAKEN OR REQUIRED:

Revised 6/8/09

Appendix B

Paint Filter Liquids Test

Operations Manual
Johnston County Landfill Facility
Smithfield, North Carolina

METHOD 9095
PAINT FILTER LIQUIDS TEST
From EPA SW-846

1.0 Scope and Application

1.1 This method is used to determine the presence of free liquids in a representative sample of waste.

1.2 The method is used to determine compliance with 40 CFR 264.314 and 265.314.

2.0 Summary of Method

2.1 A predetermined amount of material is placed in a paint filter. If any portion of the material passes through and drops from the filter within the 5 minute test period, the material is deemed to contain free liquids.

3.0 Interferences

3.1 Filter media were observed to separate from the filter cone on exposure to alkaline materials. This development causes no problem if the sample is not disturbed.

4.0 Apparatus and Materials

4.1 Conical paint filter: Mesh number 60 (fine meshed size). Available at local paint stores such as Sherwin-Williams and Glidden for an approximate cost of $0.07 each.

4.2 Glass funnel: If the paint filter, with the waste, cannot sustain its weight on the ring stand, then a fluted glass funnel or glass funnel with a mouth large enough to allow at least 1 inch of the filter mesh to protrude should be used to support the filter. The funnel is to be fluted or have a large open mouth in order to support the paint filter yet not interfere with the movement, to the graduated cylinder, of the liquid that passes through the filter mesh.

4.3 Ring stand and ring or tripod.

4.4 Graduated cylinder or beaker: 100-mL.

5.0 Reagents

5.1 None.

6.0 Sample Collection, Preservation, and Handling

6.1 All samples must be collected according to the directions in Chapter Nine of EPA SW-846.

6.2 A 100 mL or 100 g representative sample is required for the test. If it is not possible to obtain a sample of 100 mL or 100 g that is sufficiently representative of the waste, the analyst may use larger size samples in multiples of 100 mL or 100 g, i.e., 200, 300, 400 mL or g. However, when larger samples are used, analysts shall divide the sample into 100-mL or 100-g portions and test each portion separately. If any portion contains free liquids, the entire sample is considered to have free liquids.

7.0 Procedure

7.1 Assemble test apparatus as shown in Figure 1.

7.2 Place sample in the filter. A funnel may be used to provide support for the paint filter.

7.3 Allow sample to drain for 5 minutes into the graduated cylinder.

7.4 If any portion of the test material collects in the graduated cylinder in the 5-min. period, then the material is deemed to contain free liquids for purposes of 40 CFR 264.314 and 265.314.

8.0 Quality Control

8.1 Duplicate samples should be analyzed on a routine basis.

9.0 Method Performance

9.1 No data provided.

10.0 References

10.1 None required.

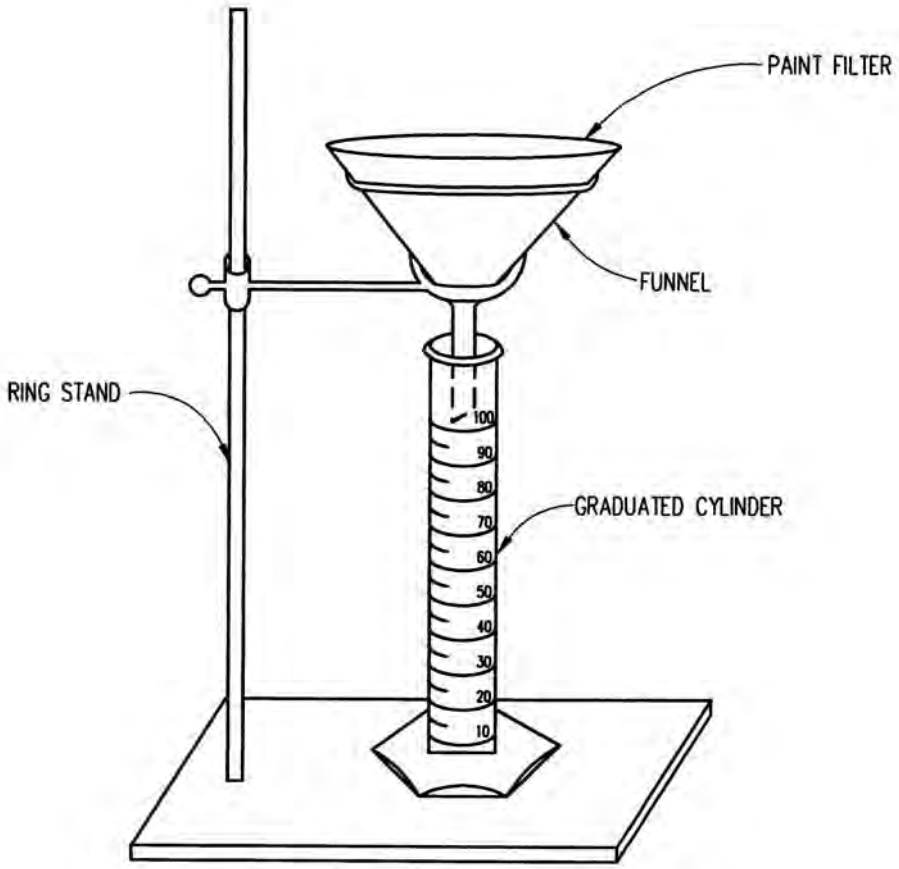
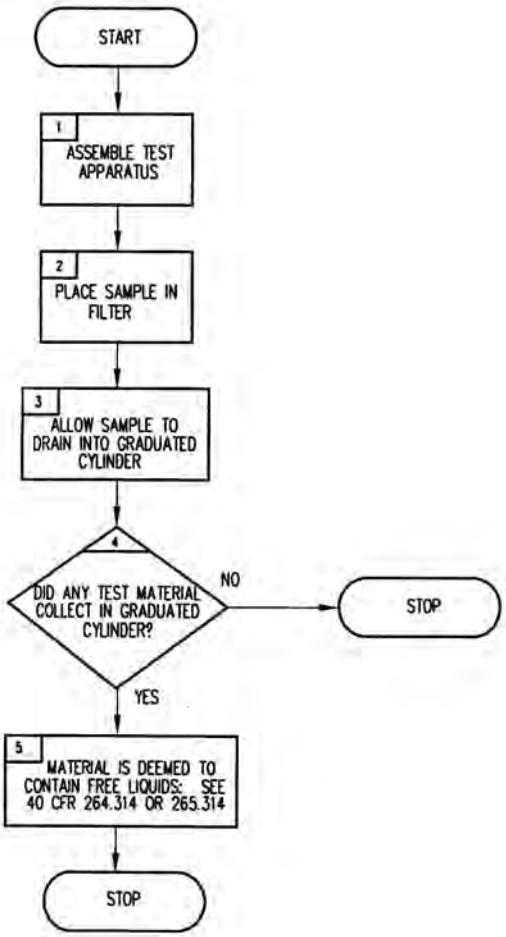


FIGURE 1. PAINT FILTER TEST APPARATUS.

METHOD 9095
PAINT FILTER LIQUIDS TEST



Appendix C

Waste Screening Form

Operations Manual
Johnston County Landfill Facility
Smithfield, North Carolina

Johnston County
Department Of Public Utilities
Solid Waste Division
P.O. Box 2263- 680 County Home Rd.
Smithfield, NC 27577

MSW / C & D / YW

Waste Load Screening Record

1. Date: September _____, 2013 Time: _____
2. Vehicle Owner:_____ Driver's Name:_____
3. Vehicle (Company) ID #: _____ Net Weight: _____lbs.
   Ticket#:_____
4. *WASTE GENERATOR:* _____
5. Purpose of inspection (circle one): Random * Concern at Scale House *
   Concern at Landfill * Quality Control * Suspect Load
6. Description of Waste Load: _____ _____
   _____ _____
   _____ _____
7. Does the load contain a *Special Waste* which has been profiled and approved? _____

   If yes, is it representative of the Waste Profile? _____

   If no, explain: _____
8. Waste Load accepted / not accepted (Signature): _____

Complete this section if waste is not accepted)

Suspect Waste:

Physical Appearance: _____ Odor: _____
Container Labels or Markings: _____Amount:_____
Comments (use an additional sheet of paper if necessary):
_____
_____
_____

Johnston County Division Manager Contacted: _____ Time:_____

Name of Waste Hauler's Representative Contacted:_____Time:_____
Waste Hauler's phone number:_____ Fax number:_____
Comments (use additional sheet of paper if necessary):_____
_____
_____

If waste was determined to be hazardous, what was its final disposition? _____
_____
_____

Signature of Johnston County Official:_____ Date:_____

Appendix D

Cell Activation Forms

Operations Manual
Johnston County Landfill Facility
Smithfield, North Carolina

JOHNSTON COUNTY MSW LANDFILL - PHASE 4A
CELL ACTIVATION FORM

Date: _____

Cell: _____

Size of Geosynthetic Rain Cover Removed (Length/Width): _____

Length of Type GT-S Geotextile Removed from Gravel Column(s): _____

Remarks: _____
_____
_____
_____
_____
_____
_____

Signed: _____

Sketch:

JOHNSTON COUNTY C&D LANDFILL - AREA 2
CELL ACTIVATION FORM

Date: _____

Cell: _____

Size of Geosynthetic Rain Cover Removed (Length/Width): _____

Length of Type GT-S Geotextile Removed from Gravel Column(s): _____

Remarks: _____
_____
_____
_____
_____
_____
_____

Signed: _____

Sketch:

Appendix E

Reclaimed Wastewater Training Information

Operations Manual
Johnston County Landfill Facility
Smithfield, North Carolina

Reclaimed Water Training for Customers and Reclaimed Water Equipment Operators

Johnston County
Department of Public Utilities

Training Requirements

- Statutory/Permit Guidelines and Requirements
- Water Quality Limits
- Facility Operation
- Spill Prevention/Response
- Information Contacts

Who Should be Trained

- Anyone operating reclaimed water equipment
- Anyone receiving reclaimed water
- Anyone hauling reclaimed water
- Anyone utilizing reclaimed water

Training is required prior to performing any duties associated with distribution of reclaimed water

Training Overview

- Reclaimed Water Information Sheet
- Spill Prevention
- Spill Response
- Enforcement
- Emergency Contact Information
- Truck Inspection/Approval
- Facility Operations

End User Information Form

Form must be completed and turned in to class instructor prior to receiving class certification card

Johnston County Public Utility Department
Reclaimed Water
End User/Firm Information

Legal Name or Business Name:

Responsible Person of Firm:

Physical Address:

Mailing Address:

Phone:

Cell Phone:

Email Address:

Reclaimed Water Information Sheet

Reclaimed Water Information Sheet

- Reclaimed Water Sources
  - Wastewater that has been treated to a high standard at either at the Central Johnston County Regional Wastewater Treatment Plant

Water Quality

Although reclaimed water quality is maintained at a high level, it is not intended for human or animal consumption.

Do Not Drink!!!!!!

Reclaimed Water Compliance Limits

Water Quality Constituent	Daily Maximum Limit	Monthly Average Limit	Continuous Monitoring Limit
TSS, mg/l	10	5	-
Fecal Coliform	25/100 ml	14/100 ml	-
BOD5, mg/l	15	10	-
NH3, mg/l	6	4	-
Turbidity, NTU	-	-	10

These water quality permit limits have been established by statutory regulation as that which will provide for protection of public health and environment.

Approved Applications

- Irrigation (residential lawns, golf courses, parks, landscape areas, and other public, industrial, or commercial grounds, agriculture)
- Vehicle washing at construction sites
- Dust control for street sweeping
- Sewer line flushing
- Aesthetic purposes (decorative ponds and fountains)
- Fire fighting and fire extinguishing
- Cooling water for industrial operations

Approved Applications

- General construction purposes (Non-potable)
  - Directional Drilling
  - Dust control
  - Soil compaction
- Power washing exterior of structures and vehicles
- Commercial car wash facilities
- Pressure and operational testing of sanitary force mains and sewers
- Any other uses subsequently approved by JCPUD and DWQ

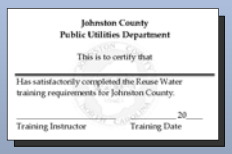
Forbidden Applications

- Direct irrigation of food crops that will <u>not</u> be peeled, skinned, cooked or thermally processed.
- Household use
- Swimming pools, hot tubs or similar uses
- Raw potable water supply for humans or animals
- Discharge into storm sewers, ditches or surface waters
- Ponds for swimming or fishing or other human use

Requirements

Reclaimed Water Requirements

Reclaimed Water Requirements


Johnston County
Public Utilities Department

This is to certify that

Has satisfactorily completed the Reuse Water training requirements for Johnston County.

Training Instructor Training Date 20

All reclaimed water customer and equipment operators shall satisfactory complete a Johnston County reclaimed water training class and possess a certification card before they receive reclaimed water. You must have this card with you to receive reclaimed water.

Reclaimed Water Load Form

JOHNSTON COUNTY PUBLIC UTILITY DEPARTMENT
LANDFILL AND WASTEWATER TREATMENT PLANT
Reuse Water Load Form

At the time of loading customer must provide the address of each site where the reclaimed water will be utilized. This will be recorded on the Reclaimed Water Load form

Reclaimed Water Load Form

Information Captured

- Date and time loaded
- Weather Code
- Quantity of reclaimed water loaded
- Customer signature and printed name
- Turbidity (recent effluent reading)
- Chlorine added or residual
- Operator initials

Requirements

- Any reclaimed water not used within 72 hours must be returned to the Central Johnston County Regional WWTP Septage Receiving Station for disposal
- Proper signage must be displayed during application
- Public access must be controlled during application
- Verify reclaimed water does not runoff the approved application site

Buffers Requirements

- For Irrigation:
  - 100 feet from all Wells
  - 25 feet from any surface waters, including wetlands, or any swimming pool
- For Storage:
  - 100 feet from all Wells
  - 50 feet from any surface waters, including wetlands
  - 50 feet from property lines

Reclaimed Water Requirements (continued)

- Ponds and decorative fountains or similar uses
  - No drain or outlet that allows reclaimed water to enter any storm drain or surface water allowed
  - County inspection required within 48 hours to confirm requirement met
- Ponds or fountains filled with reclaimed water must maintain signage in permanent location that states: REUSE WATER – DO NOT DRINK

Reclaimed Water Requirements (continued)

- For further information of reuse water, contact the Johnston County Public Utilities Department at (919) 989-5057
- All spills or discharges must be reported to the Johnston County Public Utilities Dept. immediately.

Spill Prevention

- Apply in manner to prevent spillage
- Apply such that runoff or ponding does not occur
- Customer to remain on-site until all water is absorbed into soil
- No application of water during Inclement Weather, I.E., Rain Storms or Freezing Conditions.

Spill Response

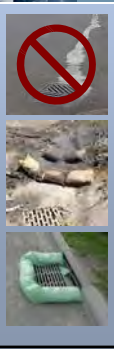
If ponding or runoff occurs and is confined to an acceptable location

- Cease application immediately
- Customer to remain on-site until absorbed into soil
- Display appropriate signage to signify presence of reclaimed water

Spill Response

- If ponding or runoff occurs and NOT confined to acceptable location
  - Cease application immediately
  - Customer to report spill to emergency contacts listed on Reclaimed Water Information Sheet
  - Display appropriate signage to signify presence of reclaimed water

Spill Response



If spill occurs on impermeable surface (sidewalks, driveways, roads, cement, asphalt) which would allow flow to nearby storm drain or catch basin

- Cease application immediately
- Block storm drain to prevent flow from entering until reclaimed water is moved or evaporated
- Customer to remain onsite until spill remedied or Johnston County personnel arrive to determine best remedy
- Report spill to Johnston County Public Utility Department
- County to report spill to NCDENR per permit requirements

Reclaimed Water Information Sheet

- A copy of the Reclaimed Water Information Sheet MUST be kept in the vehicle while reuse water is being hauled or applied
- This sheet is provided for general information and for you to use if you encounter questions from the general public

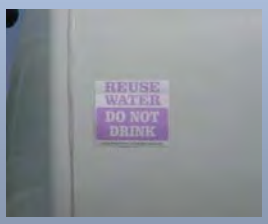
Safe Use

- Although the reclaimed water quality is maintained at a high level, it is NOT intended for human or animal consumption!!!
- Try to limit contact/exposure with reclaimed water
- For personal safety thoroughly wash hands with soap and water after contact with reclaimed water

Truck Inspection and Approval

Tanker Truck Requirements

- Must have required signage



Display tank size on truck or tank

Tank size should be displayed and visible to the load station operator

Transporting Requirements

- No transporting potable water (for potable water purposes) in reclaimed water trucks
- No filling with on board piping or removable hoses - only Johnston County hoses and equipment used for filling.
- No transporting septage, raw wastewater, or residuals in reclaimed water truck
- No removable container or portable bladder unless permanently labeled for reclaimed water

Tanker Truck Requirements

- If a removable tank or bladder is used to transport reclaimed water:
  - It must be permanently labeled for Non-Potable Water use only
  - It must have a Johnston County REUSE WATER DO NOT DRINK sticker on it
  - Owner must submit a letter to Johnston County that states that in no case shall the tank or bladder be used for both potable and non-potable water

Enforcement

- Violations (training, permit, regulations)
  - Retake training (required)
  - Repeated violations will result in revocation from approved list of drivers for a period of time between 6 months and permanent revocation, to be determined by the Johnston County staff

Enforcement (cont.)

- Citations: each day is a separate violation
- Civil penalties
  - $100 1st violation
  - $250 2nd violation
  - $500 3rd violation
- Criminal penalties
  - In addition to or in lieu of civil penalties
  - Class 3 misdemeanor ($500 and/or up o 30 days incarceration)

Information/Emergency Contact

Dan Wall, Wastewater Facility Manager
Mobile: (919) 795-1889, Work: (919) 938-4730
Address: WWTP East Huntley Street, Smithfield, NC 27577

William Denton, WWTP Supervisor
Mobile: (919) 427-7119, Work: (919) 938-4730
Address: WWTP East Huntley Street, Smithfield, NC 27577

Ben Creech, Wastewater Reuse Technician
Mobile: (919) 795-3349
Address: 620 County Home Road, Smithfield, NC 27577

Facility Operations

- Hours of Operation

Wastewater Treatment Plant (E. Huntley Dr.)
Monday-Friday 8:00am to 3:30pm

Landfill (680 County Home Rd.)
Monday-Friday 8:00am to 4:30pm

Central Johnston County Regional Wastewater Treatment Plant

Customer Entry Gate

All reclaimed water must enter the Central Johnston County Regional Wastewater Treatment Plant through this gate or at the Johnston County landfill on County Home Rd. then check in with the operator on duty or the scale operator at the landfill.

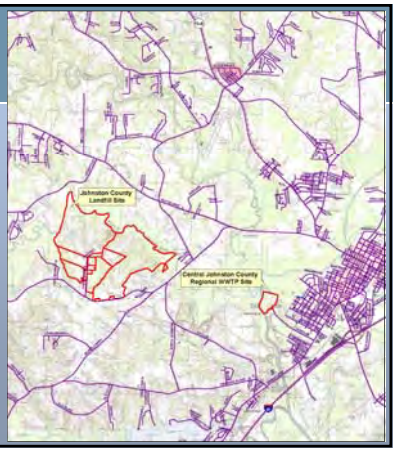
Reclaimed Water Fill Station

The reclaimed water is available at a specially designed load station located on the left of the main road inside the gate at the Landfill and at the WWTP.

Bulk Station Locations

- Johnston County Landfill
- Future Location to Include:
  - Central Johnston County Regional Wastewater Treatment Plant

Map of Location

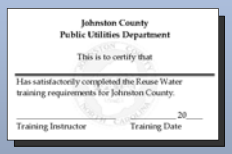


Reclaimed Water Station Operator Checks the following:

Permit displayed

Proper signage

Customer Has Certification Card



Johnston County
Public Utilities Department

This is to certify that

Has satisfactorily completed the Reuse Water training requirements for Johnston County.

_____ 20____

Training Instructor Training Date

Truck or Tank Positioning

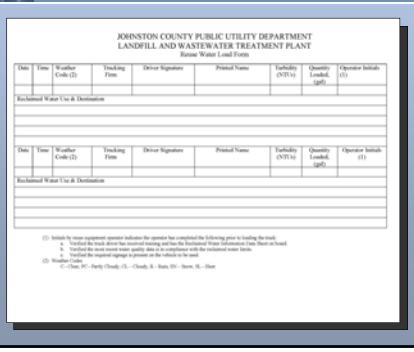
Operator checks tank size

Reclaimed Water Quality Data

Operator will check with the operator and/or SCADA to verify water quality data is in compliance with permit limits before discharging into distribution system

- Turbidity
- TSS (total suspended solids)
- NH3 (ammonia)
- BOD (biological/biochemical oxygen demand)
- Fecal coliforms
- pH above 6.0

Reclaimed Water Load Form



JOHNSTON COUNTY PUBLIC UTILITY DEPARTMENT
LANDFILL AND WASTEWATER TREATMENT PLANT
Reuse Water Load Form

Date	Time	Weather Code (2)	Trucking Firm	Driver Signature	Printed Name	Turbidity (NTU's)	Quantity Loaded, (gal)	Operator Initials (1)
Reclaimed Water Use & Destination								
Date	Time	Weather Code (2)	Trucking Firm	Driver Signature	Printed Name	Turbidity (NTU's)	Quantity Loaded, (gal)	Operator Initials (1)
Reclaimed Water Use & Destination								

(1) Initials by reuse equipment operator indicates the operator has completed the following prior to loading the truck:
a. Verified the truck driver has received training and has the Reclaimed Water Information Data Sheet on board.
b. Verified the truck driver has a valid Reuse Water Permit for the reclaimed water farm.
c. Verified the required signage is present on the vehicle to be used.

(2) Weather Codes:
C – Clear, PC – Partly Cloudy, CL – Cloudy, R – Rain, SN – Snow, SL – Sleet

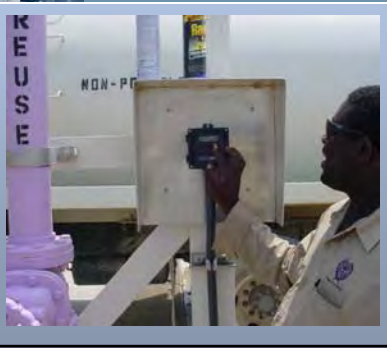
Reclaimed Water Load Form

Information Captured

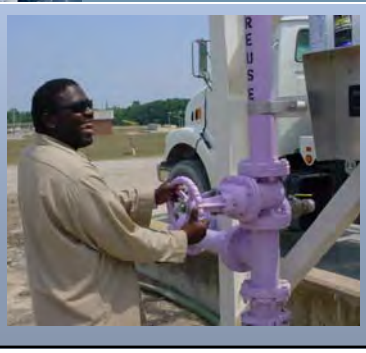
- Date and time loaded
- Weather Code
- Quantity of reclaimed water loaded
- Customer signature and printed name
- Turbidity (recent effluent reading)
- Chlorine added or residual
- Operator initials

Reuse Meter

Reuse meter readout is located on the fill station piping



Operator resets the meter



Operator turns valve and fills tank.
Operator closes valve and inspects tank for leakage.
If all Ok, Driver is permitted to leave the site.

Questions?

Closure and Post-Closure Plan

Johnston County Landfill Facility
Smithfield, North Carolina

Prepared for:

Johnston County Department of Solid Waste Services
Smithfield, North Carolina

December 2013

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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Johnston County Landfill Facility
Smithfield, North Carolina

Closure and Post-Closure Plan

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Appendix A Closure, Post-Closure, and Assessment/Corrective Action Cost Estimates

1.0 CLOSURE PLAN

This plan is intended to serve as a guide for the proposed closure. A formalized Closure Plan for each landfill unit (or incremental portion thereof) will be submitted to the Solid Waste Section of the North Carolina Department of Environment and Natural Resources Division of Waste Management (DWM) for approval prior to beginning closure construction.

1.1 Maximum Closure Area and Waste Capacity

The following are the estimated areas and capacity for each landfill unit to be closed under this plan.

Table 1.1 Closure Areas and Capacity Summary

Landfill Unit	Closure Area (Acres)	Gross Capacity (CY)[1]	Net (Waste) Capacity (CY/Tons)[1]
MSW Landfill Units			
Phase 4A (Through Cell 3 - Fill Sequence 1)	29.4	2,531,948	2,152,156 CY 1,429,288 Tons
Phase 5	19.2	1,087,199	884,625 CY 514,181 Tons
Total (MSW):	48.6	3,619,147	3,036,781 CY 1,943,469 Tons
C&D Units			
Area 2 (Cell 1)	11.9	410,676	353,056 CY 183,106 Tons
Total (C&D):	11.9	410,676	353,056 CY 183,106 Tons

Notes:

1. The volume and tonnage figures assumed for each landfill unit are based on the site's Facility Plan. Refer to Section 2.0 (Facility Report) of the Facility and Engineering Plan (**Attachment A**).

1.2 Final Cover System

The final cover system will consist of the following components (top-down):

MSW and C&D Landfill Units:

- a 24-inch thick vegetative soil layer;
- a drainage geocomposite (with drainage breaks);
- a 30-mil textured LLDPE geomembrane; and
- a 12-inch thick intermediate cover layer.

The final cover system will be placed on prepared intermediate cover at a maximum slope of 4H:1V. Surface water and landfill gas (LFG) control devices will also be incorporated into the final cover of each landfill unit. The final cover surface will be vegetated upon completion of the final cover installation according to the project seeding specifications.

Placement of the vegetative soil layer over the cover geosynthetics must be done with care to avoid damage to these materials. This soil layer should be placed from the bottom up using a small dozer equipped with low ground contact pressure (6 psi or less) tracks. A minimum of 12 inches of soil should be maintained between the dozer tracks and the underlying geosynthetics. The soil buffer should receive no compaction other than that provided by the dozer tracks. Pans or other heavy equipment should not operate on the vegetative soil layer.

Refer to the appropriate permit application for a detailed discussion and details related to the design of the final cover system for each landfill unit.

1.3 Landfill Gas System

For the MSW landfill units and C&D landfill units, a landfill gas system is provided in the final cover design. This system includes a system of collection wells or vents placed within the waste to capture the gas and either passively vent or flare the gas via utility flares or, as required, actively collect and flare the gas via header piping and a blower/flare system. The collection wells should be placed before any final cover geosynthetics are placed.

Refer to the appropriate permit application for a detailed discussion and details related to the design of the landfill gas system for each landfill unit.

1.4 Surface Water Systems

Precipitation falling on the cover will infiltrate into the cover or run off of the cover. Short-term the run-off runs down the surface of the intermediate cover. Long-term the run-off is collected in a series of drainage breaks built into the areas covered by final cover. These drainage breaks are provided along side slopes (rain gutters and diversion berms). Water captured by rain gutters or diversion berms is routed toward one of the down pipes. Flow in the down pipes is routed to the base of the landfill and to one of the site sediment basins.

Refer to the appropriate permit application for a detailed discussion and details related to the design of surface water systems for each landfill unit.

1.4.1 Incremental Operation

During much of the life of the landfill, surface run-off will be handled by the intermediate cover system. Operations must strive to provide operational grading that encourages run-off from the intermediate cover to drain to the perimeter channels along the perimeter berms or to areas covered by final cover. Corrugated polyethylene (CPE) piping and temporary soil berms must be installed if required to accomplish this run-off routing.

1.4.2 Required Maintenance

The surface water systems must be inspected annually and immediately after every major storm. Sediment build-up in the drainage features/devices must be cleaned out on a regular basis to promote run-off. Sediments removed can be used as daily or intermediate cover.

1.5 Closure Schedule

In general, closure activities will occur on the following schedule:

MSW Landfill Units (15A NCAC 13B.1627(c)(5)):

- No later than 30 days after the date on which the MSWLF unit receives the known final receipt of wastes; or
- If the MSWLF unit has remaining capacity and there is a reasonable likelihood that the MSWLF unit will receive additional wastes, no later than one year after the most recent receipt of wastes.

C&D Landfill Units (15A NCAC 13B.0543(c)(5)):

- No later than 30 days after the date on which the C&DLF unit receives the known final receipt of wastes;
- No later than 30 days after the date that a 10 acre or greater area of waste, is within in 15 feet of final design grades; or
- No later than one year after the most recent receipt of wastes, if the C&DLF unit has remaining capacity.

Prior to beginning closure of any landfill unit, the County will notify the DWM that a notice of the intent to close the unit has been placed in the operating record.

All closure activities will be completed within 180 days. Exemptions and extensions may be approved by the DWM.

1.6 Closure Verification

The following procedures will be implemented following closure:

- A Construction Quality Assurance (CQA) report will be submitted to the DWM. This report will describe the observations and tests used before, during, and upon completion of construction to ensure that the construction materials meet the final cover design specifications and the construction and certification requirements. The CQA report will contain as-built drawings.

- A signed certification from a registered Professional Engineer verifying that closure has been completed in accordance with the closure plan will be submitted to the DWM and placed in the operating record.

- At least one sign notifying all persons of the closing of the landfill (or incremental portions thereof) and that wastes are no longer accepted will be posted. Suitable barriers will be installed as necessary at former access points to prevent new waste from being deposited.

- Within 90 days, a survey plat, prepared by a registered Professional Land Surveyor, indicating the location and dimensions of landfill disposal areas, will be prepared.

- A notation will be recorded on the deed (through the County Register of Deed's Office) notifying any potential purchaser of the property that the land has been used as a landfill facility and that future use is restricted under the approved closure plan. A copy of the deed notation as recorded will be filed with the operating record and notification will be provided to the DWM.

2.0 POST-CLOSURE PLAN

This Post-Closure Plan has been developed to outline steps to be taken to ensure the integrity of the landfill during its post-closure care period. The post-closure care period will last at least 30 years after final closure and, at a minimum, will consist of the following:

- Maintaining the integrity and effectiveness of final cover system;
- Maintaining and operating the leachate management system (lined units);
- Performing groundwater and surface water monitoring;
- Maintaining and operating a landfill gas monitoring system; and
- Maintaining run-on/run-off controls.

No wastes will remain exposed after closure of the landfill. Access to the closed site by the public will not pose a health hazard.

2.1 Post-Closure Contact

All correspondence and questions concerning the post-closure care of the landfill should be directed to:

Johnston County Department of Solid Waste Services
Attn: Director
680 County Home Road
Smithfield, NC 27577
Phone: (919) 938-4750
Fax: (919) 989-7152.

2.2 Post-Closure Use

After filling operations cease at the landfill and the landfill is officially closed in accordance with the Closure Plan, each landfill unit will be maintained as a grassy hill. Johnston County will maintain control of the property and prevent public access to it during the post-closure period.

There may be (an) access road(s) on the final cover to allow proper maintenance during post-closure. Precise location of the access road(s) will be determined as a part of operations. Low ground pressure and rubber tire vehicles will be used for maintenance. Additionally, the County will maintain access to all site monitoring locations through the post-closure period.

2.3 Maintenance

2.3.1 Repair of Security Control Devices

All security control devices will be inspected and maintained as necessary to ensure access to the site is controlled. Locks, vehicular gates, and fencing will be replaced if functioning improperly. Warning signs will be kept legible at all times and will be replaced if damaged by inclement weather or vandalism.

2.3.2 Erosion Damage Repair and Vegetation

If erosion of the final cover occurs during post-closure, the affected area will be repaired and revegetated as necessary. If necessary, rolled erosion control products (RECPs) will be used to expedite rapid revegetation of slopes and to secure topsoil in place. Revegetation (including fertilization and seeding) will be performed in accordance with the most recently approved erosion and sedimentation control plan and the North Carolina Erosion and Sediment Control Planning and Design Manual.

Mowing of the final cover surfaces will occur approximately once per year in order to help maintain a healthy stand of grasses and to cut down saplings and woody-stemmed plants.

2.3.3 Correction of Settlement, Subsidence, and Displacement

Minimum slopes of 5 percent will be maintained after settlement in order to prevent ponding and allow for proper drainage without infiltration. If vertical or horizontal displacement occurs due to differential settlement, cracks will be filled with appropriate material and final cover will be reestablished. Excessive vertical displacement is not anticipated.

2.3.4 Leachate Management System (Lined Units)

In order to maintain the free flow in leachate collection piping, piping will be cleared of debris using the manholes or cleanout locations for access. If pipes should crush or buckle within the landfill, leachate will flow through the gravel columns. The leachate collection system (LCS) includes a continuous blanket drain on the base of the landfill which will allow drainage of leachate even in the very unlikely event of total failure of the leachate collection pipes.

2.3.5 Leachate Seeps

If evidence of leachate seeps is observed, the County will take the following actions. Depending on the circumstances, various combinations of actions may be appropriate.

1. If leachate is observed outside of the limits of waste disposal areas, notify the DWM.
2. Contain the flow of leachate using soil berms and/or excavation.
3. Excavate the area of seepage to attempt to allow flow into the underlying waste (i.e. break-up soil layers that may be causing the seep.).
4. For contained leachate that will not flow into underlying waste, a pump may be required to route the leachate to an existing leachate collection system cleanout pipe (lined landfill units) or to a tanker truck.
5. For lined landfill units, french drains may be utilized for routing the seepage to the leachate collection system (via cleanout pipes).
6. The use of soil (particularly clay) to plug the seepage may also be successful in the case where flows are minor.
7. Remove and dispose of impacted cover soils accordingly.
8. Repair landfill cover as necessary.

2.3.6 Closure of Storage Lagoon

After closure of the lined landfill units has been achieved, the generation of leachate will eventually curtail. The flow rate immediately after closure should decrease to approximately 100 gallons/acre/day. Toward the end of the 30-year post-closure period, the flow should approach zero, at which time the storage lagoon will not be required. The following procedures will be followed to properly close the leachate storage lagoon:

- Completely drain and remove all liquids, sludges, sediments, etc. from the storage lagoon.

- Disassemble the lagoon, piping, and appurtenances and dispose of the contents in a manner approved by the DWM.

- Sample and analyze the underlying soil for appropriate constituents inherent to leachate. Assess the results for evidence of contaminant migration.

- If contamination of underlying soils is exhibited, perform an assessment as to the degree of contamination and develop remedial actions.

- Obtain approval of the DWM for the assessment and associated remedial measures.

- Perform the remedial actions as necessary to limit any threats to public health and the environment.

- Restore the area(s) to closely match pre-existing conditions in the vicinity of the containment area(s). Activities may include: filling, grading, topsoiling, and seeding.

2.3.7 Repair of Run-On/Run-Off Control Structures

All drainage swales, ditches, and perimeter channels will be repaired, cleaned, or realigned in order to maintain their original condition. Any culverts that are damaged will be repaired or replaced. Sediment basins/ponds will be cleaned out when sediment has reached design cleanout levels.

2.3.8 Landfill Gas System

The landfill gas system will be maintained by the County and operated in accordance with any site air quality permits. Proper operation of the system is verified through testing at the landfill gas monitoring wells.

If gas wells/vents do not function as a result of irregular settlement, accumulation of liquids (condensate, leachate, and/or water), binding or corrosion, additional and/or replacement wells/vents can be installed if necessary in accordance with the current Landfill Gas Management Plan.

At the point that LFG recovery drops below the minimum rates necessary for operation of an active gas collection and control system, the active system will be decommissioned and the wells will be converted to passive vents or capped as appropriate. Decommissioning of the active system will consist of the removal of the LFG flare, blower and equipment skids, fencing, and related electrical components. Piping and structures which have been in contact with LFG condensate will be removed and disposed of in a manner approved by the DWM. LFG piping and structures within the limits of the landfill units will be abandoned in-place if possible in a manner approved by the DWM to minimize the potential for damage to the final cover system of each unit. Once decommissioning activities are complete, the area(s) will be restored (grading as required and revegetation).

Any damage caused to the landfill liner or final cover systems as the result of maintenance, repair, or decommissioning of the LFG system will be repaired following the appropriate specifications and construction quality assurance (CQA) requirements.

2.3.9 Groundwater Monitoring Wells

Procedures outlined in the current Water Quality Monitoring (WQM) Plan or subsequent revision will take precedence; however, a brief description follows. All groundwater monitoring wells have been installed with concrete pads and protective casings to prevent accidental damage by vehicles and equipment. The wells are also equipped with a locking cap to discourage vandalism. Groundwater wells will be inspected regularly (at the time of sampling) to ensure integrity. Persons inspecting a well should look at the overall condition of the well, for signs of well tampering, and cracking or degradation of the concrete pad. Should a well require replacement, the defective well should be abandoned in accordance with specifications provided in the WQM Plan and a new well installed at a location that is approved by the DWM.

2.4 Monitoring Plan

The closed unit will be monitored for a minimum of 30 years. Inspections of the closed landfill will be scheduled to ensure the integrity and effectiveness of the final cover system, surface water systems, groundwater monitoring system, landfill gas system, and to protect human health and the environment.

2.4.1 Inspection Frequencies

Inspections to be conducted by the County during the post-closure care period will occur regularly as shown in **Table 2.1**.

2.4.2 Inspection Activities

Inspections will include examination of the security control devices for signs of deterioration or vandalism to ensure access to the site is limited to authorized persons. Each disposal area will be checked to ensure the integrity of the final cover system is maintained, erosion damage is repaired, vegetative cover persists, and that cover settlement, subsidence, and displacement are minimal. Additionally, the condition of the groundwater and gas monitoring systems and permanent benchmarks will be checked.

A report of findings will be made to the responsible party, including recommendations for actions deemed necessary to ensure the site continues to meet the closure performance standard.

2.4.3 Record Keeping

Records of inspections and repairs will be kept on file by the County throughout the post-closure period.

2.5 Engineering Certification

Following completion of the post-closure care period for each landfill unit, the County will notify the DWM 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.

Table 2.1 Post-Closure Inspection Frequencies

Inspection Activity	Year 1	Years 2-30
Security Control Devices	Quarterly	Quarterly
Vegetative Cover Condition	Quarterly[1]	Quarterly
Surface Water Systems	Quarterly[1]	Quarterly
Erosion Damage	Quarterly[1]	Quarterly
Cover Drainage System	Quarterly[1]	Semi-Annually
Cover Settlement, Subsidence, and Displacement	Quarterly[1]	Semi-Annually
Leachate Management System	Quarterly	Semi-Annually
Landfill Gas System	Quarterly[2]	Semi-Annually[2]
Water Quality Monitoring	Semi-Annually[3]	Semi-Annually[3]
LFG Monitoring System	Quarterly[4]	Quarterly[4]
Benchmark Integrity	Annually	Annually
Leachate Collection Pipe Inspection/Cleanout	See Note 5	

Notes:

1. These items will be inspected after each large storm event (i.e. $\geq$ 1 inch in any 24 hours).

2. Or in accordance with the current Landfill Gas Management Plan or air quality permit(s).

3. Or in accordance with groundwater monitoring schedule described in the current Water Quality Monitoring Plan.

4. Or in accordance with the current LFG Monitoring Plan.

5. Remote camera inspection and flushing (if necessary) of leachate collection piping (portion that can be inspected and cleaned) will be performed every 5 years.

3.0 CLOSURE/POST-CLOSURE COST ANALYSIS

The purpose of this section is to provide a written estimate (in current year dollars) of costs associated with all activities specified in the written closure and post-closure plans which have been developed for the MSW and C&D landfill units of the Johnston County Landfill facility.

3.1 Estimated Closure Costs

Cost estimates for complete closure of the MSW Phase 4A (Cells 1-3), MSW Phase 5, and C&D Area 2 (Cell 1) landfill units (the maximum area to be closed) are provided in Appendix A. Table 3.1 includes a summary of the total estimated closure costs for each landfill unit. The cost estimate for each unit is based on a third party providing the necessary services and includes labor in the unit prices given. The estimated closure costs will be reviewed and updated as required to reflect adjustments for inflation, increased costs in construction or materials, or any other adjustments to the Closure Plan.

3.2 Estimated Post-Closure Costs

Cost estimates for the post-closure care activities for the MSW Phases 1-5 and C&D Areas 1-2 landfill units are provided in Appendix A. Table 3.1 includes a summary of the total estimated post-closure cost for these landfill units. The cost estimate is based on a third party providing the necessary services and includes labor in the unit prices given. The estimated post-closure costs will be reviewed and updated as required to reflect adjustments for inflation, rising costs of anticipated post-closure care, or any other adjustments to the Post-Closure Plan.

3.3 Estimated Assessment and Corrective Action Costs

A cost estimate for current potential assessment and corrective (remedial) action at the landfill facility is provided in Appendix A. The total cost is summarized in Table 3.1 and is based on the required minimum amount ($2,000,000) per NCGS 130A 295.2(h).

3.4 Financial Assurance Mechanism

Johnston County intends to continue to use the Local Government Financial Test (15A NCAC 13B.1628(e)(1)(f)) to demonstrate financial assurance for this facility.

Table 3.1 Summary of Cost Estimates

Activity	Total
MSW Phase 4A (Cells 1-3) – Closure	$3,707,126
MSW Phase 5 – Closure	$2,421,237
C&D Area 2 (Cell 1) – Closure	$1,504,208
MSW Phases 1-5 & C&D Areas 1-2 - Post-Closure (30 Year)	$4,460,445
Potential Assessment and Corrective Action	$2,000,000
Total:	**$14,093,015**

Appendix A

Closure, Post-Closure, and Assessment/Corrective Action Cost Estimates

Closure and Post-Closure Plan
Johnston County Landfill Facility
Smithfield, North Carolina

SMITH+GARDNER

SHEET:	1/5
JOB #:	JOHNSTON-13-4
DATE:	12/3/13
BY:	PKS

Johnston County Landfill - Financial Assurance
Table 1: Summary

Item No.	Description	Total
1.0	MSW Landfill - Phase 4A - Estimated Closure Cost (See Table 2)	$3,707,126
2.0	MSW Landfill - Phase 5 - Estimated Closure Cost (See Table 3)	$2,421,237
3.0	C&D Landfill - Area 2 - Estimated Closure Cost (See Table 4)	$1,504,208
4.0	MSW Phases 1-5 - C&D Areas 1 & 2 - Estimated Post-Closure Cost (See Table 5)	$4,460,445
5.0	Potential Assessment & Corrective Action Cost (See Note 2)	$2,000,000
	TOTAL =	$14,093,015

Notes:

1. All cost projections are presented in 2013 dollars. Appropriate annual escalators should be applied.
2. Per NCGS 130A 295.2(h).

SMITH+GARDNER

SHEET:	2/5
JOB #:	JOHNSTON-13-4
DATE:	12/3/13
BY:	PKS

Johnston County Landfill - Financial Assurance
Table 2: MSW Landfill - Phase 4A - Estimated Closure Cost

Item No.	Description	Estimated Quantity	Units	Unit Cost	Item Cost
1.0	Site Preparation	29.4	AC	$10,000	$294,000
2.0	Landfill Gas Wells/Vents	29.4	AC	$15,000	$441,000
3.0	30-mil Textured LLDPE Geomembrane	1,281,000	SF	$0.45	$576,450
4.0	Drainage Geocomposite	1,281,000	SF	$0.55	$704,550
5.0	Vegetative Soil Layer (24")	95,000	CY	$5.00	$475,000
6.0	Erosion Control (Diversion Berms, Down Pipes, Etc.)	29.4	AC	$15,000	$441,000
7.0	Revegetation	29.4	AC	$1,500	$44,100
8.0	Surveying	29.4	AC	$2,000	$58,800
				Subtotal (Items 1 - 8) =	$3,034,900
9.0	Bonds, Mobilization, & Insurance			4% of Subtotal (Items 1 - 8) =	$121,396
				Subtotal (Items 1 - 9) =	$3,156,296
				Contingency (10%) =	*$315,630*
				Construction Subtotal =	**$3,471,926**
10.0	Engineering	29.4	AC	$2,000.00	$58,800
11.0	CQA	29.4	AC	$6,000.00	$176,400
				TOTAL =	**$3,707,126**

Notes:

1. All cost projections are presented in 2013 dollars. Appropriate annual escalators should be applied.
2. Unit costs include materials and anticipated labor/installation costs.

SMITH+GARDNER

SHEET: 3/5
JOB #: JOHNSTON-13-4
DATE: 12/3/13
BY: PKS

Johnston County Landfill - Financial Assurance
Table 3: MSW Landfill - Phase 5 - Estimated Closure Cost

Item No.	Description	Estimated Quantity	Units	Unit Cost	Item Cost
1.0	Site Preparation	19.2	AC	$10,000	$192,000
2.0	Landfill Gas Wells/Vents	19.2	AC	$15,000	$288,000
3.0	30-mil Textured LLDPE Geomembrane	837,000	SF	$0.45	$376,650
4.0	Drainage Geocomposite	837,000	SF	$0.55	$460,350
5.0	Vegetative Soil Layer (24")	62,000	CY	$5.00	$310,000
6.0	Erosion Control (Diversion Berms, Down Pipes, Etc.)	19.2	AC	$15,000	$288,000
7.0	Revegetation	19.2	AC	$1,500	$28,800
8.0	Surveying	19.2	AC	$2,000	$38,400
				Subtotal (Items 1 - 8) =	$1,982,200
9.0	Bonds, Mobilization, & Insurance			4% of Subtotal (Items 1 - 8) =	$79,288
				Subtotal (Items 1 - 9) =	$2,061,488
				Contingency (10%) =	*$206,149*
				Construction Subtotal =	**$2,267,637**
10.0	Engineering	19.2	AC	$2,000.00	$38,400
11.0	CQA	19.2	AC	$6,000.00	$115,200
				TOTAL =	**$2,421,237**

Notes:

1. All cost projections are presented in 2013 dollars. Appropriate annual escalators should be applied.
2. Unit costs include materials and anticipated labor/installation costs.

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SHEET: 4/5
JOB #: JOHNSTON-13-4
DATE: 12/3/13
BY: PKS

Johnston County Landfill - Financial Assurance
Table 4: C&D Landfill - Area 2 - Estimated Closure Cost

Item No.	Description	Estimated Quantity	Units	Unit Cost	Item Cost
1.0	Site Preparation	11.9	AC	$10,000	$119,000
2.0	Landfill Gas Wells/Vents	11.9	AC	$15,000	$178,500
3.0	30-mil Textured LLDPE Geomembrane	519,000	SF	$0.45	$233,550
4.0	Drainage Geocomposite	519,000	SF	$0.55	$285,450
5.0	Vegetative Soil Layer (24")	39,000	CY	$5.00	$195,000
6.0	Erosion Control (Diversion Berms, Down Pipes, Etc.)	11.9	AC	$15,000	$178,500
7.0	Revegetation	11.9	AC	$1,500	$17,850
8.0	Surveying	11.9	AC	$2,000	$23,800
				Subtotal (Items 1 - 8) =	$1,231,650
9.0	Bonds, Mobilization, & Insurance			4% of Subtotal (Items 1 - 8) =	$49,266
				Subtotal (Items 1 - 9) =	$1,280,916
				Contingency (10%) =	*$128,092*
				Construction Subtotal =	**$1,409,008**
10.0	Engineering	11.9	AC	$2,000.00	$23,800
11.0	CQA	11.9	AC	$6,000.00	$71,400
				TOTAL =	**$1,504,208**

Notes:

1. All cost projections are presented in 2013 dollars. Appropriate annual escalators should be applied.
2. Unit costs include materials and anticipated labor/installation costs.

SMITH+GARDNER

SHEET:	5/5
JOB #:	JOHNSTON-13-4
DATE:	12/3/13
BY:	PKS

Johnston County Landfill - Financial Assurance
Table 5: MSW Phases 1-5 - C&D Areas 1-2 - Estimated Post-Closure Cost (30-Year)

Item No.	Description	Estimated Quantity	Units	Unit Cost	Item Cost
1.0	Site Inspection & Record Keeping	80	HR	$75	$6,000
2.0	Revegetation (2% Total Area)	3	AC	$1,500	$4,500
3.0	Mowing (once per year)	125	AC	$100	$12,500
4.0	Erosion Control	1	LS	$7,500	$7,500
5.0	Gates/Fences/Access	1	LS	$2,500	$2,500
6.0	Water Quality Monitoring & Reporting (See Note 4)	1	LS	$30,000	$30,000
7.0	LFG Monitoring & Reporting (See Note 5)	1	LS	$3,000	$3,000
8.0	LFG System (See Note 6)	1	LS	$5,000	$5,000
9.0	Leachate Management (See Note 7)	1	LS	$64,165	$64,165
				Subtotal (Items 1 - 9) =	$135,165
				Contingency (10%) =	*$13,517*
				Annual Total =	**$148,682**
				30-YEAR TOTAL =	**$4,460,445**

Notes:

1. All cost projections are presented in 2013 dollars. Appropriate annual escalators should be applied.
2. Unit costs include materials and anticipated labor/installation costs.
3. Assumes total of 100 acres (MSW Phases 1-5 and C&D Areas 1 & 2).
4. The water quality monitoring and reporting cost assumes sampling, analysis, and reporting for 13 wells (detection monitoring), 6 wells (detection monitoring - C&D), 4 wells (assesment monitoring), 5 surface water locations, and 4 leachate locations (current annual cost = $30,000).
5. The LFG monitoring and reporting cost assumes quarterly monitoring @ $750 per event (annual cost = $3,000).
6. LFG System cost includes basic maintenance necessary for regulatory compliance ($4,000 per year) and decommissioning ($1,000 per year to account for half of assumed $60,000 cost) at end of post-closure period.
7. Leachate management cost is based on 100 gallons/acre/day x 60.5 acres (lined) x 365 x $20/100 gallons ($44,165/year) plus $5,000/year staff cost plus $3,000/year laboratory cost plus $2,000/year leachate collection piping cleanout costs. Cost also includes $10,000/year to account for decommissioning leachate facilities (storage lagoon) ($300,000 assumed cost) at the end of the post-closure period.

Water Quality Monitoring Plan

Johnston County Landfill Facility
Solid Waste Permit No. 51-03

Prepared for:

Johnston County Department of Public Utilities
Smithfield, North Carolina

Original Submittal:
September 2013

Revised:
March 2014

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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Water Quality Monitoring Plan

Johnston County Landfill
Solid Waste Permit No. 51-03

Prepared For:

Johnston County Department of Public Utilities
Smithfield, North Carolina

S+G Project No. Johnston 12-4

Madeline German, P.G.
Project Geologist

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Senior Hydrogeologist

Original Submittal: **September 2013**

Revised:
March 2014

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JOHNSTON COUNTY LANDFILL
WATER QUALITY MONITORING PLAN

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Figure 1 Water Quality Monitoring Locations

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Appendix A Environmental Monitoring Reporting Form

1.0 INTRODUCTION

1.1 OVERVIEW

This Water Quality Monitoring Plan (WQMP) specifies the procedures and requirements to satisfy North Carolina Solid Waste Management Rule 15A NCAC 13B.1632. The WQMP addresses two major elements: groundwater system monitoring/sampling and surface water monitoring/sampling.

The WQMP will meet the following requirements:

- *Represent the quality of the background groundwater that has not been affected by leakage from the unit (.1631(1)).*
- *Represent the quality of the groundwater passing the relevant point of compliance as approved by the Division (.1631(2)).*
- *The groundwater monitoring programs must include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide an accurate representation of groundwater quality at the background and down-gradient wells (..1632(a)).*
- *Detection Groundwater monitoring program (.1633).*
- *The sampling procedures and frequency must be protective of human health and the environment (.1632(c) and .1633(b)).*
- *Responsibility of sample collection and analysis must be defined as a part of the monitoring plan (.1632).*

This WQMP also addresses the following procedures that will be implemented to ensure the integrity of each sampling event:

- Sample preservation and shipment;
- Laboratory analytical procedures;
- Sample Chain-of-custody control; and
- Quality assurance/quality control programs.

The methods and procedures described in the WQMP are intended to facilitate the collection of true and representative samples and test data. Field procedures are presented in Section 2.0 in their general order of implementation. Equipment requirements for each field task are presented within the applicable section. Laboratory procedures, quality assurance methods, and record keeping requirements are presented in Sections 3.0 through 6.0.

Strict adherence to the procedures stipulated in this plan is required. Any variations from these procedures should be thoroughly documented.

1.2 CONTACT INFORMATION

In case of emergencies, or if questions arise during the implementation of this program, please contact the following:

1.2.1 Johnston County Landfill

680 County Home Road
Smithfield, North Carolina 27577
Phone: (919) 638-4750
Fax: (919) 934-7174
Mr. Rick Proctor – Director
rick.proctor@johnstonnc.com

1.2.2 Engineer

Smith Gardner, Inc.
14 N. Boylan Avenue
Raleigh, North Carolina 27603
Phone: (919) 828-0577
Fax: (919) 828-3899

Ms. Joan A. Smyth, P.G. – Senior Hydrogeologist
joan@smithgarnderinc.com

Mr. Pieter K. Scheer, P.E. – Senior Engineer
pieter@smithgardnerinc.com

1.2.3 NCDENR

North Carolina Department of Environment and Natural Resources
Division of Waste Management:

Raleigh Central Office (RCO)
217 W Jones Street
Raleigh, North Carolina 27603
Phone: (919) 707-8200

Fayetteville Regional Office (FRO)
225 Green Street, Suite 714
Fayetteville, North Carolina 28301
Phone: (910) 486-1541
Fax: (910) 486-0707

Division of Waste Management (DWM) – Solid Waste Section

Field Operations Branch Head:	TBD
Eastern District Supervisor:	Dennis Shackelford (FRO)
Waste Management Specialist:	Mary Whaley ((919) 693-5023)

1.3 SITE BACKGROUND

The Johnston County Landfill Facility (Permit 51-03), located at 680 Country Home Road, Smithfield, NC, has been in operation since 1973, and contains multiple lined and unlined municipal solid waste (MSW) and construction and demolition debris (C&D) units. The facility is located approximately 5 miles west of Smithfield. Local development is mixed residential and agricultural use. The site and monitoring locations are shown on Figure 1.

1.3.1 Site History

The Johnston County Landfill Facility originally was developed with three separate unlined MSW landfill units. These units were named Phases 1&2, Phase 3 and Phase 4. The various units were in operation from the 1970's through 1997. Phase 5 was designed and constructed as the first lined MSW landfill at the facility.

In 1995, assessment monitoring was initiated at the original unlined landfill for a monitoring well network that expanded across most of the facility. Assessment monitoring historically indicated detectable concentrations of both inorganic and organic constituents as well as pesticides.

In 2005[1], additional site assessment work was performed to evaluate groundwater quality in what is now the C&D landfill footprint. This assessment was conducted to evaluate the extent of impact in the future C&D landfill footprint as a baseline for future monitoring. Results from this assessment indicated detectable concentrations of organic and pesticide constituents across this area. Detectable concentrations of inorganic constituents were determined to be due to high sample turbidity as proven by low to non-detectable concentrations of these same constituents in filtered samples. Assessment results also indicated the presence of a diabase dike within the proposed C&D landfill unit footprint. The diabase dike is shown on Figure 1.

To control rainwater infiltration into the unlined Phase 3 and 4 landfill units and minimize leachate creation within these unlined waste units, Johnston County permitted and constructed a double-lined MSW landfill in the valley between Phase 3 and 4 as a piggy-back landfill. The Phase 4A landfill unit fills the valley and partially overlaps the top of Phases 3 and 4. Additionally, the County permitted and constructed a lined C&D landfill which piggy-backs over the other sideslope of Phase 3. It should be noted that the liner system for the C&D landfill includes a leachate collection system that meets 15A NCAC 13B.1600 (et seq.) rule requirements and a liner system that consists of 12" of 10^{-5} cm/sec material and a 40-mil LLDPE liner. Once the piggy-backs are filled and closed, these landfills should cover approximately 70% of the Phase 3 landfill. The liner and leachate collection systems for these landfills will minimize future rainfall infiltration which will

[1] Johnston County Proposed C&D Landfill Ground Water Assessment Report, G. N. Richardson & Associates, Inc., Revised through February, 2005.

minimize the leachate generation from the bottom of the unlined landfills. This "presumptive remedy" strategy is sanctioned by the U.S. EPA.

1.3.2 Geology

The site is located in the western portion of the Coastal Plain Province in the fall zone. The formations found in this area consist of sediments of Cretaceous and Tertiary age, unconformably overlying metamorphic rocks of Pre-Cambrian to Cambrian age. The site is underlain by sediments of the Middendorf Formation which were deposited largely in a deltaic system. According to Geology of the Carolinas (Horton/Zullo, 1991) the formation consists of unfossiliferous, interbedded, thin clay and sand. The stratigraphy tends to be very discontinuous, indicating that the sediment deposits are lenticular. Most of the sediments range from silty clay to a coarse clayey sand and gravel with thin lenses of dense clay. There are occasional concretions of iron oxide minerals which form very hard thin layers within the sand layers. The Middendorf Formation dips very gently to the east, and is underlain by highly weathered metamorphic rocks of the Carolina Slate Belt.

Borings advanced at the site encountered sandy silts consistent with the Middendorf Formation, and partially weathered rock above bedrock. The bedrock encountered was a metamorphosed mudstone. The depths of these borings ranged between 15 feet and 75 feet deep. The unconsolidated sediments consisted of mostly silty sands and sandy silts with some clayey sand as well. The metamudstone bedrock was encountered at a depth of approximately 15 feet in the floodplain around the site, and at a depth of approximately 50 feet elsewhere on-site. Diabase dikes have also been located at the site beneath the Area 2 C&D landfill unit, the floodplain of Middle Creek, and the Phase 5 MSW landfill unit.

1.3.3 Hydrogeology

The hydrogeology at this site has been investigated through numerous piezometers, groundwater monitoring wells, aquifer slug tests and aquifer pumping tests. Groundwater flow is generally north across the site, except for the Phase 5 unit where the flow is generally northwest; in both instances groundwater flows toward Middle Creek, the local discharge feature. The uppermost aquifer consists of sands and silts and is unconfined in nature. Depth to groundwater ranges from approximately 5 to 40 feet below grade across the site.

The uppermost aquifer at the site primarily consists of silty and clayey sands. Hydraulic conductivity values measured in the soil aquifer varies on the order of 0.0083 ft/day to 0.289 ft/day based upon prior investigations.

2.0 MONITORING PROGRAM

2.1 OVERVIEW

This section of the Water Quality Monitoring Plan addresses each aspect of the monitoring program. At a minimum, Johnston County Landfill will monitor the groundwater quality on a semi-annual basis.

2.2 MONITORING NETWORK AND ANALYTICAL PARAMETERS

The Johnston County Landfill Facility (Permit#51-03) is composed of multiple adjacent and "piggy-back" landfill units that have previously been monitored as three separate units: Johnston County C&D, Johnston County MSW Phases 1-4 and 4A and Johnston County MSW Phase 5. The various units were installed at different times creating multiple well sets with each expansion.

Due to the fragmented nature of well monitoring network installation during these permitting events, the current monitoring network has significant redundancy, and also includes wells that are located inordinately close to individual waste units. To improve cohesiveness, avoid redundancy, and remove potential false positive detections, the monitoring network has been revised as outlined below and the facility will have one network which will be sampled and reported together. Modifications to the monitoring network are discussed in Section 2.2.1. Figure 1 shows the current and proposed monitoring network and potentiometric contours from the most recent sampling event (April 2013). Table 1 presents well construction details for the current monitoring network. Additionally, Table 1 summarizes which wells are proposed for inclusion in the future Detection Monitoring and Assessment Monitoring programs (discussed below).

2.2.1 Modifications from Previous Monitoring Network

Groundwater Monitoring

This monitoring plan combines the previously separate plans for the C&D landfill, the Phase 1-4A landfill and the Phase 5 landfill.

Table 1 provides sampling location, construction details, sampling group (Detection or Assessment Monitoring) and relevant information regarding their status in the updated monitoring network.

Detection Monitoring Network

Monitoring well MW-3 has historically been used as the background (upgradient) well for the entire facility; however, it has been dry over the past 4 semi-annual sampling events. Monitoring well MW-5-1 will replace MW-3 as the background well for the facility.

Wells identified as detection monitoring wells (CDMW-3, CDMW-4, CDMW-6, CDMW-7, CDMW-8, MW-9D, MW-8D, MW-9C, MW-15D, MW-16D, MW-5-1, MW5-2, MW-5-5 and MW-5-6) will be sampled semi-annually for Appendix I parameters. Their positioning is designed for early detection of a release from the landfill units. Background locations and those wells furthest from the landfill were selected for this group. If detection monitoring well sampling results indicate constituent concentrations show landfill impact, those wells may be considered for assessment monitoring status (pending NCDENR approval)

One new well (PM-1) is proposed as a replacement well for cross-gradient wells CDMW-2, MW-4B and PZ-3 due to acquired property added to the facility footprint. The currently existing monitoring wells (CDMW-2, MW-4B and PZ-3) are located immediately adjacent to waste and are not representative of aquifer conditions near the compliance boundary. PM-1 will be included with the detection monitoring group.

Additionally, the leachate storage pond located on-site will be monitored by surrounding wells (leachate lagoon #1, leachate lagoon #2, leachate lagoon #3 and leachate lagoon #4). These wells will be sampled semi-annually.

Assessment Monitoring Network
Wells identified as assessment monitoring wells (MW-6, MW-7B, MW-11, MW-12B, MW-14D,) will be sampled semi-annually. These locations have historically been part of assessment monitoring associated with the Phase 1 – 4A landfill. If assessment monitoring results indicate constituent concentrations below the standard for two consecutive sampling events, those wells may be considered for detection monitoring (pending NCDENR approval). Wells can move between the detection monitoring and assessment monitoring group in accordance with rules .1633 and 1634.

As shown on Figure 1, twenty-three wells were removed from the monitoring network because they were interior locations, yielded redundant data, were located cross-gradient, or were historically dry. These wells will not be abandoned but will remain in place for additional water level data or potential additional sampling in the event further delineation data is necessary in the future. Table 1 summaries existing well locations, their monitoring program and reasons for network removal if necessary.

Surface Water Monitoring
Surface water sampling locations (SWPT-1, SWPT-2, SW5-1 and SW5-2) will be utilized to monitor Middle Creek and its tributaries for potential impact from the landfill. Sampling point CDSW-1 has been moved from its previous location of an unnamed tributary of Buzzard Branch, to a point where Buzzard Branch meets Middle Creek. The surface water monitoring locations are shown on Figure 1.

Leachate Monitoring
Four leachate locations will be included in the monitoring network. Leachate sampling locations for the Phase 4A MSW Landfill, the Phase 4A leak detection zone, the Phase 5 – north end manhole and lined C&D landfill will be sampled semi-annually.

The leachate junction box for multiple landfill units was removed from the monitoring network because it is a composite leachate sample that yields redundant data.

Leachate will be monitored in accordance with the guidance detailed in Section 2.3.1.1.

2.2.2 Analytical Parameters

As the landfill facility contains both lined and unlined landfill units, samples from certain wells in the monitoring network will be analyzed for Detection Monitoring parameters, while samples from other wells will be analyzed for Assessment Monitoring parameters. In general, the entire facility is operating under .1600 rules; therefore C&D parameters including tetrahydrofuran will not be monitored. Additionally, since the C&D landfill is a lined facility these additional parameters are unnecessary. The following sections

summarize the wells and parameters related by monitoring type. Analytical parameters are presented in Table 2.

2.2.2.1 Detection Monitoring

Wells in the monitoring network selected for detection monitoring will be sampled for Appendix I parameters semi-annually in accordance with SWS approved methods. Detection monitoring locations are listed in Table 1.

2.2.2.2 Assessment Monitoring

Wells in the monitoring network selected for assessment monitoring will be sampled semi-annually. During one event, these samples will be analyzed for Appendix II parameters (typically during the spring event) and during the second event these samples will be analyzed for Appendix I parameters (typically during the fall event) in accordance with SWS approved methods. Assessment monitoring locations are listed in Table 1.

2.2.2.3 Leachate Monitoring

Leachate sampling locations will be sampled for Appendix I metals and VOCs plus nitrate, sulfate, phosphorous, total suspended solids, biochemical oxygen demand, chemical oxygen demand and ammonia. These locations are summarized in Table 1.

2.2.2 Contingency Plan

There are currently groundwater monitoring wells on this site that are in Detection Monitoring in accordance with 15A NCAC.13B.1633, and wells that are in Assessment Monitoring in accordance with 15A NCAC 13B.1634. This section addresses contingencies for detection and assessment monitoring should negative changes in water quality occur. If routine groundwater data from the wells in the detection monitoring network indicates a contaminant plume may be present, additional samples may be collected, as needed, from existing groundwater wells not included in the network. Results from these wells would be used to identify specific contaminants of concern, address contaminant concentrations, evaluate if there has been a release from the landfill that should be addressed and implement an assessment monitoring program, if necessary.

The monitoring wells that are currently following Assessment Monitoring are associated with the "piggy-back" landfill remedial strategy (see Section 1.3.1). As these wells are already part of a remedial action, any significantly negative changes in water quality will be evaluated on a case by case basis.

2.3 GROUNDWATER SAMPLE COLLECTION

2.3.1 Introduction

This section presents details of the procedures and equipment required to perform groundwater field measurements and sampling from monitoring wells during each monitoring event. Where possible, sampling will proceed from least to (potentially) most contaminated, or from the upgradient (background) wells to downgradient (compliance) wells.

2.3.1.1 Guidance Documents

Sampling, analysis, and submittals will be performed in accordance with this plan and the following guidance documents:

1. Groundwater, Surface Water and Soil Sampling for Landfills – NCDENR Guidance updated April 2008.

2. October 27, 2006 Memo from NCDENR entitled "New Guidelines for Electronic Submittal of Environmental Monitoring Data."

3. February 23, 2007 Memo from NCDENR entitled Addendum to October 27, 2006, North Carolina Solid Waste Section Memorandum Regarding New Guidelines for Electronic Submittal of Environmental Data.

4. October 16, 2007 Memo from NCDENR entitled Environmental Monitoring Data for North Carolina Solid Waste Management Facilities.

2.3.1.2 Fuel-Powered Equipment

Fuel-powered equipment, such as generators for pumps, must be situated away and downwind from sampling activities (i.e. purging and sampling). If field conditions prevent such placement, then the fuel source must be placed as far away as possible from the sampling activities. Sampling conditions must be described in detail in the field notes.

If fuel must be handled, it should be done the day before sampling. Effort should be made to avoid handling fuels on the day of sampling. If fuels must be dispensed during sampling activities, dispense fuel downwind and well away from any sampling locations. Wear gloves while working with fuel and dispose of the gloves away from sampling activities. Wash hands thoroughly after handling any fuels.

2.3.1.3 Equipment Decontamination

Non-dedicated equipment that may come in contact with the well casing and water will be decontaminated between wells. The procedure for decontaminating non-dedicated equipment is as follows:

1. Don new powder-free gloves.

2. Clean item with tap water and phosphate-free laboratory detergent Liqui-Nox or equivalent using a brush if necessary to remove particulate matter and surface films.

3. Rinse thoroughly with pesticide grade isopropanol and allow to air dry.

4. Rinse with organic-free water (Milli-Q water or other ultra-pure water) and allow to air dry.

5. Wrap with commercial-grade aluminum foil, if necessary, to prevent contamination of equipment during storage or transport.

Please note that Liqui-Nox detergent solutions will be stored in a clearly marked HDPE or PP container. Containers for pesticide-grade isopropanol will be made of inert materials such as Teflon, stainless steel, or glass.

Sampling will be planned and conducted to minimize the need for decontamination in the field through the use of dedicated sampling equipment, or a new, disposable, Teflon bailer at each well. Unclean equipment will be segregated from clean equipment during field activities. Clean equipment will remain in the manufacturer's packaging until use, or will be wrapped in commercial-grade aluminum foil or untreated butcher paper.

2.3.2 Water Level Measurements

2.3.2.1 Static Water Levels

Static water level and depth to the well bottom will be measured in each well prior to any purging or sampling activities. Static water level and well depth measurements are necessary to calculate the volume of stagnant water in the well prior to purging. Additionally, these measurements provide a field check on well integrity, degree of siltation, and are used to prepare potentiometric maps, calculate aquifer flow velocities and monitor changes in site hydrogeologic conditions.

Groundwater depths will be measured to a vertical accuracy of 0.01 feet relative to established wellhead elevations. Each well will have a permanent, easily identified reference point on the lip of the well riser from which water level measurements will be taken. The elevation of the reference point will be established by a Registered Land Surveyor.

2.3.2.2 Contamination Prevention

Upon opening each well, new powder-free nitrile surgical gloves will be donned. Appropriate measures will be implemented during measurement activities to prevent soils, decontamination supplies, precipitation, and other potential contaminants from entering the well or contacting clean equipment.

2.3.2.3 Equipment

An electronic water level indicator will be used to accurately measure depth to groundwater in each well and/or piezometer. The electronic water level indicator will be constructed of inert materials such as stainless steel and Teflon. Between each well, the device will be thoroughly decontaminated by washing with non-phosphate (Liqui-Nox) soap and rinsing with organic-free water to prevent cross contamination from one well to another.

The following measurements will be recorded in a dedicated field book prior to sample collection (see Section 6.0 for a detailed description of collected field notes):

- Depth to static water level and well bottom (to the nearest 0.01 foot);
- Height of water column in the riser (based upon measured depth of well);

- Condition of wellhead protective casing, base pad and riser; and
- Changes in condition of well and surroundings.

2.3.3 Monitoring Well Evacuation

2.3.3.1 Description

Water accumulated in each well may be stagnant and unrepresentative of surrounding aquifer conditions and therefore must be removed to insure that fresh formation water is sampled. Each well will be purged of standing water in the well casing following the static water level measurement. Ideally, monitoring well evacuation should be performed in upgradient wells first then systematically move to downgradient well locations.

2.3.3.2 Contamination Prevention

New, non-powdered, nitrile surgical gloves will be donned for well purging and sampling activities and whenever handling decontaminated field equipment. Appropriate measures will be applied during measurement, purging and sampling activities to prevent surface soils, decontaminated supplies, precipitation, and other potential contaminants from entering the well or contacting cleaned equipment.

2.3.3.3 Calculations

The volume of standing water in the well riser and screen will be calculated immediately before well evacuation during each monitoring event. A standing water volume will be calculated for each well using measured static water level, well depth and well casing diameter according to the following equation:

$$V = (TD - SWL) \times C$$

Where:
- V = One well volume (gallons)
- TD = Total depth of the well (in feet)
- SWL = Static water level (in feet)
- C = Volume constant for given well diameter (gallons/foot)
  - C = 0.163 gal/ft for two-inch wells.
  - C = 0.653 gal/ft for four-inch wells.

2.3.3.4 Well Purging

Several options for well purging are used at this site including:

- Bailers;
- Low Flow Pumps; and
- Grundfos Redi-Flo Pumps.

Bailers – Where bailers are used, new, disposable bailers with either double or bottom check-valves will be used to purge each well. Disposable purge bailers will be constructed of fluorocarbon resin (Teflon) or inert plastic suitable for the well and ground conditions. Each bailer will be factory-clean and remain sealed in a plastic sleeve until use. A new Teflon-coated stainless steel, inert mono-filament line or nylon cord will be used for each well to retrieve the bailers.

Where bailers are used, a minimum of three well volumes will be purged unless the well runs dry.

Low Flow Pumps – Monitoring wells may be purged and sampled using the low-flow sampling method in accordance with the *Solid Waste Section Guidelines for Groundwater, Soil, and Surface Water Sampling* (NCDENR, 2008).

Obtain depth-to-water measurements using an electronic water level indicator capable of recording the depth to an accuracy of 0.01 foot. Determine if the water table is located within the screened interval of the well. If the water table is not within the screened interval, the achievable drawdown before intersection with the screen will be calculated. If the water table is within the screened interval, total drawdown should not exceed 1 foot to minimize the aeration and turbidity. If the water table is above the top of the screened interval, drawdown should be minimal to prevent screen exposure.

If the purging equipment is non-dedicated, the equipment will be lowered into the well, taking care to minimize water column disturbance. If conditions (i.e., water column height and well yield) allow, the pump will be situated in the upper portion of the water column (minimum of 18 inches of pump submergence is recommended).

The minimum volume/time period for obtaining independent Water Quality Parameter Measurements (WQPM) will be determined. The minimum volume/time period is determined based on the stabilized flow rate and the amount of volume in the pump and the discharge tubing (alternatively, the volume of the flow cell can be used, provided it is greater than the volume of the pump and discharge tubing). Bladder pump volume should be obtained from the manufacturer. Discharge tubing volumes are as follows:

3/8-inch inside diameter tubing:	20 milliliters per foot
1/4-inch inside diameter tubing:	10 milliliters per foot
3/16-inch inside diameter tubing:	5 milliliters per foot

Begin purging the well after calculating the volume of the flow-cell or the pump and the discharge tubing. The flow rate should be based on historical data for that well (if available) and should not exceed 500 milliliters per minute. The initial round of WQPM should be recorded and the flow rate adjusted until drawdown in the well stabilizes. Water levels should be measured periodically to maintain a stabilized water level. The water level should not fall within 1 foot of the top of the well screen. If the purge rate has been reduced to 100 milliliters or less and the head level in the well continues to decline, the required water samples should be collected following stabilization of the WQPM, based on the criteria presented below.

If neither the head level nor the WQPM stabilize, a passive sample should be collected. Passive sampling is defined as sampling before WQMP have stabilized if the well yield is low enough that the well will purge dry at the lowest possible purge rate (generally 100 milliliters per minute or less).

WQPM stabilization is defined as follows: pH (+/- 0.2 S.U.), conductance (+/- 5% of reading), temperature (+/- 10% of reading or 0.2°C) and dissolved oxygen [+/- 20%

of reading or 0.2 mg/L (whichever is greater)]. Oxidation reduction potential (ORP) will be measured and ideally should also fall within +/- 10mV of reading; however, this is not a required parameter. At a minimum, turbidity measurements should also be recorded at the beginning of purging, following the stabilization of the WQPM, and following the collection of the samples. The optimal turbidity range for micropurging is 25 Nephelometric Turbidity Units (NTU) or less. Turbidity measurements above 25 NTU are generally indicative of an excessive purge rate or natural conditions related to excessive fines in the aquifer matrix.

Stabilization of the WQPM should occur in most wells within five to six rounds of measurements. If stabilization does not occur following the removal of a purge volume equal to three well volumes, a passive sample will be collected.

The direct-reading equipment used at each well will be calibrated in the field according to the manufacturer's specifications prior to each day's use and checked at a minimum at the end of each sampling day. Calibration information should be documented in the instrument's calibration logbook and the field book.

Each well is to be sampled immediately following stabilization of the WQPM. The sampling flow rate must be maintained at a rate that is less than or equal to the purging rate. For volatile organic compounds, lower sampling rates (100 - 200 milliliters/minute) should be used. Final field parameter readings should be recorded prior to and after sampling.

Grundfos Redi-Flo Pumps – Where Redi-Flo pumps are used, the same low flow techniques for sampling will be used as described in the above Low Flow Pump section.

2.3.3.5 Purge Rate

Wells will be purged at a rate that will not cause recharge water to be excessively agitated or cascade through the screen. Methods will minimize disturbance to well sidewalls and bottoms which could result in silt and fine particulate matter suspension. The water volume purged from each well and the relative recharge rate will be documented in sampling field notes. Wells with very low recharge rates will be purged until dry. Damaged, dry or low yielding and high turbidity wells will be documented for reconsideration before the next sampling event.

2.3.3.6 Purge Water Disposal

Purge water will be managed to prevent possible soil and surface water contamination. Well site management options may include temporary containment and disposal as leachate or portable activated carbon filtration if warranted by field characteristics.

2.3.3.7 Non-Dedicated Equipment

Durable, non-dedicated equipment that is lowered into the well or which may come in contact with the water samples will be thoroughly decontaminated before each use. Equipment will be disassembled to the degree practical, washed with (non-phosphate) soapy potable tap water, and triple rinsed using de-ionized water. Detailed equipment decontamination procedures are detailed in Section 2.3.1.3.

2.3.4 Sample Collection

After purging activities are complete, groundwater samples will be collected for laboratory analysis. Samples should be collected from least contaminated location(s) first, followed by locations of increasing contamination across the site. Prior to sample collection, sample labels should be properly filled-out with permanent ink, such as Sharpie Pen. At a minimum, the label should identify the sample with the following information:

- Sample Location or Well Number;
- Sample Identification Number;
- Date and Time of Collection;
- Analysis Required;
- Sampler's Initials;
- Preservative Used (if any); and
- Other Pertinent Information As Necessary.

Affix completed sample labels to the sample bottle prior to sampling.

Sampling will occur within 24-hours of the well purging and as soon after well recovery as possible. Wells that fail to recharge or produce an adequate sample volume within 24-hours of purging will not be sampled.

2.3.4.1 Field Parameters

Field measurements for temperature, pH and specific conductance will be recorded immediately prior to sampling each monitoring point. Additionally, turbidity measurements should be collected for metals evaluation. The field test specimens will be collected with the sampling bailer and placed in a clean, non-conductive glass or plastic container for observation. PH, temperature, conductivity and turbidity meter calibration will be completed according to the manufacturers' specifications and consistent with Test Methods for Evaluating Solid Waste -Physical/Chemical Methods (SW-846). A pocket thermometer and litmus paper will be available in case of meter malfunction.

2.3.4.2 Sample Equipment

Several options for sample collection are used at this site including:

- Teflon Bailers;
- Low Flow Pumps and
- Grundfos Redi-Flo Pumps.

Of these, Low Flow purging/sampling systems are the most prevalent as the Grundfos pumps are utilized for low flow purging/sampling. Low flow purging/sampling is recommended for this site wherever possible.

Teflon Bailers – Where bailers are used, each well will be sampled using a new, factory-cleaned, disposable Teflon bailer with bottom check-valve and sample discharge mechanism. A new segment of Teflon-coated stainless steel wire, inert mono-filament line or nylon cord will be used to lower and retrieve each bailer. The bailer will be lowered into each well to the point of groundwater contact and allowed to fill as it sinks below the water table. Bottom contact will be avoided in order to avoid suspending sediment in the samples. The bailer will be retrieved and emptied in a manner which minimizes sample agitation.

Low Flow Pumps – After purging with the low flow pump systems samples may be collected immediately from the pumping system following the order outlined in Section 2.3.4.4.

Redi-Flo Pumps - After purging three well volumes samples may be collected from the Redi-Flo pumps in the order outlined in Section 2.3.4.4.

2.3.4.3 Sample Transfer

Samples will be transferred directly from the Teflon bailer into a sample container that has been specifically prepared for the preservation and storage of compatible parameters. A bottom emptying device provided will be used to transfer samples from bailer to sample container. The generation of air bubbles and sample agitation will be minimized during bailer discharge. Groundwater samples will be collected and contained in the order of volatilization sensitivity.

2.3.4.4 Sample Collection Order

The following sampling order will be observed:

- Volatile Organics and Volatile Inorganics;
- Extractable Organics, Petroleum Hydrocarbons, Aggregate Organics and Oil and Grease;
- Total Metals;
- Inorganic Nonmetallics, Physical and Aggregate Properties and Biologicals;
- Microbiologicals.

Note: If the pump used to collect groundwater samples is not suitable to collect volatile or extractable organics then collect the other parameters and withdraw the pump and tubing. Then collect the volatile and extractable organics.

Samples will be collected and analyzed in an unfiltered state during sampling events. Samples for dissolved metal analysis, if subsequently required, will be prepared by field filtration using a decontaminated peristaltic pump and a disposable 0.45 micron filter cartridge specifically manufactured for this purpose.

2.3.4.5 Decontamination

Reusable sampling equipment including water level probes, water quality meters, interface probes and filtering pumps which might contact aquifer water or samples will be thoroughly decontaminated between wells by washing with non-phosphate soapy, de-ionized water and rinsing with isopropanol and organic-free water. Detailed equipment decontamination procedures are discussed in Section 2.3.1.3.

2.3.4.6 Sample Preservation

Following sampling at each location, the sample bottles will be placed in a cooler with ice for preservation and transport.

2.3.4.7 Field Quality Assurance

Equipment and trip blanks will be prepared, handled and analyzed as groundwater samples to ensure cross-contamination has not occurred. Trip blanks will be prepared before leaving the laboratory to ensure the sample containers or handling processes have not affected the sample quality. Equipment blanks will be poured through the bailer into laboratory prepared sampling containers at the time of sampling to ensure the field conditions, equipment and handling during sampling collection have not affected the sample quality. This sample will be collected using the same equipment utilized for well sampling. A duplicate groundwater sample may be collected from a single well as a laboratory accuracy check. Blanks and duplicate containers, preservatives, handling and transport procedures for surface water samples are identical to those noted for groundwater samples. Additional information on Field Quality Assurance can be found in Section 3.0.

2.3.4.8 Sample Containers

Sample containers will be provided by the laboratory for each sampling event. Containers must be either new, factory-certified analytically clean by the manufacturer, or cleaned by the laboratory prior to shipment for sampling. Laboratory cleaning methods will be based on the bottle type and analyte of interest. Metal containers are thoroughly washed with non-phosphate detergent and tap water and rinsed with (1:1) nitric acid, tap water, (1:1) hydrochloric acid, tap water and non-organic water, in that order. Organic sample containers are thoroughly washed with non-phosphate detergent in hot water and rinsed with tap water, distilled water, acetone, and pesticide quality hexane, in that order. Other sample containers are thoroughly washed with non-phosphate detergent and tap water, rinsed with tap water, and rinsed with non-organic water. The laboratory will provide proper preservatives in the sample containers prior to shipment.

2.4 SURFACE WATER SAMPLE COLLECTION

This section presents procedure and equipment details required to perform surface water field measurements and sampling from springs, streams and ponds during each monitoring event.

2.4.1 Surface Water Level Observations

Surface water quality analyses are sensitive to site hydrologic conditions and recent precipitation events. Water levels may fluctuate significantly in comparison the groundwater table and may result in either diluting or increasing contaminant loading. Sampling event scheduling and the interpreted surface water data must account for recent weather and sampling station conditions.

2.4.1.1 Monitoring Conditions

Surface water level and sampling station conditions may be observed one day prior to and during each sampling event, if warranted by site conditions. Surface water observations will include the flood stage in streams, seasonal base flow conditions, and confirmation of location and timing for meaningful surface water quality sampling. The following objective observations will be recorded in a dedicated field book prior to sample collection:

- Relative stream water level;
- Surface water clarity; and
- Changes in surface monitoring station conditions and surroundings.

2.4.1.2 Monitoring Condition Modification

Modifications to surface sampling station conditions may be required prior to each sampling event. These modifications may include surface and submerged debris removal, slightly deepening the location to allow sample container immersion, or channeling/piping to consolidate local discharge. When modifications are required, sufficient time will be allowed for suspended solid settlement between the disturbance and sample collection. A four-hour minimum settling period prior to sampling will be observed.

2.4.2 Sample Collection

2.4.2.1 Collection Procedure

Surface water samples will be obtained from areas of minimal turbulence and aeration. Samples will be collected if flowing water is observed during the sampling event. New powder-free, surgical gloves will be donned prior to sample collection. The following procedure will be implemented regarding surface water sampling:

1. Put-on new powder-free surgical gloves.

2. Hold the bottle by the bottom with one hand and remove the cap with the other.

3. Push the sample container slowly into the water and tilt up toward the current to fill. A water depth of six inches is generally satisfactory. The sampler will avoid breaching the surface or losing sample preservatives while filling the container.

4. If there is little current movement, the container should be moved slowly, in a lateral, side to side direction, with the mouth of the container pointing

upstream.

2.4.2.2 Field Parameters

Temperature, pH, specific conductivity, and turbidity will be logged at the start of sampling as a measure of field conditions and check for groundwater stability over time. Temperature, pH, specific conductivity, and turbidity measurements will be recorded for surface water samples. Temperature, pH, conductivity, and turbidity meter calibration will be completed at the beginning of each sampling event, according to the manufacturers' specifications and consistent with Test Methods for Evaluating Solid Waste - Physical/Chemical Methods (SW-846).

2.4.2.3 Observation

Surface water samples will be collected and contained in the order of parameter volatilization sensitivity as follows:

- Volatile Organics and Volatile Inorganics;
- Extractable Organics, Petroleum Hydrocarbons, Aggregate Organics and Oil and Grease;
- Total Metals;
- Inorganic Nonmetallics, Physical /Aggregate Properties, Biologicals;
- Microbiologicals.

Surface water samples will be collected unfiltered. If future dissolved metal analysis is required, samples will be prepared by field filtration using a decontaminated peristaltic filtering pump (or equivalent) and a disposable 0.45 micron filter cartridge manufactured for this purpose.

Surface water samples will be collected from surface water monitoring points shown on the attached Figure 1. Samples will be collected directly from the station in the container that has been prepared for the preservation and storage of compatible parameters. Samples will be collected in a manner that assures minimum agitation. Additional blanks and duplicate samples will not be collected with the surface water samples.

2.4.2.4 Decontamination

Field meters which might contact surface water samples will be thoroughly decontaminated between stations by washing with non-phosphate soapy, de-ionized water and rinsed with isopropanol and organic-free water. Detailed equipment decontamination procedures are detailed in Section 2.3.1.3.

2.4.2.5 Sample Containers

Sample containers will be prepared and provided by the laboratory for each surface water sampling event. Each container's preparation and preservatives will be the same as those utilized for groundwater sampling and addressed previously in Section 2.3.4.8.

3.0 FIELD QA/QC PROGRAM

3.1 OVERVIEW

Field Quality Assurance/Quality Control (QA/QC) requires the routine collection and analysis of trip blanks to verify that the handling process has not affected the quality of the samples. Contaminants found in the trip blanks could be attributed to:

1. Interaction between the sample and the container;
2. Contaminated source water; or
3. A handling procedure that alters the sample.

3.2 BLANK SAMPLES

3.2.1 Trip Blanks

The laboratory will prepare a trip blank by filling sample bottles with laboratory grade distilled or deionized water. Trip blanks will be placed in bottles of the specific type required for the analyzed parameters from a bottle pack specifically assembled by the laboratory for each groundwater sampling event. Trip blanks will be transported with the empty bottle packs and remain in the coolers throughout the sampling event. The blanks will be analyzed for volatile and purgeable organics.

3.2.2 Equipment Blanks

For wells sampled with non-dedicated equipment, equipment blank samples will be collected at a rate of one sample every other day. To collect a "field" or "equipment" blank, a bailer will be filled with non-organic (milli-Q) water. Handling the bailer in a manner identical to well sampling, the water is transferred into equipment blank sample collection jars for the specified analysis. These samples are packed and sent to the laboratory with the other samples.

3.3 BLANK CONCENTRATIONS

The concentration levels of contaminants found in the trip or equipment blanks will be reported but will not be used to immediately correct the groundwater data. In the event that elevated parameter concentrations are found in a blank, the analysis will be flagged for further evaluation and possible re-sampling.

3.4 FIELD INSTRUMENTS

Field instruments utilized to measure groundwater characteristics will be calibrated prior to entering the field and recalibrated in the field as required to insure accurate measurement for each sample. The specific conductivity and pH meter shall be recalibrated utilizing two prepared solutions of known concentration in the range of anticipated values. A permanent thermometer, calibrated against a National Bureau of Standards Certified thermometer, will be used for temperature meter calibration. Other field equipment should be calibrated at least daily using the manufacturer's recommended specifications.

4.0 SAMPLE PRESERVATION AND SHIPMENT

4.1 OVERVIEW

Sample preservation, shipment, and chain-of-custody procedures to be observed between sampling and laboratory analysis are presented in the following sections.

4.2 SAMPLE PRESERVATION

Pre-measured chemical preservatives will be provided by the analytical laboratory. Hydrochloric acid will be used as a chemical stabilizer and preservative for volatile and purgeable organic specimens. Nitric acid will be used as the preservative for samples for metals analysis.

4.3 STORAGE/TRANSPORT CONDITIONS

Proper storage and transport conditions must be maintained to preserve sample integrity between collection and analysis. Ice and chemical cold packs will be used to cool and preserve samples, as directed by the analytical laboratory. Samples will be maintained at a temperature of 4° C. Dry ice is not to be used. Samples will be packed and/or wrapped in plastic bubble wrap to inhibit breakage or accidental spills.

Chain-of-Custody control documents will be placed in a waterproof pouch and sealed inside the cooler with the samples for shipping. Tape and/or custody seals will be placed on the outside of the shipping coolers, in a manner to prevent and detect tampering with the samples.

4.4 SAMPLE DELIVERY

Samples will be delivered to the analytical laboratory within a reasonable period of time in person or using an overnight delivery service to insure hold times are not exceeded. If samples are not shipped the same day, the ice used to keep the samples cool will be replenished to maintain the required 4° C temperature. Shipment and sample receipt will be coordinated with the laboratory. Do NOT store or ship highly contaminated samples (concentrated wastes, free product, etc.) or samples suspected of containing high concentrations of contaminants in the same cooler or shipping container with other environmental samples.

4.5 CHAIN OF CUSTODY

Chain-of-Custody control will be maintained from sampling through analysis to prevent tampering with analytical specimens. Chain-of-Custody control procedures for samples consist of the following:

1. Chain-of-Custody will originate at the laboratory with the shipment of prepared sample bottles and a sealed trip blank. Identical container kits will be shipped by express carrier to the sampler or site or picked up at the laboratory in sealed coolers.

2. Upon receipt of the sample kit, the sampler will inventory the container kit and check its consistency with number and types of containers indicated in the Chain-of-Custody forms and required for the sampling event.

3. Labels for individual sample containers will be completed, indicating the site, sampling time, sampling date, sample location/well number and preservation methods used for the sample (if any).

4. Collected specimens will be placed in ice filled coolers and will remain in the continuous possession of the field technician until shipment or transferal as documented by the Chain-of-Custody form has occurred. If continuous possession can not be maintained by the field technician, the coolers will be temporarily sealed and placed in a secure area.

5. Upon delivery to the laboratory, samples will be given laboratory sample numbers and recorded into a logbook indicating client, well number and delivery date and time. The laboratory director or his designee will sign the Chain-of-Custody control forms to formally receive the samples. The field technician, project manager and the laboratory director will work together to ensure that proper refrigeration of the samples is maintained.

6. Complete Chain-of-Custody form copies will be placed in the laboratory's analytical project file and attached to the laboratory analysis report upon completion.

Chain-of-Custody forms will be used to transfer direct deliveries from the sampler to the laboratory. A coded, express delivery shipping bill shall constitute the Chain-of Custody between the sampler and laboratory for overnight courier deliveries.

5.0 LABORATORY ANALYSIS

5.1 OVERVIEW

The ground and surface water parameters will be analyzed for field indicators of water quality (pH, conductivity, temperature, and turbidity) and those constituents listed in Table 1. Analytical methods from Test Methods For Evaluating Solid Waste - Physical/Chemical Methods (SW-846) or Methods For the Chemical Analysis of Water and Wastes will be used and be consistent with the Division of Waste Management's policies regarding analytical methods and reporting limits. Analysis will be performed by a laboratory certified by the North Carolina DENR for the analyzed parameters.

5.2 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

Formal environmental laboratory Quality Assurance/Quality Control (QA/QC) procedures are to be utilized throughout the event. The landfill owner/operator is responsible for selecting a laboratory contractor and ensuring that laboratory is utilizing proper QA/QC procedures. The laboratory must have a QA/QC program based on specific routine procedures outlined in a written laboratory Quality Assurance/Quality Control Manual. The QA/QC procedures listed in the manual shall provide the lab with the necessary assurances and documentation that accuracy and precision goals are achieved in analytical determinations. Internal quality control checks will be undertaken regularly by the lab to assess the precision and accuracy of analytical procedures.

5.3 LABORATORY QUALITY CONTROL CHECKS

The internal quality control checks include the use of calibration standards, standard references, duplicate samples and spiked or fortified samples. Calibration standards will be verified against a standard reference obtained from a second (alternate) source. For most analytical methods calibration curves shall be developed using at least one blank and three standards. Samples will be diluted, if necessary, to ensure that analytical measurements fall within the linear portion of the calibration curve. Where required, duplicate samples shall be processed at an average frequency of 10 percent to assess the precision of testing methods, and standard references shall be processed not less than monthly to assess the accuracy of analytical procedures. Method or procedural blanks and spiked or fortified samples shall be carried through all stages of sample preparation and measurement to validate the efficiency and accuracy of the analysis.

5.4 DATA REVIEW

During the analyses, quality control and sample data shall be reviewed by the laboratory manager to identify questionable data and determine if the necessary QA/QC requirements are being followed. If a portion of the lab work is subcontracted, it is the responsibility of the contracted laboratory to verify that the subcontracted work is performed by certified laboratories, using identical QA/QC procedures.

6.0 RECORD KEEPING AND REPORTING

6.1 OVERVIEW

This section addresses documentation and reporting requirements associated with the WQMP implementation.

6.1 FIELD LOGBOOK

The field technician will keep an up-to-date logbook documenting important information pertaining to the technician's field activities. The field logbook will document the following:

- Site Name and Location;
- Date and Time of Sampling;
- Climatic Conditions During Sampling Event;
- Sampling Point/Well Identification Number;
- Well Static Water Level;
- Height of Water Column in Well;
- Purged Water Volume and Well Yield (High or Low);
- Presence of Immiscible Layers and Detection Method;
- Observations on Purging and Sampling Event;
- Sample Collection Time;
- Temperature, pH, Temperature, DO, ORP, Turbidity and Conductivity Readings;
- Field Technician Signature;
- Relative stream water level ;
- Surface water clarity; and
- Changes in surface monitoring station conditions and surroundings.

6.2 GROUNDWATER SYSTEM EVALUATIONS

After each monitoring event, the potentiometric surface will be evaluated to determine whether the monitoring system remains adequate and to determine the rate and direction of groundwater flow at the site. The direction of groundwater flow will be determined by a comparison of groundwater surface elevations across the site through the construction of a potentiometric surface map. Groundwater flow rate will be determined using the following equation:

$$V = KI/n$$

Where: V = Velocity (feet/day)
K = Hydraulic Conductivity (feet/day)
I = Hydraulic Gradient (foot/foot)
n = Effective Porosity of aquifer soils (unit less)

If evaluation indicates the groundwater monitoring network is insufficient in meeting the rule requirements, the monitoring network will be modified accordingly and a work plan will be submitted to NCDENR for review prior to modifications to enhance the monitoring system.

6.3 RESULT REPORTING

Laboratory analytical data will be forwarded to the DWM within 60 calendar days of the receipt. The analytical data submitted will specify the sample collection date, the sampling point identification and include a sampling location map. Should a significant concentration of contaminants be detected in ground and surface water, as defined in North Carolina Solid Waste Rules, Groundwater Quality Standards, or Surface Water Quality Standards, the County will notify the DWM and will place a notice in the landfill records as to which constituents were detected.

Monitoring reports will be submitted with the following:

1. A potentiometric surface evaluation
2. Analytical laboratory reports and summary tables
3. A Solid Waste Environmental Monitoring Data Form (included in **Appendix A**)
4. Laboratory Data submitted in accordance with the Electronic Data Deliverable Template.

Monitoring reports may be submitted electronically by e-mail or in paper copy form. Copies of laboratory results and water quality reports for the Johnston County Landfill will be kept at the landfill office. Reports summarizing groundwater quality results and data evaluation will be submitted to the Division of Waste Management for each sampling event. Depending on the analytical results received, graphical analyses may be performed to evaluate plume movement and contaminant trends over time.

7.0 MONITORING PROGRAM MODIFICATIONS

7.1 OVERVIEW

This section addresses the procedures that should be followed with respect to water quality program modifications.

7.2 WELL ABANDONMENT/REHABILITATION

After each groundwater monitoring event, the potentiometric surface will be evaluated to determine whether the monitoring system remains adequate and to determine the rate and direction of groundwater flow at the site.

Should wells become irreversibly damaged or require rehabilitation, the DWM) will be notified. If monitoring wells and/or piezometers are damaged irreversibly they will be abandoned under the direction of the DWM. The abandonment procedure in unconsolidated materials will consist of over-drilling and/or pulling the well casing and plugging the well with an impermeable, chemically-inert sealant such as neat cement grout and/or bentonite clay. For bedrock well completions the abandonment will consist of plugging the interior well riser and screen with an impermeable neat cement grout and/or bentonite clay sealant.

7.3 ADDITIONAL WELL INSTALLATIONS

Additional well installations will be carried out in accordance with DWM directives. If the potentiometric maps reveal that the depth, location, or number of wells is insufficient to monitor potential releases of solid waste constituents from the landfill units, new well locations and depths will be submitted to the DWM for approval.

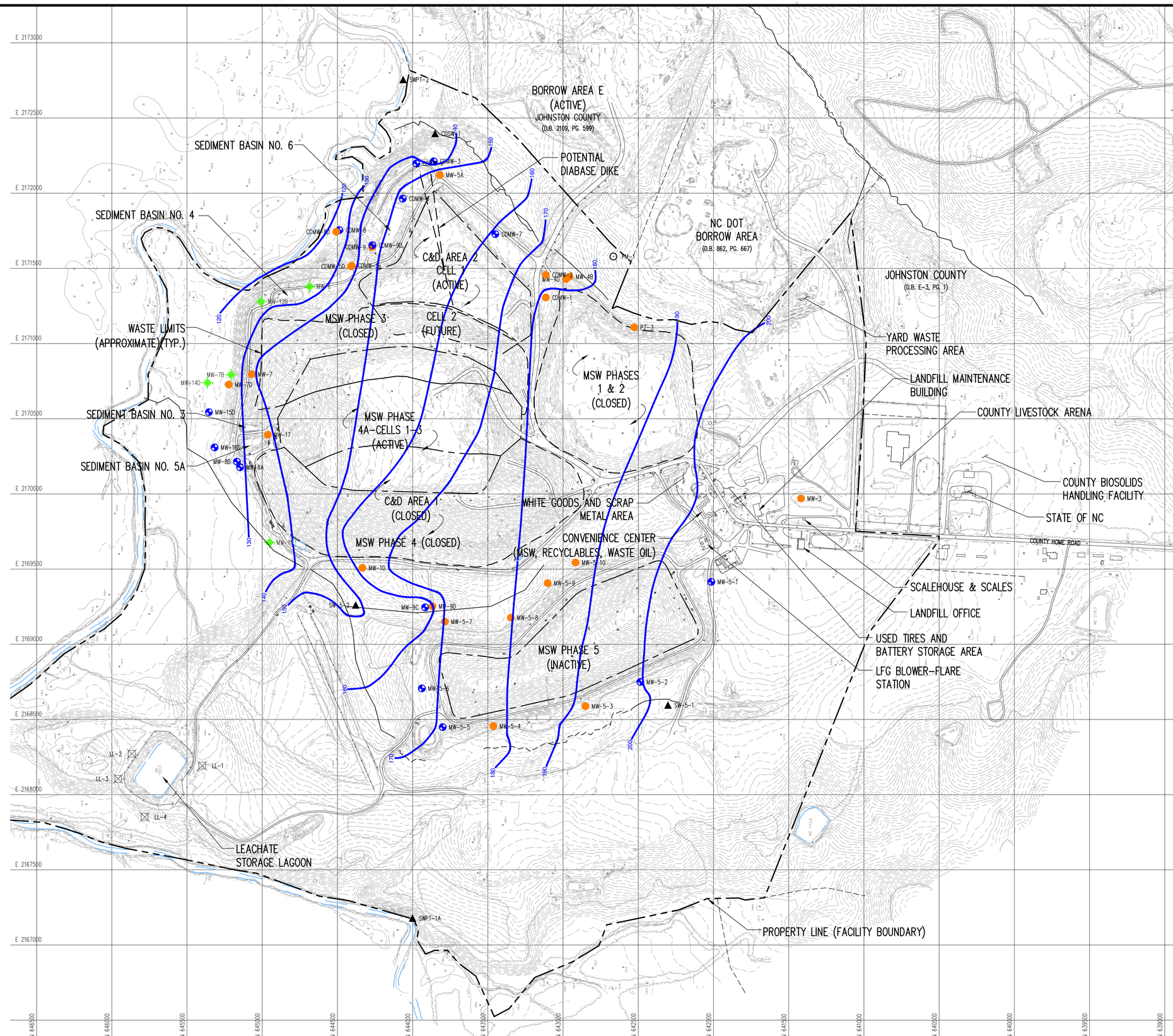
Monitoring wells will be installed under the supervision of a geologist or engineer who is registered in North Carolina and who will certify to the DWM that the installation complies with the North Carolina Regulations. Following installation, the documentation for the well construction will be submitted by the registered geologist or engineer within 30 days.

7.4 IMPLEMENTATION SCHEDULE

This Monitoring Program will be implemented with the approval of this Water Quality Monitoring Plan.

Figure

Johnston County Landfill
Water Quality Monitoring Plan
Solid Waste Permit No. 51-03



LEGEND

- EXISTING 10' CONTOUR (SEE REFERENCE 1)
- EXISTING 2' CONTOUR
- PROPERTY LINE (FACILITY BOUNDARY)
- PROPERTY LINE (OTHER)
- LIMIT OF LINER (EXISTING LINED UNITS)
- APPROXIMATE EXISTING WASTE LIMITS (UNLINED UNITS)
- EXISTING STREAM
- DIABASE DIKE
- POTENTIOMETRIC SURFACE CONTOUR
- CDMW-1 — EXISTING MONITORING WELL (REMOVED FROM MONITORING NETWORK)
- MW5-1 — DETECTION MONITORING LOCATION (SEMI-ANNUAL SAMPLING)
- MW-6 — ASSESSMENT MONITORING LOCATION (ANNUAL APP II & SEMI-ANNUAL APP I)
- LL-1 — LEACHATE MONITORING LOCATION
- PM-1 — PROPOSED DETECTION MONITORING LOCATION
- SW-5-2 — SURFACE WATER MONITORING LOCATION

NOTE

1. GROUNDWATER CONTOURS REFLECT POTENTIOMETRIC SURFACE CREATED BASED ON SPRING 2012 SAMPLING MEASUREMENTS.

REFERENCE

1. OVERALL SITE TOPOGRAPHY PROVIDED BY GEODATA CORPORATION, BASED ON MARCH 8, 2001 AERIAL PHOTOGRAPHY. TOPOGRAPHY IN LANDFILL AREA AND BORROW AREA PROVIDED BY GEODATA CORPORATION BASED ON JUNE 14, 2013 AERIAL PHOTOGRAPHY.

0 300' 600' 900'

PREPARED FOR:

JOHNSTON COUNTY NORTH CAROLINA DEPARTMENT OF PUBLIC UTILITIES

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+ GARDNER
ENGINEERS
14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

SEAL

SEAL

REV.	DATE	DESCRIPTION

PROJECT TITLE:

JOHNSTON COUNTY LANDFILL

DRAWING TITLE:

WATER QUALITY MONITORING NETWORK

DESIGNED: J.A.S.	PROJECT NO: JOHN 12-4
DRAWN: K.C.B.	SCALE: AS SHOWN
APPROVED:	DATE: JULY 2013
FILENAME: JOHN-D0679	
SHEET NUMBER:	DRAWING NUMBER: FIG.1

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Tables

Johnston County Landfill
Water Quality Monitoring Plan
Solid Waste Permit No. 51-03

Well	Date Installed	Northing	Easting	Ground Surface Elevation	Top of Casing Elevation	Well Depth	Bottom Elevation	Screen Interval	Screen Lithology	Notes
Proposed Groundwater Detection Monitoring Network										
CDMW-3	8/28/2006	643860.05	2172212.35	167.70	170.65	36	131.70	26-36	NA	monitors diabase dike
CDMW-4	8/28/2006	643975.97	2172197.24	169.90	172.84	45	124.90	35-45	NA	monitors diabase dike
CDMW-6*	6/16/2004	644066.12	2171963.60	160.00	162.12	31.5	128.50	21.5-31.5	bedrock	
CDMW-7*	6/16/2004	643451.38	2171727.87	172.00	175.27	45	127.00	35-45	mudstone	
CDMW-8*	6/17/2004	644487.10	2171754.20	126.00	127.41	10	116.00	5-10	silty sand	
CDMW-9D	7/8/2003	644268.20	2171653.67	157.60	160.71	45	112.60	40-45	metamudstone	
MW-8D	12/7/1999	645168.55	2170214.84	152.26	153.44	33	119.26	28-33	metamudstone	
MW-9C	NA	643917.72	2169245.90	165.30	167.89	NA	NA	NA	NA	
MW-15D	6/26/2003	645354.15	2170543.68	125.60	128.70	24	101.60	19-24	metamudstone	
MW-16D	6/26/2003	645317.05	2170309.20	130.60	133.96	24	106.60	18-23	metamudstone	
MW5-1	4/16/1997	642015.58	2169415.40	229.62	232.17	30	199.62	14-29	silty sand with gravel	Site background well
MW5-2	4/22/1997	642487.14	2168749.63	211.23	206.77	22	189.23	5-20	silty clay	
MW5-5	4/22/1997	643800.44	2168449.11	197.73	185.42	22	175.73	5-20	silty clay	
MW5-6	4/22/1997	643938.92	2168706.91	195.12	199.11	39	156.12	21-36	silty clay	
PM-1	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	proposed replacement for PZ-3, MW-4B & CDMW-2
LL-1	NA	645398.84	2168192.54	151.50	153.82	NA	NA	NA	NA	Leachate Lagoon Monitoring Location
LL-2	NA	645867.44	2168271.33	148.10	150.33	NA	NA	NA	NA	Leachate Lagoon Monitoring Location
LL-3	NA	645957.48	2168106.00	149.03	151.57	NA	NA	NA	NA	Leachate Lagoon Monitoring Location
LL-4	NA	1/31/3668	5/16/7835	136.44	138.81	NA	NA	NA	NA	Leachate Lagoon Monitoring Location
Proposed Groundwater Assessment Monitoring Network										
MW-6	6/14/1991	644684.58	2171378.66	161.78	166.60	50	111.78	30-50	slate	
MW-7B	9/10/1993	645206.96	2170792.55	127.84	129.84	18	109.84	6-16	saprolite	
MW-11	9/15/1994	644950.77	2169676.92	134.00	144.32	25	109.00	14-24	clayey silt	
MW-12B	4/24/1997	645008.00	2171279.00	153.82	156.12	38	115.82	21.5-36.5	PWR - slate	
MW-14D	6/26/2003	645363.72	2170739.06	125.50	128.66	31	94.50	26-31	metamudstone	
Existing Wells - Proposed for Removal from Monitoring Network										
CDMW-1	8/29/2006	643114.61	2171305.99	186.70	189.46	20	166.70	5-20	NA	interior location - RFN
CDMW-2	8/29/2006	643114.86	2171456.69	183.20	186.13	20	163.20	5-20	NA	redundant, replaced - RFN
CDMW-5	8/29/2006	644405.08	2171517.29	164.20	167.39	34	130.20	19-34	NA	interior location - RFN
CDMW-5D	8/29/2006	644409.22	2171513.79	164.40	167.43	47	117.40	36-47	NA	interior location - RFN
CDMW-8D*	6/21/2004	644509.00	2171743.00	125.00	127.63	30	95.00	35-30	mudstone	historically dry - RFN
CDMW-9	3/10/2008	644270.74	2171641.69	157.70	160.50	30	127.70	20-30	siltstone	interior location - RFN
PZ-3	12/8/1998	642528.15	2171107.90	194.17	194.91	15	179.17	5-15	silty sand	replaced - RFN
MW-3	4/16/1991	641418.01	2169969.56	233.60	234.16	28	205.60	17.8-27.8	sand	interior location (between landfills) - RFN
MW-4B	9/10/1993	642957.03	2171444.05	179.57	182.97	20	159.57	8-18	sandy silty clay	replaced - RFN
MW-4D	12/15/1998	642980.96	2171427.56	182.74	182.98	68	114.74	63-68	metamudstone	interior location - RFN
MW-5A	12/8/1998	643820.20	2172120.74	171.90	173.70	24	147.90	14-24	sandy silt	interior location - RFN
MW-7	6/14/1991	645068.98	2170795.87	164.55	163.24	35	129.55	20-35	clay	interior location - RFN
MW-7D	12/8/1998	645222.32	2170726.50	126.89	127.91	30	96.89	25-30	metamudstone	interior location - RFN
MW-8A	NA	645147.30	2170177.01	NA	NA	NA	NA	NA	NA	redundant - RFN
MW-9D	12/7/1998	643868.45	2169252.80	166.08	170.25	40	126.08	35-40	metamudstone	redundant - RFN
MW-10	9/15/1994	644334.57	2169508.35	167.79	175.65	35	132.79	19-34	clayey silt	redundant & cross-gradinet - RFN
MW-17	NA	644963.10	2170393.58	NA	NA	NA	NA	NA	NA	interior location - RFN
MW5-3	4/22/2997	642851.56	2168588.27	205.58	203.80	22	183.58	5-20	silty clay	redundant & cross-gradinet - RFN
MW5-4	4/22/1997	643464.18	2168455.67	191.84	186.58	22	169.84	5-20	sandy clayey silt	cross gradient - RFN
MW5-7	4/18/1997	643786.20	2169150.69	167.96	182.73	23	144.96	6-21	silt	interior location (between landfills) - RFN
MW5-8	4/21/1997	643347.86	2169177.25	183.10	189.31	22	161.10	5-20	silt	interior location (between landfills) - RFN
MW5-9	3/18/1995	643102.64	2169406.82	194.51	198.31	30	164.51	NA	clayey silt	interior location (between landfills) - RFN
MW5-10	4/21/1997	642917.77	2169543.59	198.56	202.88	25	173.56	8-28	sand	interior location (between landfills) - RFN

Well	Date Installed	Northing	Easting	Ground Surface Elevation	Top of Casing Elevation	Well Depth	Bottom Elevation	Screen Interval	Screen Lithology	Notes
Surface Water Monitoring Locations										
CDSW-1	NA	644527.55	2171717.4	NA	NA	NA	NA	NA	NA	
SWPT-1	NA	643982.528	2166379.022	NA	NA	NA	NA	NA	NA	
SWPT-2	NA	644062.774	2172755.306	NA	NA	NA	NA	NA	NA	
SW5-1	NA	642303.119	2168595.202	NA	NA	NA	NA	NA	NA	
SW5-2	NA	644378.433	2169260.65	NA	NA	NA	NA	NA	NA	
Leachate Monitoring Locations										
Phase 5	NA	NA	NA	NA	NA	NA	NA	NA	NA	Monitors Phase 5 Leachate
Phase 4A	NA	NA	NA	NA	NA	NA	NA	NA	NA	Monitors Phase 4A Leachate
Phase 4A Witness	NA	NA	NA	NA	NA	NA	NA	NA	NA	Monitors Phase 4A Leak Detection Zone (double liner)
C&D	NA	NA	NA	NA	NA	NA	NA	NA	NA	Monitors C&D Landfill Leachate

NA = Not Available
RFN - Removed from Groundwater Monitoring Network
* Groundsurface estimated from topography shown on Figure 1

Table 2
Water Quality Monitoring Parameters
Johnston County Landfill Facility

Appendix I Constituents	Synonyms
Antimony	
Arsenic	
Barium	
Beryllium	
Cadmium	
Chromium	
Cobalt	
Copper	
Lead	
Nickel	
Selenium	
Silver	
Thallium	
Vanadium	
Zinc	
Temperature	
pH	
Turbidity	
Specific Conductance	
Acetone	2-Propanone
Acrylonitrile	2-Propenenitrile
Benzene	
Bromochloromethane	Chlorobromomethane
Bromodichloromethane	Dibromochloromethane
Bromoform	Tribromomethane
Carbon Disulfide	
Carbon Tetrachloride	Tetrachloromethane
Chlorobenzene	
Chloroethane	Ethyl chloride
Chloroform	Trichloromethane
Dibromochloromethane	Chlorodibromomethane
1,2-Dibromo-3-chloropropane	DBCP
1,2-Dibromoethane	Ethylene dibromide, EDB
1,2-Dichlorobenzene	o-Dichlorobenzene
1,4-Dichlorobenzene	p-Dichlorobenzene
trans-1,4-Dichloro-2-butene	
1,1-Dichloroethane	Ethyldidene chloride
1,2-Dichloroethane	Ethylene dichloride
1,1-Dichloroethylene	Vinylidene chloride
cis-1,2-Dichloroethylene	
trans-1,2-Dichloroethylene	
1,2-Dichloropropane	Propylene dichloride
cis-1,3-Dichloropropene	
trans-1,3-Dichloropropene	
Ethylbenzene	
2-Hexanone	Methyl butyl ketone
Methyl bromide	Bromomethane
Methyl chloride	Chloromethane
Methyl ethyl ketone	2-Butanone
Methyl iodide	Iodomethane
4-Methyl-2-pentanone	Methyl isobutyl ketone
Methylene bromide	Dibromomethane
Methylene chloride	Dichloromethane
Styrene	Ethenylbenzene
1,1,1,2-Tetrachloroethane	
1,1,2,2-Tetrachloroethane	
Tetrachloroethylene	Perchloroethylene
Toluene	Methyl benzene
1,1,1-Trichloroethane	Methyl chloroform
1,1,2-Trichloroethane	
Trichloroethylene	
Trichloroflouromethane	CFC-11
1,2,3-Trichloropropane	
Vinyl acetate	Acetic acid, ethenyl ester
Vinyl chloride	Choroethene
Xylenes	Dimethyl benzene
Leachate Additional Parameters:	
BOD	
COD	
phosphate	
nitrate	
sulfate	

Appendix A

Johnston County Landfill
Water Quality Monitoring Plan
Solid Waste Permit No 51-03

DENR USE ONLY: ☐ Paper Report ☐ Electronic Data - Email CD (data loaded: Yes / No) Doc/Event #:

NC DENR
Division of Waste Management - Solid Waste

Environmental Monitoring Reporting Form

Notice: This form and any information attached to it are "Public Records" as defined in NC General Statute 132-1. As such, these documents are available for inspection and examination by any person upon request (NC General Statute 132-6).

Instructions:

- **Prepare one form for each individually monitored unit.**
- **Please type or print legibly.**
- Attach a notification table with values that attain or exceed NC 2L groundwater standards or NC 2B surface water standards. The notification must include a preliminary analysis of the cause and significance of each value. (e.g. naturally occurring, off-site source, pre-existing condition, etc.).
- Attach a notification table of any groundwater or surface water values that equal or exceed the reporting limits.
- Attach a notification table of any methane gas values that attain or exceed explosive gas levels. This includes any structures on or nearby the facility (NCAC 13B .1629 (4)(a)(i).
- Send the original signed and sealed form, any tables, and Electronic Data Deliverable to: Compliance Unit, NCDENR-DWM, Solid Waste Section, 1646 Mail Service Center, Raleigh, NC 27699-1646.

Solid Waste Monitoring Data Submittal Information

Name of entity submitting data (laboratory, consultant, facility owner):

Contact for questions about data formatting. Include data preparer's name, telephone number and E-mail address:

Name: _____ Phone: _____

E-mail: _____

Facility name:	Facility Address:	Facility Permit #	NC Landfill Rule: (.0500 or .1600)	Actual sampling dates (e.g., October 20-24, 2006)

Environmental Status: (Check all that apply)

☐ Initial/Background Monitoring ☐ Detection Monitoring ☐ Assessment Monitoring ☐ Corrective Action

Type of data submitted: (Check all that apply)

☐ Groundwater monitoring data from monitoring wells
☐ Groundwater monitoring data from private water supply wells
☐ Leachate monitoring data
☐ Surface water monitoring data
☐ Methane gas monitoring data
☐ Corrective action data (specify) _____
☐ Other(specify) _____

Notification attached?

☐ No. No groundwater or surface water standards were exceeded.
☐ Yes, a notification of values exceeding a groundwater or surface water standard is attached. It includes a list of groundwater and surface water monitoring points, dates, analytical values, NC 2L groundwater standard, NC 2B surface water standard or NC Solid Waste GWPS and preliminary analysis of the cause and significance of any concentration.
☐ Yes, a notification of values exceeding an explosive methane gas limit is attached. It includes the methane monitoring points, dates, sample values and explosive methane gas limits.

Certification

To the best of my knowledge, the information reported and statements made on this data submittal and attachments are true and correct. Furthermore, I have attached complete notification of any sampling values meeting or exceeding groundwater standards or explosive gas levels, and a preliminary analysis of the cause and significance of concentrations exceeding groundwater standards. I am aware that there are significant penalties for making any false statement, representation, or certification including the possibility of a fine and imprisonment.

Facility Representative Name (Print) Title (Area Code) Telephone Number

Affix NC Licensed/ Professional Geologist Seal

Signature Date

Facility Representative Address

NC PE Firm License Number (if applicable effective May 1, 2009)

Revised 6/2009

Landfill Gas Monitoring Plan

Johnston County Landfill Facility
Solid Waste Permit No. 51-03

Prepared for:

Johnston County Department of Public Utilites
Smithfield, North Carolina

Original Submittal:
September 2013

Revised:
March 2014

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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Landfill Gas Monitoring Plan

Johnston County Landfill Facility
Solid Waste Permit No. 51-03

Prepared For:

Johnston County Department of Public Utilites
Smithfield, North Carolina

S+G Project No.Johnston 12-4

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Original Submittal:
September 2013

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March 2014

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Johnston County Landfill Facility
Smithfield, North Carolina

Landfill Gas Monitoring Plan

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- Figure 1 Site Map
- Figure 2 Landfill Gas Monitoring Plan

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1.0 INTRODUCTION

This Landfill Gas (LFG) Monitoring Plan (plan) prepared by Smith Gardner, Inc. presents a comprehensive landfill gas (LFG) monitoring program for the Johnston County Landfill Facility (NC Solid Waste Permit 51-03), which is located off of Country Home Road in Smithfield, North Carolina. This plan describes the necessary procedures to satisfy applicable regulatory requirements (see **Section 1.1**) for landfill gas monitoring.

The Engineer has utilized the best available site data, practices, experience, and judgment to develop this plan. However, the plan may require modifications over time to accommodate changing landfill conditions, changing receptors in areas adjacent to and around the landfill, or other conditions that cannot be fully anticipated.

Uncontrolled migration of LFG (particularly methane (CH_4)) can result in, loss of life, injury, loss of property, vegetative damage, and intolerable odors. Landfill monitoring includes exposure to explosive gases. Monitoring personnel should be specifically trained in the management and response for situations such as fire or explosion and confined space entry and possess an awareness of changing conditions around the landfill.

Note that this plan does not address landfill gas collection and control, air quality, or other related landfill gas regulations or requirements which may be applicable to this site at present or in the future.

1.1 Regulatory Requirements

Rules 15A NCAC 13B. .0544(d) and 1626(4) of the North Carolina Solid Waste Management Rules requires the following for facilities having a MSW landfill:

- Owners or operators of C&D and MSW landfill units must ensure that:
    - the concentration of methane gas generated by the facility does not exceed 25% of the lower explosive limit (LEL) for methane (1.25% methane) in facility structures (excluding gas control or recovery system components); and
    - the concentration of methane gas does not exceed the LEL for methane (5% methane) at the facility property boundary.

- Owners or operators of C&D and MSW landfill units must implement a routine methane monitoring program and perform monitoring on at least a quarterly basis.

- If regulatory limits for methane gas concentrations are exceeded, a contingency plan must be implemented for the protection of human health and safety.

1.2 Guidance Document

This plan was developed generally following the Landfill Gas Monitoring Guidance document prepared by the North Carolina Department of Environment and Natural Resources (NC DENR), Division of Waste Management (DWM)[1].

1.3 Contact Information

Correspondence and questions concerning this plan should be directed to the appropriate contact below:

1.3.1 Owner

Johnston County
Johnston County Solid Waste Management Department
680 County Home Road
P.O. Box 2263
Smithfield, North Carolina 27577
Phone: (919) 938-4750

Contact: Rick Proctor, Director
rick.proctor@johnstonnc.com

1.3.2 Engineer

Smith Gardner, Inc.
14 N. Boylan Avenue
Raleigh, North Carolina 27603
Phone: (919) 828-0577

Contacts: Joan A. Smyth, P.G., Senior Hydrogeologist
joan@smithgardnerinc.com
Pieter K. Scheer, P.E., Project Manager
pieter@smithgardnerinc.com

1.3.3 North Carolina Department of Environment and Natural Resources Division of Waste Management (DWM) - Solid Waste Section:

Raleigh Central Office (RCO)
217 W Jones Street
Raleigh, North Carolina 27603
Phone: (919) 707-8200

[1] NC DENR DWM (2010), "Landfill Gas Monitoring Guidance", NC DENR DWM Solid Waste Section, November 2010.

Fayetteville Regional Office (FRO)
225 Green Street, Suite 714
Fayetteville, North Carolina 28301
Phone: (910) 486-1541
Fax: (910) 486-0707

Division of Waste Management (DWM) – Solid Waste Section

Field Operations Branch Head:	TBD
Eastern District Supervisor:	Dennis Shackelford (FRO)
Waste Management Specialist:	Mary Whaley ((919) 693-5023)

1.4 Existing Site Conditions

The site is located approximately 5 miles east of Smithfield off Hwy 210 in Johnston County. The landfill facility includes unlined (closed) Phases 1 – 4, lined (active) Phase 4a, lined (inactive) Phase 5, the lined (active) C&D landfill, the offices and scalehouse. There are existing landfill gas monitoring wells and three passive landfill gas trenches located on-site. The site is primarily surrounded by undeveloped land.

Site topography ranges from 120 to 289 feet above mean sea level (fmsl) between the top of Phase 5 and Middle Creek to the north and northeast of the site. The site is bounded by two streams, Middle Creek to the north, and an unnamed tributary of Middle Creek to the west. Additionally, Buzzard Branch (a.k.a Little Juniper Creek) is located east of the waste disposal units within the property line. Middle Creek is a perennial stream with a large flood plain along some portions of the site. Buzzard Branch and the unnamed tributary are smaller first and second order intermittent streams which lead to Middle Creek.

The facility is located approximately five miles west of Smithfield, NC. Site access is from the NC-HWY 210 and County Home Road on the southern side of the facility. The site is primarily surrounded by woodlands, agricultural fields and some homes along Highway 210, and across Middle Creek. The site's location is shown on **Figure 1**, while details of the site are shown on **Figure 2**.

1.4.1 Site Geology

The site is located in the western portion of the Coastal Plain Province in the fall zone. The formations found in this area consist of sediments of Cretaceous and Tertiary age, unconformably overlying metamorphic rocks of Pre-Cambrian to Cambrian age. The site is underlain by sediments of the Middendorf Formation which were deposited largely in a deltaic system. According to Geology of the Carolinas (Horton/Zullo, 1991) the formation consists of unfossiliferous, interbedded, thin clay and sand. The stratigraphy tends to be very discontinuous, indicating that the sediment deposits are lenticular. Most of the sediments range from silty clay to a coarse clayey sand and gravel with thin lenses of dense clay.

There are occasional concretions of iron oxide minerals which form very hard thin layers within the sand layers. The Middendorf Formation dips very gently to the east, and is underlain by highly weathered metamorphic rocks of the Carolina Slate Belt.

Borings advanced at the site encountered sandy silts consistent with the Middendorf Formation, and partially weathered rock above bedrock. The bedrock encountered was a metamorphosed mudstone. The depths of these borings ranged between 15 feet and 75 feet deep. The unconsolidated sediments consisted of mostly silty sands and sandy silts with some clayey sand as well. The metamudstone bedrock was encountered at a depth of approximately 15 feet in the floodplain around the site, and at a depth of approximately 50 feet elsewhere on-site. Diabase dikes have also been located at the site beneath the Area 2 C&D landfill unit, the floodplain of Middle Creek, and the Phase 5 MSW landfill unit.

1.4.2 Local Groundwater Regime

The uppermost aquifer at the site appears to exhibit mostly lateral flow with potentiometric surfaces that reflect a subdued expression of the surface topography. The uppermost aquifer at the site primarily consists of silty and clayey sands. Hydraulic conductivity values measured in the soil aquifer varies on the order of 0.0083 ft/day to 0.289 ft/day based upon prior investigations.

2.0 MONITORING PROGRAM

The monitoring program consists of the monitoring of LFG monitoring wells and facility structures.

2.1 Monitoring Wells

Existing and proposed monitoring wells are shown on **Figure 2**.

2.1.1 Existing LFG Monitoring Wells

The LFG monitoring network for the Johnston County Landfill includes five buildings (locations LFG-1 through LFG-5 and six existing LFG monitoring wells (LFG-6 through LFG-12)). Currently, LFG-7 is damaged and is not monitored.

2.1.2 Proposed LFG Monitoring Wells

The proposed landfill gas monitoring network has been prepared with an understanding of site geology and hydrogeology as well as an objective to monitoring the entire facility rather than the individual cells within. The close location of perennial streams to the north, east and west of the site limit the possibility of landfill gas migration in these directions. Typically, in these areas groundwater is encountered at a depth of 5 feet below grade or less (based on nearby groundwater monitoring wells).

Several existing landfill gas monitoring wells are located in the small strip of land between the old closed landfill units and the perennial streams. Therefore, we propose removal of five existing landfill gas monitoring wells (LFG-8 through LFG-12) due to the location and proximity of surface water bodies and because they are too close to the landfill waste limits to provide useful data.

Existing well LFG-7 is damaged, it will be replaced with LFG-7A if it cannot be repaired. Additionally, a replacement well for LFG 8 will be installed at the new facility boundary to ensure area coverage. The proposed new well is located across the headwaters of Buzzard Branch, where the stream may be more ephemeral in nature. Additionally, LFG-1 through LFG-5 have been renamed to SS-1 through SS-5 to more easily identify those sampling locations as structures.

The closed lined Phase 5 unit is not surrounded by LFG wells, because its location is not conducive to off-property migration. Two unlined landfill units are located to the east of phase 5 and this area includes multiple LFG wells undergoing quarterly monitoring. LFG monitoring wells are located south of Phase 5 and the unlined landfill units. As LFG migration is far more likely due to unlined landfills than lined landfills, we believe this coverage is sufficient for the site. Should well LFG-6 indicate elevated LFG measurements, additional evaluation of the area between the unlined landfills, Phase 5 and the well may be

performed to determine the source of LFG. To the noth and west of Phase 5, Middle Creek and one if its tributaries provide natural barriers to landfill gas migration. Additionally, there is a significant distance between Phase 5 and Middle Creek and its tributary which are near their respective property lines.

The following table lists the proposed LFG monitoring network.

LFG Monitoring Point	Location	Notes
SS-1	Old Dog Pound Facility	
SS-2	Landfill Shed Structure	
SS-3	Landfill Shop	
SS-4	Landfill Offices	
SS-5	Scalehouse	
LFG-6	S. of Unlined Landfills	
LFG-7A	S. E. of Yard Waste Processing Area	Replacement for LFG-7
LFG-8A	East of Ph. 1 & 2	Across Buzzard Branch Near Headwaters

2.1.3 LFG Monitoring Well Construction

The existing LFG monitoring wells were installed (ca1994) by C.T. Clayton and Associates and Patterson Exploration Drilling. Each monitoring well consists of a 1-inch in diameter PVC pipe with a screened section and solid riser pipe to the surface. Unfortunately, no well records for these wells could be located. Quick-connect fittings or stopcock valves will be installed on existing LFG-6 in accordance with DWM guidance on the PVC portion of the well or in the cap as a monitoring port

The additional monitoring well(s) will be installed to approximately the depth of groundwater. The well will be screened from the total well depth to 5 feet below grade. The well will be completed with a landfill gas monitoring well cap and outer steel casing.

2.2 Monitoring and Reporting

Monitoring and reporting of LFG concentrations will be performed as outlined below.

2.2.1 Frequency

Routine LFG monitoring will be conducted on a quarterly basis.

2.2.2 Personnel

LFG monitoring will be performed by personnel who are familiar with the requirements of this plan and who are trained in LFG hazards and explosive gas

meter use. As practical, a designated technician will be assigned to regular LFG monitoring duty.

2.2.3 Equipment

A portable gas analyzer will be used to monitor probes and LFGCCS components. This analyzer, which is calibrated to methane (CH_4), operates using the infrared spectral property of methane to measure concentrations in air. Measurements of oxygen (O_2) and carbon dioxide (CO_2) will also be made with this meter. This meter may be used in oxygen deficient areas (less than 10% O_2) since oxygen is not required for a chemical combustion of flammable gases within the meter.

On the day of monitoring, prior to monitoring activities, this meter will be field calibrated. Additionally, all monitoring equipment should be regularly calibrated in accordance with manufacturer's specifications and operated only as instructed.

2.2.4 Procedures

Prior to each monitoring event, the portable gas analyzer will be calibrated with a known calibration standard in accordance with manufacturer's recommendations. General information related to the monitoring event, equipment used, calibration procedures, weather conditions, and results for each monitoring event will be recorded on the landfill gas monitoring data form (see **Appendix A**).

The following steps outline the procedure for the monitoring of LFG wells and facility structures:

- Check calibration date on the meter and calibrate according to manufacturers instructions; allowing equipment to warm up properly prior to use, per manufacturers direction.
- Purge sample tube for one minute before monitoring.

  LFG Monitoring Wells:
  - Connect instrument tubing to sample port on the monitoring well without removing the cap.
  - Open the valve and record both the initial and stabilized methane concentrations. A stabilized concentration will not vary more than 0.5 percent by volume on the instrument's scale. Also record the oxygen concentration (at two percent per volume or less to indicate air is not being drawn into the system and providing false readings) and the carbon dioxide concentration.
  - Close the valve and disconnect the tubing.
  - Record monitoring data on the LFG monitoring data form provided in **Appendix A**.

- If any methane concentration is **greater than 50% of the LEL (2.5% CH_4)**, monitoring personnel should implement the Precautionary Action Plan (see **Section 2.3.5**).
- If both initial and stabilized methane concentrations are less than 50% of the LEL (2.5% CH_4), move to next LFG monitoring well.

Structures:

- Walk through the facility structure with a methane analyzer and monitor the perimeter wall interface of the structure, the floor to wall interface in hallways and rooms, and any floor penetrations in the structure. Record the initial and stabilized methane concentrations, oxygen concentration, and carbon dioxide concentration.
- Record monitoring data on the LFG monitoring data form provided in **Appendix A**.
- Notify the Landfill Superintendent and the Engineer for any methane concentration greater than 0% of the LEL.

IF A STABILIZED METHANE CONCENTRATION IS GREATER THAN 100% OF THE LEL IN A LFG MONITORING WELL OR GREATER THAN 25% OF THE LEL IN A FACILITY STRUCTURE, THE FOLLOWING ACTIONS WILL BE IMPLEMENTED:

1) Recalibrate monitoring equipment and confirm results.
2) If results are confirmed, **IMMEDIATELY** contact the Landfill Manager and the Engineer.
3) Implement the Compliance Action Plan located in **Section 3.1**.

2.2.5 Precautionary Action Plan

If an initial or stabilized methane concentration is equal to or greater than 50% of the LEL in a LFG monitoring well, monitoring personnel should perform the following additional steps at this location:

- Measure gas pressure in the well head (in inches of water) using magnehelic gauge or other appropriate metering device.
- Record at least one additional methane concentration measurement, inside the well just below the top of casing.
- Evaluate the surrounding area for potential receptors to or signs of LFG migration. LFG can stress vegetation and can kill trees and grass by root asphyxiation. Note stressed/dead vegetation areas on the monitoring form.
- Notify the Landfill Manager and the Engineer for further evaluation.

2.2.6 Record Keeping

Routine LFG monitoring events will be documented on the LFG monitoring data form provided in **Appendix A**. Completed forms will be placed in the landfill operating record located at the landfill office at 680 County Home Road Smithfield, NC. These forms will be available for review by DWM personnel on request.

Documentation of any contingency plan actions (see **Section 3.0**) will also be kept in the operating record.

2.3 Maintenance

Periodic maintenance and site observations will be conducted routinely to address monitoring program components (at a minimum):

- Maintain access to LFG monitoring locations.
- Perform LFG monitoring well maintenance (maintain well locks, steel casing, concrete pad, etc.).
- Observe landfill cover conditions, areas of dead vegetation, leachate seeps, odors, etc. as indications of potential LFG-related problems.

Note deficiencies on the monitoring forms and report to the Landfill Manager for repair or replacement as necessary.

3.0 CONTINGENCY PLAN

If a stabilized methane concentration is **greater than 100% of the LEL in a LFG monitoring well or greater than 25% of the LEL in a facility structure**, the County will perform both an immediate action and plan and a remediation plan as described below and as summarized on **Figure 3**.

3.1 Immediate Action Plan

The Landfill Manager will perform the following actions for the protection of human health and safety:

1) Evacuate affected facility structures and the immediately surrounding area.
2) Determine nearby potential receptors (facility and off-site structures).
3) Perform monitoring in any other facility structure near the monitoring location having the high concentration.
4) Contact the County Fire Department (911). Coordinate evaluation of potentially affected off-site structures with the Fire Department.
5) Verbally notify the Public Services Director, or his designee.
6) Verbally notify the DWM (see **Section 1.1**) as soon as practical.
7) Investigate and identify the potential source(s) and conduit(s) for LFG migration that may have caused the high concentration (i.e. the path that the LFG may be taking to the monitoring location).
8) Identify the LFG extent using bar hole punch sampling methodology or other applicable alternative method as practical.
9) As appropriate, begin corrective action to control methane concentrations in structures surrounding the landfill site.

3.1.1 Reporting and Documentation

Following the Immediate Action Plan, within seven days the County will record the methane levels and a description of actions performed to protect human health in the operating record. Within sixty days a remediation plan, describing the nature and extent of the problem and proposed remedy, will be submitted to NCDENR and a copy will be kept in the operating record. Once approved, notification to the division the plan has been implemented will also be kept in the operating record.

3.2 Remediation Plan

In the event the prolonged explosive gas concentrations exist and as identified during the Immediate Action Plan, the County will prepare and implement a Remediation Plan to mitigate landfill gas migration off property. Extensions may be granted by the Division of Waste Management on written request and depending on severity of the situation.

Figures

Landfill Gas Monitoring Plan
Johnston County Landfill
Solid Waste Permit No. 51-03

REFERENCE:
AERIAL PHOTOGRAPHY OBTAINED FROM BING MAPS.

0 1000' 2000'

PREPARED FOR:

JOHNSTON COUNTY LANDFILL
SMITHFIELD, NORTH CAROLINA
AERIAL PHOTOGRAPHY

DRAWN:	APPROVED:	SCALE:	FIGURE NO.
JAL	JAS	AS SHOWN	1
DATE:	PROJECT NO:	FILENAME:	
Jan 2014	JOHN 12-4	JOHN-B0660	

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

LEGEND

———	PROPERTY LINE (SHOWN WHITE ON MAP)
— — — —	ADJACENT PROPERTY LINES (SHOWN WHITE ON MAP)
— — —	PHASE BOUNDARY
LFG-6	EXISTING LANDFILL GAS WELL (APPROXIMATE LOCATION)
LFG-10	PROPOSED FOR ABANDONMENT
LFG-8A	PROPOSED LFG WELL
	PASSIVE VENT TRENCH

NOTE

1. LFG-7 IS CURRENTLY DAMAGED AND NOT MONITORED.
2. LFG-1 THROUGH LFG-5 REPRESENT BUILDINGS NEXT TO EACH LABEL.

REFERENCES

1. AERIAL PHOTOGRAPHY PROVIDED BY GEODATA CORP. ON MAY 31, 2012.
2. PROPERTY LINE SURVEY PERFORMED BY JERRY BALL LAND SURVEYING, P.C. DATED AUGUST 21, 2012.

PREPARED BY:

NC LIC. NO. C-1828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

DRAWN: JAL	APPROVED: JAS	SCALE: AS SHOWN	FIGURE NO. 2
DATE: Jan 2014	PROJECT NO: JOHN 12-4		FILENAME: JOHN-B0658

PREPARED FOR:

JOHNSTON COUNTY LANDFILL
SMITHFIELD, NORTH CAROLINA
EXISTING LANDFILL GAS
MONITORING NETWORK

Appendix A

Reporting Forms

Landfill Gas Monitoring Plan
Johnston County Landfill
Solid Waste Permit No. 51-03

NC Division of Waste Management - Solid Waste Section

Landfill Gas Monitoring Data Form

Notice: This form and any information attached to it are "Public Records" as defined in NC General Statute 132-1. As such, these documents are available for inspection and examination by any person upon request (NC General Statute 132-6).

Facility Name: _____ Permit Number: _____

Date of Sampling: _____ NC Landfill Rule (.0500 or .1600): _____

Name and Position of Sample Collector: _____

Type and Serial Number of Gas Meter: _____ Calibration Date of Gas Meter: _____

Date and Time of Field Calibration: _____

Type of Field Calibration Gas (15/15 or 35/50): _____ Expiration Date of Field Calibration Gas Canister: _____

Pump Rate of Gas Meter: _____

Ambient Air Temperature: _____ Barometric Pressure: _____ General Weather Conditions: _____

Instructions: Under "Location or LFG Well" identify the monitoring wells or describe the location for other tests (e.g., inside buildings). A drawing showing the location of test must be attached. Report methane readings in both % LEL and % methane by volume. A reading in percent methane by volume can be converted to % LEL as follows: % methane by volume = % LEL/20

Location or LFG Well ID	Sample Tube Purge	Time	Time Pumped (s)	Initial %LEL	Stabilized %LEL	%CH4 by Volume	%O2	%CO2	Notes

If your facility has more gas monitoring locations than there is room on this form, please attach additional sheets listing the same information as contained on this form.

Certification
To the best of my knowledge, the information reported and statements made on this data submittal and attachments are true and correct. I am aware that there are significant penalties for making any false statement, representation, or certification including the possibility of a fine and imprisonment.

_____ _____
SIGNATURE TITLE

DENR USE ONLY: ☐ Paper Report ☐ Electronic Data - Email CD (data loaded: Yes / No) Doc/Event #:

NC DENR
Division of Waste Management - Solid Waste

Environmental Monitoring Reporting Form

Notice: This form and any information attached to it are "Public Records" as defined in NC General Statute 132-1. As such, these documents are available for inspection and examination by any person upon request (NC General Statute 132-6).

Instructions:

- **Prepare one form for each individually monitored unit.**
- **Please type or print legibly.**
- Attach a notification table with values that attain or exceed NC 2L groundwater standards or NC 2B surface water standards. The notification must include a preliminary analysis of the cause and significance of each value. (e.g. naturally occurring, off-site source, pre-existing condition, etc.).
- Attach a notification table of any groundwater or surface water values that equal or exceed the reporting limits.
- Attach a notification table of any methane gas values that attain or exceed explosive gas levels. This includes any structures on or nearby the facility (NCAC 13B .1629 (4)(a)(i).
- Send the original signed and sealed form, any tables, and Electronic Data Deliverable to: Compliance Unit, NCDENR-DWM, Solid Waste Section, 1646 Mail Service Center, Raleigh, NC 27699-1646.

Solid Waste Monitoring Data Submittal Information

Name of entity submitting data (laboratory, consultant, facility owner):

Contact for questions about data formatting. Include data preparer's name, telephone number and E-mail address:

Name: _____ Phone: _____

E-mail: _____

Facility name:	Facility Address:	Facility Permit #	NC Landfill Rule: (.0500 or .1600)	Actual sampling dates (e.g., October 20-24, 2006)

Environmental Status: (Check all that apply)

☐ Initial/Background Monitoring ☐ Detection Monitoring ☐ Assessment Monitoring ☐ Corrective Action

Type of data submitted: (Check all that apply)

☐ Groundwater monitoring data from monitoring wells
☐ Groundwater monitoring data from private water supply wells
☐ Leachate monitoring data
☐ Surface water monitoring data
☐ Methane gas monitoring data
☐ Corrective action data (specify) _____
☐ Other(specify) _____

Notification attached?

☐ No. No groundwater or surface water standards were exceeded.
☐ Yes, a notification of values exceeding a groundwater or surface water standard is attached. It includes a list of groundwater and surface water monitoring points, dates, analytical values, NC 2L groundwater standard, NC 2B surface water standard or NC Solid Waste GWPS and preliminary analysis of the cause and significance of any concentration.
☐ Yes, a notification of values exceeding an explosive methane gas limit is attached. It includes the methane monitoring points, dates, sample values and explosive methane gas limits.

Certification

To the best of my knowledge, the information reported and statements made on this data submittal and attachments are true and correct. Furthermore, I have attached complete notification of any sampling values meeting or exceeding groundwater standards or explosive gas levels, and a preliminary analysis of the cause and significance of concentrations exceeding groundwater standards. I am aware that there are significant penalties for making any false statement, representation, or certification including the possibility of a fine and imprisonment.

Facility Representative Name (Print) Title (Area Code) Telephone Number

Affix NC Licensed/ Professional Geologist Seal

Signature Date

Facility Representative Address

NC PE Firm License Number (if applicable effective May 1, 2009)

Revised 6/2009