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NCDENR

North Carolina Department of Environment and Natural Resources

Dexter R. Matthews, Director — Division of Waste Management — Michael F. Easley, Governor; William G. Ross Jr., Secretary

July 20, 2005

Jennifer Ballard
McGill Associates, P.A.
P.O. Box 2259
Asheville, North Carolina 28802

Re: Closure plan for Madison County MSW, Permit Number 58-03

Dear Ms. Ballard:

The Solid Waste Section has received and hereby approves the document titled "Closure Plan Submittal Package, MSW Landfill, Madison County, North Carolina" dated 30 December 2004 and revised 27 April 2005. Please notify the Waste Management Specialist for Madison County, Jim Patterson, in the Asheville Regional Office when you plan to begin construction of the MSW landfill cap to schedule an informational site meeting.

If you have any questions or concerns, please feel free to contact Tim Jewett, Western Area Engineer, at 336-771-4608, ext. 337 or Jim Patterson at 828-296-4701.

Sincerely,

Jim Barber
Permitting Branch Head
Solid Waste Section
Division of Waste Management

RECEIVED
April 28, 2005
Solid Waste Section
Asheville Regional Office

APPROVED DOCUMENT
Division of Waste Management
Solid Waste Section
Date **March 24, 2008** By **AW Gaither**

Document ID No. **4227**
Scanned By **AW Gaither** Date **March 24, 2008**

cc: Tim Jewett, SWS
Brent Rockett, SWS
Jim Patterson, SWS
Jim Huff, Madison County
Raleigh Central Files - Permit No. 58-03

McGill
ASSOCIATES

RECEIVED
N.C. Dept. of ENR
APR 2 8 2005
Winston-Salem
Regional Office

April 27, 2005

Mr. Tim Jewett
NCDENR, Division of Waste Management
Solid Waste Section
585 Waughtown Street
Winston-Salem, NC 27107

RE: MSW Revised Closure Plan
Madison County, North Carolina

Dear Mr. Jewett:

Pursuant to our conversation on March 24, 2005, we have modified the site specific construction quality assurance plan and the technical specifications for the Madison County Closure Plan. I have enclosed three (3) copies of the modified sections of the Closure Plan.

The following modifications were made to the site specific construction quality assurance plan:

1. Section 1.4.3 of Appendix C (page 41) was modified to prohibit extrusion welding the flap to repair inadequate fusion seams which have an exposed edge.

2. Section 1.5 of Appendix D (page 46) was modified to add needles to the visual examination for harmful foreign objects to be performed over the entire surface of the landfill after installation of the geocomposite.

3. The testing frequency for the LLDPE liner was updated to the latest Geosynthetic Research Institute recommended values in Section 1.3 of Appendix B on page 27.

The following modifications were made to the technical specifications:

1. The Table of Contents has been modified to reflect the new specification numbers which were assigned when the bid documents were compiled.

2. The Vegetative Support Soil Layer specification number was changed from 02201 to 02202.

3. The Borrow specification number was changed from 02203 to 02212.

4. The Compacted Clay Liner specification number was changed from 03260 to 02300. The confining pressure during the permeability test was changed from 15 psi to 3 psi (on Page 2, Section 02300.2) to agree with the site specific construction quality assurance plan.

5. The Geocomposite Drainage Layer specification number was change from 02621 to 02622. A sentence was added to the Warranty section (on Page 3, Section 1.03) stating that damage due to foreign matter such as needles shall be warranted against indefinitely. Another sentence was added to the Manufacturing Quality Control section (on Page 5, Section 2.02) which states that the geocomposite shall be continuously inspected for the presence of needles using a metal detector. These sentences along with the added sentence in Section 1.5 of Appendix D of the site specific construction quality assurance plan should prevent damage to the LLDPE from needles in the geocomposite.

6. The LLDPE Geomembrane Liner specification number was changed from 04800 to 02623. Tables 1 and 2 were updated to the latest Geosynthetic Research Institute test methods and values. The minimum thickness level in Table 1 was changed to 40 mils.

We look forward to working with you on this project to complete the approval for the Closure Plan for the Madison County MSW Landfill. Please send us a written approval as soon as possible as we are getting ready to bid this project.

Sincerely,
McGILL ASSOCIATES, P.A.

Jennifer J. Ballard

JENNIFER J. BALLARD, P.E.

Enclosures
cc: Mr. Jim Huff, Madison County
Mr. Jim Patterson, NCDENR, Asheville

04302/letters/tj27apr05.doc

McGill ASSOCIATES

RECEIVED
N.C. Dept. of ENR
DEC 2 8 2004
Winston-Salem
Regional Office

December 23, 2004

Mr. Tim Jewett
NCDENR, Division of Waste Management
585 Waughtown Street
Winston-Salem, NC 27107

RE: Topographical Survey
Madison County MSW Landfill
Madison County, North Carolina

Dear Mr. Jewett:

On behalf of Madison County, please find enclosed the topographical survey of Madison County MSW Landfill. The survey was based on aerial photography completed on July 19, 2004. In addition, the updated Closure Plan for the MSW area will be submitted for your review next week.

If you have any questions or need additional information, please do not hesitate to call me or Mark Cathey.

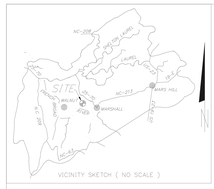
Sincerely,

McGILL ASSOCIATES, P.A.

JEFFREY R. BISHOP, P.E.

Enclosure
cc: Mr. Jim Brown, Madison County

m:\04302\tj23dec04.doc



AERIAL TOPO LEGEND

- Flag Pole
- Power Pole
- Light Pole
- Guy Wire
- Guy Pole
- Traffic Signal
- Manhole
- Catch Basin
- Curb Inlet
- Fire Hydrant
- Elec. Service Box
- Sign
- Post
- Misc. Object
- Misc. Pole
- Sprinkler Head
- Valve
- Culvert
- Swamp Symbol
- Single Tree
- Single Bush
- Satellite Dish
- Antenna
- Tree Line
- Brush Line
- Orchard Outline
- Fence Line
- Water Line
- Swamp Outline
- Guard Rail
- Railroad

NOTES:

THE INITIAL POSITIONS FOR THIS PROJECT WERE PRODUCED FROM STATIC GPS OBSERVATIONS (MIN. 4 HOUR SESSIONS) UTILIZING TRIMBLE DUAL FREQUENCY 4700 RECEIVERS AND WERE COMPUTED BY NGS UTILIZING THE ONLINE POSITIONING USER SERVICE (OPUS) AND ARE RELATIVE TO THE FOLLOWING NGS CORS BASE STATIONS.

REF FRAME: NAD83(CORS96)(EPOCH:2002.0000) NSRS

DATE: August 10, 2004

TIME: 22:44:40 utc

CORS BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE
DE8228	HAYW HAYWOOD CORS ARP	N35°31'35.396"	W082°50'30.123"	56421.6(m)
DG5211	NCSW SWANNANOA CORS AR	N35°35'46.036"	W082°25'24.230"	35788.0(m)
DE8230	MARI MARION CORS ARP	N35°59'13.385"	W081°57'16.172"	71404.7(m)

POSITIONAL ACCURACY: X= 0.003(m), Y=0.019(m), Z=0.018(m)

ELEVATIONS ARE NGVD 1988 (GEOID MODEL=GEOID03)

AVERAGE COMBINED GRID FACTOR = 0.99982488.

COORDINATE UNITS ARE IN U.S. SURVEY FEET UNLESS DESIGNATED OTHERWISE

BENCH MARKS ELEVATION

NCGS JENKINS 2076.41
NCGS N 153 1624.18

ALL ELEVATIONS ARE NGVD 1929

DISTANCES SHOWN ON THIS PLAT ARE GRID LENGTHS. TO OBTAIN HORIZONTAL GROUND DISTANCES, THEY MUST BE DIVIDED BY A COMBINED SCALE AND SEA LEVEL FACTOR OF 0.99982488.

ALL SPOT ELEVATION ARE AT GROUND LEVEL.

DASHED-LINES CONTOURS SHALL HAVE AN ACCURACY WITH RESPECT TO TRUE ELEVATION OF ONE (1) CONTOUR INTERVAL OR ONE-FOURTH (1/4) THE AVERAGE HEIGHT OF THE GROUND COVER, WHICHEVER IS GREATER.

NO BOUNDARY LINES ARE SHOWN HEREON.

EXCEPT AS SPECIFICALLY STATED OR SHOWN ON THIS PLAT, THIS SURVEY DOES NOT PURPORT TO REFLECT ANY OF THE FOLLOWING WHICH MAY BE APPLICABLE TO THE SUBJECT REAL ESTATE: EASEMENTS, OTHER THAN POSSIBLE EASEMENTS THAT WERE VISIBLE AT THE TIME OF MAKING OF THIS SURVEY; ZONING OR OTHER LAND USE REGULATIONS, AND ANY OTHER FACTS THAT AN ACCURATE AND CURRENT TITLE SEARCH MAY DISCLOSE.

OTHER THAN SHOWN, NO ATTEMPT HAS BEEN MADE AS A PART OF THIS AERIAL AND FIELD TOPOGRAPHIC SURVEY TO OBTAIN OR SHOW DATA CONCERNING EXISTENCE, SIZE, DEPTH, CONDITION, CAPACITY, OR LOCATION OF ANY UTILITY OR MUNICIPAL/PUBLIC SERVICE FACILITY. FOR INFORMATION REGARDING THESE UTILITIES OR FACILITIES, PLEASE CONTACT THE APPROPRIATE AGENCIES.

THE LOCATIONS OF UNDERGROUND UTILITIES AS SHOWN HEREON ARE BASED ON ABOVE GROUND STRUCTURES AND RECORD DRAWINGS PROVIDED THE SURVEYOR. LOCATIONS OF UNDERGROUND UTILITIES AND STRUCTURES MAY VARY FROM LOCATIONS SHOWN HEREON. ADDITIONAL BURIED UTILITIES/STRUCTURES MAY BE ENCOUNTERED. NO EXCAVATIONS WERE MADE DURING THE PROGRESS OF THIS SURVEY TO LOCATE BURIED UTILITIES/STRUCTURES. BEFORE EXCAVATIONS ARE BEGUN, THE APPROPRIATE AGENCIES SHOULD BE CONTACTED FOR VERIFICATION OF UTILITY TYPE AND FOR FIELD CONDITIONS.

PHOTOGRAMMETRIC CERTIFICATION
PROJECT REPORT

I, Shawn M. Spicer L-4069, certify that this project was completed under my direct and responsible charge from an actual photogrammetric survey made under my supervision.

I further certify,
That the aerial Photography was flown July 19, 2004 at a nominal scale of 1" = 300' using a Wild RC30 precision aerial camera.
That the data were compiled by standard photogrammetric methodologies using a Wild BC2 analytical stereo plotter. The map was compiled September 2004.
That the data were drawn to meet National Map Accuracy Standards.
Data enclosed by obscure area outlines or contours shown as dashed lines may not meet National Map Accuracy Standards

That the data were compiled at 1"= 100' with a 2' contour interval. The area compiled was approximately 37 acres located in Madison County, North Carolina.

That all items compiled, except ground control points were obtained using photogrammetric methodologies.
That the data were compiled by :

SMAPS
2300 Millhouse Lane
Matthews, N.C. 28104
Phone: (704) 882-8031

AS REVISED	BY	FIELD PARTY CHIEF	DATE FLOWN	JOB KEY NO.
No. 1		DRAWN BY	JULY 19, 2004	030831-2D-1169
No. 2		CHECKED BY	DATE	PRECISION
No. 3		SCALE 1 IN. = 100 FT.	SEPT. 2004	1:1200
No. 4		CMC FILE: 030831.DWG		AREA BY SAPS
				PSG FILE: 030831.PSD
		RECORD REFERENCES: PIN #7971-79-3852		

0 100 200 300
SCALE 1" = 100'

DATE: SEPTEMBER 30, 2004
THIS PLAT REPRESENTS AN AERIAL CONTROL SURVEY THAT MEETS OR EXCEEDS THE REQUIREMENTS FOR A CLASS A SURVEY IN ACCORDANCE WITH THE STANDARDS OF PRACTICE FOR NORTH CAROLINA.

WEBB A. MORGAN, P.L.S.
N.C. NO. L-1463

AERIAL TOPOGRAPHIC SURVEY OF THE
COUNTY OF MADISON
LANDFILL
MADISON COUNTY N.C.
SCALE 1" 100' CONTOUR INTERVAL 2'
NATIONAL GEODETIC VERTICAL DATUM OF 1929
NORTH AMERICAN DATUM OF 1983 (NSRS)

Date of Photography July 19, 2004
COMPILED BY PHOTOGRAMMETRIC METHODS
WITH NO FIELD CHECK OR SURVEY
MATTHEWS, NORTH CAROLINA
PHOTOGRAMMETRIC GROUND CONTROL BY
WEBB A. MORGAN & ASSOCIATES, P.A.
(JOB No.03008)

WEBB A. MORGAN & ASSOCIATES, P.A.
PROFESSIONAL LAND SURVEYORS
95 CENTRAL AVENUE ASHEVILLE, NORTH CAROLINA, 28801
PHONE:(828) 253-1300

SHEET 1 OF 1

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY
WEBB A. MORGAN, PLS, L-1463, ON SEPTEMBER 30, 2004.
THIS MEDIA SHOULD NOT BE CONSIDERED A CERTIFIED
DOCUMENT.

SITE SPECIFIC CONSTRUCTION QUALITY ASSURANCE PLAN
Madison County MSW Landfill
Madison County, North Carolina
MSW Closure

This Construction Quality Assurance Plan has been prepared as required under 15A NCAC 13B .1617 and in accordance with 15A NCAC 13B .1621 of Section 15A NCAC 13B of the North Carolina Solid Waste Management Rules.

1.0 INTRODUCTION

1.1 Project Background

The Madison County MSW Landfill Site has been utilized for disposal of Municipal Solid Wastes. The current project involves the construction of a closure cap on the municipal solid waste landfill. This project will include using structural fill to achieve the desired gradients followed by a compacted, 18" thick low-permeability clay liner layer, a 40-mil linear low density polyethylene (LLDPE) textured geomembrane liner, a 6-ounce double-sided geocomposite, and 24" of vegetative supportive soil. The site is located in Madison County.

1.2 Project Scope

The purpose of this Site Specific Construction Quality Assurance Plan (SSCQAP) is to provide guidance to McGill Associates and sub-contractor personnel on required documentation activities during the construction of the engineered closure cap. This guidance is intended to ensure that construction meets the requirements of Madison County and the Project Construction Quality Assurance (CQA) Plan and project drawings and specifications.

The overall goals of the SSCQAP are to ensure that proper construction techniques and procedures are used to verify that the materials and installation techniques used meet Project CQA Plan and project drawings and specifications. Additionally, the program will identify and define problems that may occur during construction and ensure that these problems are corrected before the construction is complete. At completion of work, the program will culminate in a certification report, which will document that the clay liner, geosynthetic liners and vegetative supportive soils have been constructed in substantial compliance with this SSCQAP and project drawings and specifications. The primary emphasis of the SSCQAP is careful documentation during the preparation and placement of the clay and the geosynthetic liner, with a secondary emphasis on placement of the vegetative supportive soil. The vegetative supportive soil is not considered less important than the other components, but it will be visually inspected over time and can be repaired if problems are identified. The vegetative supportive soil will be tested, but at a lower frequency than the other cap components.

1.2.1 Scope of Services

The Scope of Services provided by McGill Associates for the construction of engineered base is as follows:

1. Pre-Construction materials evaluation (structural fill, clay liner, geosynthetics, vegetative supportive soil).
2. Structural Fill observation, testing, documentation, and verification of construction procedures.
3. Clay liner observation, testing, documentation, and verification of construction procedures.
4. Geosynthetic observation, testing, documentation, and verification of construction procedures.
5. Vegetative supportive soil observation, testing, documentation, and verification of construction procedures.
6. Provide CQA Report and CQA Certification that cap was constructed in accordance with this SSCQAP.

1.2.2 Construction Schedule

Construction of the cap shall be completed within 90 consecutive calendar days.

Description
Preconstruction Meeting
Structural Fill Installation
Clay Liner Installation
Geomembrane Liner Installation
Geocomposite Installation
Installation of Vegetative Supportive Soil Layer
Submit CQA Report and CQA Certification

2.0 Parties Involved

2.1 Madison County

Contact: Mr. Jim Huff (828) 649-2311

Title: Solid Waste Director

2.2 McGill Associates, P.A.

Contact: Mark D. Cathey, P.E. (828) 252-0575

Title: Project Engineer

2.3 General Contractor

Contact: Unknown

Title:

2.3.1 Surveyor

Contact: Unknown

Title:

2.3.2 Geosynthetic Manufacturer

Contact: Unknown

Title:

2.3.3 Geosynthetic Installer

Contact: Unknown

2.5 Construction Quality Assurance Consulting Firm

Contact: Unknown

Title:

2.5.1 CQA Certifying Engineer

Name: Unknown

Title:

2.5.2 CQA Resident Engineer

Name: Unknown

Title:

2.5.3 Geosynthetic Testing Laboratory

Contact: Unknown

Title:

2.5.4 Soils Laboratory (permeability testing)

Contact: Unknown

Title:

3.0 Preconstruction Meeting

A Preconstruction meeting will be held prior to the beginning of construction. The following people shall be present: Owner representative, Solid Waste Section representative, Design Engineer, Certifying CQA Engineer/CQA Project Manager, Resident CQA Engineer, General Contractor, Geosynthetics Installer, and all other subcontractors.

The following items will be discussed at a minimum:

- Any questions about the SSCQAP will be addressed and any modifications that result will be documented. Any modifications to the approved SSCQAP must be approved by the Division of Solid Waste.
- Special permits and state and/or federal regulations.
- Responsibilities, expectations, and roles of each party.
- Lines of authority and proper lines of communication.
- Procedures for documenting and reporting information.
- Distribution and storage of documents and reports.
- Protocol for testing and geosynthetic sample management.
- Protocol for handling construction deficiencies.
- Protocol for repairs and re-testing.
- Conduct site walk through:

    a) Discuss work plans
    b) Inspect material handling and storage locations
    c) Review office facilities (copy machine, mailing, etc.)

- Review detailed time schedule for all operations.
- Review work area security, check-in procedure, and safety protocol.
- Establish procedures for material processing.
- Review site health and safety requirements.

McGill Associates will document the Preconstruction Meeting and a copy of the meeting minutes will be distributed to all parties who attend.

4.0 Definitions

4.1 Construction Quality Assurance

A planned and systematic application of all means and actions designed to provide adequate confidence that items or services meet design and specifications requirements and will perform satisfactorily in service. In the context of the geosynthetic liner system, construction quality assurance refers to means and actions employed by the CQA Resident Engineer, CQA Senior Lead Technician, and the CQA Monitors to ensure conformity of the liner system installation with guidelines set forth in the SSCQAP, construction plans, and construction specifications.

4.2 Construction Quality Control

Those actions that provide a means to measure and regulate the characteristics of an item or services to design and specifications requirements. In the context of the geosynthetic liner system installation, quality control refers to those actions taken by the Geosynthetic Contractor/Manufacturer to ensure that the product and the workmanship meets the requirements set forth in the SSCQAP, construction plans, and construction specifications.

4.3 Design Engineer

The individual or firm responsible for the implementation of this SSCQAP, construction drawings, and construction specifications.

4.4 General Contractor

The firm responsible for the complete construction of the soil and geosynthetic components of the landfill as specified in this SSCQAP and as shown on the construction drawings and construction specifications.

4.5 Construction Quality Assurance Consultant

The firm responsible for observing, testing and documenting activities related to construction quality assurance during the installation of the clay liner, geomembrane liner, and the leachate collection system. The CQA Certifying Engineer is responsible for issuing a summary certification and documentation report bearing his/her Professional Engineering Seal. The CQA Resident Engineer is responsible for the management of on-site CQA personnel and providing the Project Engineer and Owner with a daily report of the construction activities.

5.0 DOCUMENTATION PROCEDURES

5.1 Standard Reporting Procedures

The CQA Technicians shall issue a daily report of construction activities. These reports shall include, as a minimum, the following information:

1. An identifying sheet number for cross-referencing and documentation control.
2. Date, project name, location and other identification.
3. Weather conditions.
4. Problems encountered and resolutions.
5. Descriptions and locations of ongoing construction.
6. Equipment and personnel in each work area, including subcontractors.
7. Descriptions and specific locations of areas or units of work being tested and/or observed and documented (identified by coordinates or seam/panel numbers).
8. Locations where samples were taken.
9. A summary of test results, failures, and re-tests.

5.2 Geosynthetic Installation Monitoring

The monitors of geosynthetic installation shall perform and/or provide the following information and services:

1. Record information about material delivery (time, date, and physical condition of material).
2. Observe unloading and on-site storage and transport.
3. Perform sampling for conformance testing.
4. Observe deployment operations and record needed information (roll #, panel #, approved QA\QC cert, thickness, overlap, defects, etc.).
5. Observe seam preparation (proper overlap and cleanliness).

6. Observe seaming operations and record needed information (seaming method, seam#, welding technician, welding apparatus #, welder settings, ambient temperature, chronological order of seams welded, seam length, etc.).

7. Observe conditions of panel before and after placement.

8. Locate and document all defects in the geosynthetic material.

9. Observe repairs (location, method, technician, date, etc.).

10. Observe trial seams (monitor preparation and testing).

11. Observe nondestructive testing (visual observation and documentation).

12. Observe sampling for destructive seam testing (locating test location).

13. Conduct final walkovers (confirm defect repairs).

5.3 Applicable Forms

As a minimum, the CQA monitors will utilize the following forms for the project:

1. Daily Field Report

2. Weekly Progress Report

3. Nuclear Density Testing

4. Drive Cylinder Test Report

5. Soil Testing Tracking Log

6. Certificate of Acceptance of Soil Subgrade

7. Geosynthetic Materials Inventory Checklist

8. Weather Log

9. Trial Weld Form

10. Panel Deployment

11. Panel Seaming

12. Nondestructive Seam Testing

13. Destructive Sample Test Log

14. Geosynthetic Defect Log

15. Geosynthetic Repair Log

16. Construction Site Safety Form

17. Construction Photo Log

18. Certificate of Completion

5.4 Problem/Deficiency Identification and Corrective Action Report

The CQA Monitor is required to inform the General Contractor and/or the Geosynthetic Contractor, or their representatives, in a timely manner, of any difference between the interpretation of the SSCQAP, the construction plans and construction specifications by the contractor versus the CQA Monitor's interpretation. In addition, any actual or suspect work deficiencies shall be brought to the Project Engineer and Owner's attention.

A special meeting shall be held when and if a problem or deficiency is present. At a minimum, the meeting shall be attended by the General Contractor, the Owner, the CQA Resident Engineer, and the CQA Monitor. If the problem involves a possible design modification, the Project Engineer shall be notified. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

1. Define and discuss the problem or deficiency

2. Review alternative solutions

3. Implement an action plan to resolve the problem or deficiency

The CQA Resident Engineer or his representative will document all proceedings.

The CQA Resident Engineer and the Design Engineer shall be authorized to stop work at the construction site.

The Owner, Project Engineer, CQA Certifying Engineer, and the Division of Solid Waste must approve any changes and/or modifications to the SSCQAP.

5.5 Plan Modifications

Design and/or specification changes shall be made only with written approval of the Owner and the Project Engineer. Substantial design changes shall also require approval from the Division of Solid Waste.

5.6 Scope Change

The CQA Resident Engineer shall notify the Project Engineer whenever additional engineering services are requested by Owner that exceeds the original scope of services.

5.7 Photographic Documentation

Photographs taken to document observations, problems, and/or deficiencies, or work in progress will include identification of the date, location, direction of view, and time period. Photographs will be filed in chronological order in a permanent protective file by the CQA team. One set of prints shall be turned over to both the Owner and Project Engineer at the conclusion of the project.

The permanent file will also contain a comprehensive index of each photo, which the CQA Monitor is responsible for preparing and maintaining. This index will include the following information:

1. Date of photograph
2. Provide a location and scale where photographed, including information regarding the orientation of the photograph itself for proper viewing
3. Subject description
4. Photo file number

The following is a list of minimum photographs to be taken during cell construction:

1. Subgrade/subbase proof rolling
2. Geosynthetic conformance sampling
3. Geomembrane deployment
4. Fusion welding devices

5. Extrusion welding devices

6. Air testing

7. Vacuum box testing

8. Seaming

9. Destructive sample location and removal

10. Trial welds

11. Tensiometer testing

12. Geotextile deployment

13. On-site lab soil testing

14. Soil layer construction

15. Progress photographs

16. Design modifications

17. Construction deficiencies

18. Completed construction

5.8 Final Construction Documentation Report

During placement of the soil layer, the CQA Resident Engineer shall prepare a final certification-documentation report covering the installation and testing of the clay and geosynthetic lining system. This report shall certify that the clay and geosynthetic liner system has been constructed in substantial accordance with this SSCQAP, the construction drawings, and the construction specifications. A Draft Copy of this report shall be issued to the Project Engineer following completion of the lining system. The final report shall be issued to the Project Engineer following completion of the cap. For this project, two (2) copies of the draft version and five (5) copies of the final version of the report shall be issued.

5.9 Format of CQA Report

As a minimum, the certification report will contain the following items for discussion in the narrative portion of the report. The proposed table of contents is:

5.9.1 Table of Contents

Section

1.0 Summary of Information

- 1.1 Narrative
- 1.2 Reference Information

2.0 Soil Preconstruction Data (embankment and clay liner)

- 2.1 Proctors
- 2.2 Soil Density/Moisture
- 2.3 Soil Classification

3.0 Subgrade Field Data

- 3.1 Moisture Content
- 3.2 Field Density Testing

3.0 Clay Liner Field Data

- 3.1 Moisture Content
- 3.2 Field Density Testing
- 3.3 Permeability Testing

4.0 Soil Laboratory Data

- 4.1 Construction Proctors
- 4.2 Soil Classification
- 4.3 Permeability

5.0 Geosynthetic Quality Control

- 5.1 Manufacturer's Q.C.
- 5.2 Installer Resumes
- 5.3 Material Conformance Testing

6.0 Geosynthetic Liner Field Data

6.1 Weather Log
6.2 Trial Welds
6.3 Panel Placement
6.4 Panel Seaming
6.5 Non-Destruct Test
6.6 Destruct Test
6.7 Repair Log
6.8 Installed Quantities
6.9 Defect Location Map

7.0 Vegetative Supportive Soil Layer Data

7.1 Preconstruction testing

7.2 Field and laboratory testing

7.2.1 Sieve analysis
7.2.2 Permeability testing

8.0 Project Meeting Minutes

9.0 Construction Photographs

10.0 Pertinent Information

5.9.2 Draft List of Drawings

As a minimum, the certification will include in an appendix the following proposed list of drawings:

- Geomembrane Panel Layout
- Defect Location Map
- Map giving elevation of subgrade, clay liner, and soil layer at a minimum frequency of every fifty (50) feet.

5.10 Site Surveying Requirements

The CQA Resident Engineer shall coordinate all survey activities with the surveyor. Survey services will be required for initial site layout, final grade verification, and primary geomembrane as-built survey. All grade surveying shall be conducted on a 50-foot grid. The certification surveys will be as directed by the CQA Resident Engineer and shall include the following items:

- Panel placement and seaming locations
- Location of destructive testing samples
- Location of all significant repairs
- Topographic survey of base grades
- Topographic survey of top of clay liner
- Topographic survey of top of vegetative supportive soil layer

6.0 LANDFILL CONSTRUCTION-EARTHWORK

6.1 Subgrade Preparation

Subgrade preparation shall be performed by the General Contractor and in accordance with the construction drawings and construction specifications. See Appendix A for CQA monitoring and testing requirements.

6.2 Structural Fill Placement

Structural fill shall be the soil placed to achieve the design subgrade contours. The subgrade will be tested for field density and field moisture content at a minimum frequency of one (1) test per 5,000 cubic yards placed. Testing will also consist of visual observation and documentation of proofrolling with loaded rubber-tired earthmoving equipment. If a nuclear gauge is used as the primary means of construction testing, the instrument shall be calibrated properly and test data shall be verified using alternate test methods such as drive cylinders. An alternate test method shall be used at least once for every hundred tests performed with the nuclear gauge. The alternate test method should be performed in the same area as an instrument reading in order to allow accurate comparison of the data resulting from the two tests.

6.3 Clay Liner Material

The clay liner shall consist of low-permeability soils placed on the subgrade.

Clay liner material generally consists of cohesive soils with low hydraulic conductivity used as barriers in lining systems. Soils used in clay liners shall consist of clean, select material free of debris, excessive coarse particles or other deleterious matter. Soils with a visibly identifiable organic content, or soils classified according to the Unified Soil Classification System as organic silt or organic clay (OL, OH) shall not be used.

Table 1 - QA Testing Frequencies and Criteria for Clay Liner Layer

Preconstruction Qualification		
Test	**ASTM Method**	**Quantity**
Moisture Content	D2216	1/1,000 YD^3
Grain Size	D422 or D1140	1/5,000 YD^3
Atterberg Limits	D4318	1/5,000 YD^3
Laboratory Compaction	D698 - Standard	1/5,000 YD^3
Permeability	D5084	1/5,000 YD^3
*** Preconstruction test samples shall be taken from the borrow source and or clay stockpiled prior to construction.**		
Construction Testing		
Test	**ASTM Method**	**Quantity**
Field Density	D2922, D1556, D2167	1/10,000 FT^2/Lift
Field Moisture	D2216, D3017, D4643	1/10,000 FT^2/Lift
Permeability	D5084	1/40,000 FT^2/Lift
Atterberg Limits	D4318	1/5,000 YD^3
Grain Size	D422 or D1140	1/5,000 YD^3
Testing Criteria		
Classification	CL, CH, ML or MH	
Maximum Particle Size		3-inch diameter (lower 18 inches) 1/4-inch diameter (top 6 inches)

If a nuclear gauge is used as the primary method for construction testing of the clay liner, the test data shall be verified by alternate test methods at least once for every 25 tests performed.

Any modifications made to these testing frequencies will require prior approval from the Division of Solid Waste.

6.4 Clay Liners

Prior to the construction of a clay liner, soil evaluation tests shall be performed to confirm the adequacy of clay liner materials procured from each on-site or off-site source area. All tests shall be performed in a geotechnical laboratory, which may be the Soil QAL or another laboratory approved by the Project Engineer. The Earthwork Contractor shall submit the results of source

evaluation tests to the Project Engineer. Previous testing and evaluations of the soil sources may also be used to evaluate the soil material. The material shall be accepted or rejected by the Project Manager according to these results. The acceptance and rejection criteria for the clay liner material will be verified by the construction of a test pad in accordance with the construction specifications

6.4.1 Quality Control Acceptance Criteria

The following tests and/or information shall be conducted and provided prior to acceptance of clay liner material:

1. Moisture content (ASTM D2216)
2. Particle size distribution analysis (ASTM D1140, D422)
3. Atterberg limits (ASTM D4318)
4. Laboratory compaction (ASTM D698)
5. Triaxial cell laboratory permeability (ASTM D5084)
6. Percent bentonite admixed with soil, if applicable
7. Moisture-density-permeability relation

* Refer to Section 6.3, Table 1 for testing frequencies.
* Acceptance of the clay liner will be based on the material's ability to achieve a permeability not greater than 1.0×10^{-5} cm/sec.

The project engineer shall approve the materials prior to construction and verify that testing was performed according to Division approved plans and specifications.

If identification of additional clay liner material sources becomes necessary during construction, the same material qualification and testing procedures shall be applied to each new source. Additional testing may be required by the project specifications. Project specifications may modify testing frequencies if the clay liner material has been previously evaluated or used.

6.4.2 Quality Assurance Testing

Each lift of the compacted clay liner shall be tested for moisture content, density, and permeability at the frequencies shown in the technical specifications. Permeability tests shall be performed at a confining pressure of 3 psi +/- 1 psi and with a gradient in accordance with ASTM method D5084. Samples taken from each location shall be compared to the approved moisture-density-permeability relation. Test frequencies for construction testing are given in Table 1 of section 6.3. The project engineer shall certify that the clay liner was constructed using

the same methods and acceptance criteria consistent with test pad construction and tested according to the Division approved plans. Index tests will be performed during construction at a frequency of one (1) test/5,000 YD^3. The index tests will consist of an Atterberg Limits test and Grain Size test performed from the same bulk sample taken from the field.

6.4.3 Test Pad Construction

The test pad shall be constructed in accordance with the technical specifications. The results of the test pad testing shall be in accordance with Table 1 in section 6.3 and the previously approved moisture-density-permeability relationship established from preconstruction testing. Field moisture and density tests and laboratory permeability tests will be performed by the CQA Engineer for each lift placed on the test pads to verify the construction method, equipment, and material achieve a permeability not greater than $1.0x10^{-5}$ cm/sec for the clay liner. If the contractor chooses to construct the test pads within the cell, all lifts of the test pads must pass to enable them to remain as part of the clay liner. The Contractor shall allow sufficient time for construction and testing of the test pad prior to placement of the Compacted Clay Liner.

6.4.4 Clay Liner Placement

The clay liner shall be placed in accordance with Section 03260 of the technical specifications.

6.4.5 Clay liner Acceptance

The Resident CQA Engineer must approve the condition of the clay liner prior to the geosynthetic installer deploying the geomembrane.

The soil components of the lining system will be approved by the Resident CQA Engineer when:

1. The installation of the soil components is finished.

2. Verification of the adequacy of the constructed components, including repairs, if any, is completed in accordance with this SSCQAP and the technical specifications.

3. All documentation of installation is completed.

4. The depth and grade of the clay liner has been verified by a licensed surveyor and has been approved by the project engineer.

5. The appropriate frequency of permeability tests has been performed and the results have been approved by the Certifying CQA Engineer.

6. The Soil CQA monitors are able to recommend acceptance.

The Soil CQA Monitors shall certify that installation of the soil components has proceeded in accordance with this SSCQAP and the technical specifications.

6.5 Permeability Testing

Permeability testing shall be performed in accordance with section 6.4.2 of this document and the technical specifications.

6.6 Vegetative Supportive Layer

6.6.1 Materials and Construction

The final layer of the cap will be composed of 24" of soil. The hydraulic conductivity, or permeability, must be a maximum of 1×10^{-5} cm/sec. The bottom 18" of the soil layer may be constructed of native soils with no stones larger than 2" in diameter. The soil is not required to have a specific classification or permeability, however, it should be a cohesive soil.

The final cover will be a minimum of 24-inches thick including at least 6-inches of soil suitable for sustaining native plant growth. The soil cover will provide support for a vegetative cover and protect the low-permeability barrier.

The friction angle between the geocomposite and the vegetative supportive soil layer shall be a minimum of 24 degrees. Direct Shear Box testing prior to construction shall verify this friction angle. The tests shall be performed using representative bulk samples of the proposed construction materials.

The bottom soil layer shall be placed with a minimum compacted thickness of 18 inches. Equipment used during placement of the soil layer shall not be allowed to operate directly on the geomembrane. Equipment will not be allowed on any portion of the geomembrane without the protective geocomposite and a minimum of 18 inches of soil layer material in place. Soil layer material shall not be pushed along the surface of the geomembrane under any circumstances. Pushing of the soil layer material will only be allowed on areas where the material has a depth greater than 18 inches, and the required 18-inch depth shall be maintained at all times.

Table 2 - QA Testing Frequencies and Criteria for Vegetative Supportive Soil Layer

Preconstruction Qualification		
Test	**ASTM Method**	**Quantity**
Moisture Content	D2216	1/5,000 YD^3
Laboratory Compaction	D698 - Standard	1/5,000 YD^3
Permeability	D5084	1/5,000 YD^3
*** Preconstruction test samples shall be taken from the borrow source and or material stockpiled prior to construction.**		
Construction Testing		
Test	**ASTM Method**	**Quantity**
Field Density	D2922, D1556, D2167	1/ACRE
Field Moisture	D2216, D3017, D4643	1/ACRE
Permeability	D5084	1/ACRE
Testing Criteria		
Classification	CL, CH, ML or MH	
Maximum Particle Size		3-inch diameter (lower 18 inches) 1/4-inch diameter (top 6 inches)

If a nuclear gauge is used as the primary method for construction testing of the clay liner, the test data shall be verified by alternate test methods at least once for every 25 tests performed.

Any modifications made to these testing frequencies will require prior approval from the Division of Solid Waste.

6.6.2 Placement

Placement of the vegetative supportive soil layer shall be performed by a light tracked dozer or light dump truck not in direct contact with the geomembrane. A minimum depth of 18 inches of soil layer material must be maintained at all times during placement activities when vehicles other than the light tracked dozer are needed. High traffic areas, such as access roads constructed to transport material into the landfill, should have a minimum depth of three (3) feet. This depth may be changed by written approval from Owner or an engineered design approved by the Design Engineer.

The soil layer shall be placed in the coolest part of the day when possible in order to reduce the potential for wrinkles forming in the geomembrane. See Sections 1.4.2 and 1.1.5 of Appendix C for information on evaluating and repairing wrinkles in the geomembrane.

McGill Associates and/or the Resident CQA Engineer will observe placement activities. The General Contractor is to provide laborers ahead of soil material placement to assist in minimizing wrinkle formation of the geomembrane. Temperature variations may impact the Contractor's ability to place this material.

6.6.3 Depth Verification

CQA Monitor(s) will randomly verify soil layer depth utilizing test pits or survey means. A Licensed Surveyor will survey the top of the soil layer to certify proper depth was achieved. The General Contractor may use depth markers (i.e., painted tubes, flags, traffic cones, etc.) during placement to provide depth control and minimize possible damage to geomembrane. Depth markers shall be removed as the soil layer is completed. Depth markers shall not be constructed of a material that could potentially puncture the geomembrane and shall be approved by the Project Engineer.

7.0 LANDFILL CAP-GEOMEMBRANE

7.1 Geomembrane Liner

The geosynthetic components of the lining system will be approved by the Resident CQA Engineer when:

1. The installation of the geosynthetic components has been completed in accordance with this SSCQAP and the technical specifications.

2. Verification of the adequacy of all seams including associated testing and repairs, if any, is completed in accordance with this SSCQAP and the technical specifications.

3. All documentation of installation is completed.

4. The Geosynthetic CQA Monitor(s) are able to recommend acceptance.

7.2 Geomembrane Quality Control

The Geosynthetic Contractor/Manufacturer will provide geosynthetic quality control in accordance with Appendix B.

7.3 Geomembrane Quality Assurance

7.3.1 Conformance Sampling

Conformance testing will be done on-site as material arrives and is inventoried. Conformance sampling procedures will be in accordance with Appendix B.

7.4 Geomembrane Seaming

Field seaming will be done in accordance with Appendix C.

7.4.1. Double Tracked Fusion Welding

All seaming performed shall utilize the double-tracked fusion process when possible. Detailing and repairs do not require double tracked fusion welding.

7.4.2 Extrusion Welding

Extrusion welding shall only be used when double-tracked fusion welding is not possible. The extrusion process will be utilized for repair or detail work, attaching the boots around the methane wells, capping a failed seam, or completion of other appurtenances that cannot be performed with fusion welding.

7.5 Geomembrane/Seam Repairs

All repairs to the geomembrane or seams shall be done utilizing the extrusion welding process. All repair work shall be conducted in accordance with Appendix C.

7.6 Geotextile Quality Control

The Geosynthetic Contractor/Manufacturer shall provide quality control information in accordance with Appendix D.

7.7 Geotextile Quality Assurance

Conformance sampling will be performed on-site as material arrives and is inventoried. All conformance sampling will be in accordance with Appendix D.

8.0 METHANE GAS COLLECTION PIPING

8.1 Materials

Materials for the methane gas collection piping shall be in accordance with the technical specifications. Pipe for the methane gas collection system shall be ACS N12 perforated High-Density Polyethylene (HDPE) pipe, or approved equal.

1. HDPE piping shall have nominal diameters as noted on the Contract Drawing.

2. The HDPE pipe shall be manufactured from first quality virgin polyethylene with the following nominal properties:

Nominal Diameter	6 inches
Pipe Stiffness (minimum)	50 psi

1. The pipe placed in the methane collection trenches shall be perforated.

2. Piping that penetrates the landfill cap at the vent locations should be solid HDPE pipe.

8.2 Construction

The perforated high density polyethylene pipe shall be as shown on the Construction Drawings and technical specifications.

a) The pipe section connections shall be made by:

(1) Threaded connection;

(2) Snap-couplings (approved mechanical); and/or

(3) Combination of any two or more of the above. No solvent or glued joints are allowed.

APPENDIX A

1.0 Subgrade Preparation

1.1 Surface Preparation

The Earthwork Contractor shall be responsible for preparing the subgrade prior to placement of the cap liner system and is responsible for constructing the subgrade in accordance with the technical specifications.

Before beginning placement of the compacted clay liner:

1. The project engineer shall document that a licensed land surveyor has verified that all grades and elevations are consistent with Division approved engineering plans.

2. The project engineer shall document that he/she has visually inspected the subgrade surface to evaluate its suitability and that the subgrade meets the criteria specified in the project specifications.

3. The subgrade shall be proof-rolled using a procedures and equipment specified by the project engineer.

4. The project engineer shall document that the subgrade has been tested for conformance to the construction specifications at the following minimum frequencies:

SUBGRADE TESTING FREQUENCIES			
TEST	ASTM METHOD	QUANTITY	ACCEPTABLE VALUES
Field Density	D2922, D1556, D2937 D2216, D3017,	1/40,000 ft^2/lift	95% maximum dry density
Field Moisture	D4643	1/10,000 ft^2/lift	+/- 4% optimum

APPENDIX B

1.0 Geomembranes

1.1 Description and Applicability

Geomembranes are low permeability geosynthetic barriers used in lining systems. This Section is applicable to smooth and textured linear low density polyethylene (LLDPE) geomembranes. This Section may need to be modified when using other geomembranes.

1.2 Manufacturing Plant Inspection

The Owner or other appropriate representative will conduct an annual inspection of the Manufacturer's plant. In addition, the Project Engineer, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the geomembrane rolls for that particular project. The purpose of the plant inspection is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection shall include:

1. Verification that properties guaranteed by the manufacturer are met and meet all the project specifications.

2. Verification that the measurement of properties by the Manufacturer is properly documented and test methods used are acceptable.

3. Spot inspection of the rolls and verification that they are free of imperfections or any sign of contamination by foreign matter.

4. Review of handling, storage, and transportation procedures, and verification that these procedures will not damage the geomembrane.

5. Verification that roll packages have a label indicating the name of the manufacturer, type of geomembrane, thickness, roll number, and roll dimensions.

6. Verification that extrusion rods and/or beads are produced from the same base resin type as the geomembrane.

A report describing the inspection shall be retained by the Owner for annual inspections and by the Project Engineer for project-specific inspections.

1.3 Quality Control Documentation

Prior to the installation of any geomembrane, the Manufacturer or Installer shall provide the Resident CQA Engineer with the following information:

1. The origin (supplier's name and production plant) and identification (brand name and number) of the resin used to manufacture the geomembrane.

2. Copies of dated quality control certificates issued by the resin supplier.

3. Results of tests conducted by the Manufacturer to verify that the resin used to manufacture the geomembrane meet the project specifications.

4. A statement indicating that the amount of reclaimed polymer added to the resin during manufacturing was done with appropriate cleanliness.

5. A list of the materials that comprise the geomembrane, expressed in the following categories as percent by weight: polyethylene, carbon black, and other additives.

6. A specification for the geomembrane that includes all properties contained in the project specifications measured using the appropriate test methods.

7. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.

8. Quality control certificates, signed by a responsible party employed by the Manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. At a minimum, results shall be given for the following:

Property	Test Method	Frequency
Thickness	ASTM D-5994	Each Roll
Sheet Density	ASTM D-1505	Every 200,000 lb
Tensile Properties	ASTM D-6693 Type IV	Every 20,000 lb
Tear Resistance	ASTM D-1004	Every 45,000 lb
Puncture Resistance	ASTM D-4833	Every 45,000 lb
Carbon Black Content	ASTM D-1603	Every 45,000 lb
Carbon Black Dispersion	ASTM D-5596	Every 45,000 lb

The Manufacturer shall identify all rolls of geomembranes with the following:

1. Manufacturer's name
2. Product identification
3. Thickness
4. Roll number
5. Roll dimensions

The Resident CQA Engineer shall review these documents and shall report any discrepancies with the above requirements to the Project Engineer. The Resident CQA Engineer shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Rolls are appropriately labeled.

5. Certified minimum properties meet the project specifications.

1.3.1 Quality Control Test Results

All conformance test results shall be reviewed and accepted or rejected by the Certifying CQA Engineer prior to shipping the geomembrane to the project site. The Certifying CQA Engineer shall examine all results from manufacturer's testing and shall report any non-conformance to the Design Engineer. The Certifying CQA Engineer shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications.

If a test result is in nonconformance, all material from the lot represented by the failing test shall be considered out-of-specification and rejected. Alternatively, at the option of the Design Engineer, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting the project specification. This procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line. To isolate the out-of-specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next large roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

1.4 Geomembrane Specifications

1.4.1 Materials

The geomembrane materials used for construction shall be in strict accordance with the technical specifications.

1.4.2 Construction

The geomembrane liner shall be constructed as soon as practical after completion and approval of the compacted clay liner or portion thereof. The top of the compacted clay liner will be surveyed to ensure adequate thickness of clay material and proper grades have been achieved. The geomembrane is to cover the cap in accordance with the Contract Drawings.

Areas to receive liner installation should be relatively smooth and even, free of ruts, voids, etc., to the extent required by the Engineer. This shall be accomplished by final dressing of the compacted liner with smooth drum rollers. No vehicles are permitted on final dressed surfaces unless authorized by the Engineer.

No loose soil will be allowed to underlie the geomembrane in anchor trenches. The time schedule for excavation and backfilling of anchor trenches is to be approved by the Engineer so that desiccation of trench soils does not occur prior to backfilling.

Before the geomembrane installation begins, the Resident CQA Engineer shall verify that:

1) A licensed Professional Land Surveyor has verified all lines and grades of the compacted clay liner.

2) A qualified and licensed Professional Engineer has verified that the clay liner surface meets the criteria specified in the project specifications.

3) The clay liner surface to be lined has been rolled, compacted, or hand-worked so as to be free of irregularities, protrusions, loose soil, and abrupt changes in grade.

4) The surface of the clay liner does not contain stones, which may be damaging to the geomembrane.

5) There is no area excessively softened by high water content.

6) There is no area where the clay liner surface contains desiccation cracks, which may damage the geomembrane.

7) The clay liner has sufficient thickness and that all permeability tests have not exceeded a permeability of 1.0×10^{-5} cm/sec.

8) The geomembrane to be deployed has an absolute minimum thickness of 40 mils and passing Quality Control testing, at the frequencies specified in section 1.3.1 of this Appendix can be documented.

The Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. The Installer shall give a certificate of acceptance to the Resident CQA Engineer prior to commencement of geomembrane deployment in the area under consideration. The Resident CQA Engineer shall give the Certifying CQA Engineer a copy of this certificate.

After the underlying soil has been accepted by the Installer, it is the Installer's responsibility to indicate to the General Contractor any change in the underlying soil condition that may require repair work. The General Contractor will consult with the Resident CQA Engineer regarding the need for repairs. If the Resident CQA Engineer concurs with the Installer, the General Contractor shall ensure that the underlying soil is repaired.

At any time before or during the geomembrane installation, the Resident CQA Engineer shall indicate to the General Contractor any locations that may not be adequately prepared for the geomembrane.

The Resident CQA Engineer shall verify that the anchor trench is constructed in accordance with the following:

1) The anchor trench has been constructed according to the project plans and specifications.

2) If the anchor trench is excavated in a clay material susceptible to desiccation, the amount of trench open at any time is minimized. The Resident CQA Engineer shall inform the Contractor and Project Engineer of any signs of significant desiccation associated with the anchor trench construction.

3) Rounded corners are provided in the trench so as to avoid sharp bends in the geomembrane.

4) Excessive amounts of loose soil are not allowed to underlie the geomembrane in the anchor trench.

5) The anchor trench is adequately drained to prevent ponding or softening of the adjacent soils while the trench is open.

6) The anchor trench is backfilled and compacted as outlined in the project specifications.

Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic components. The Resident CQA Engineer shall observe the backfilling operation and advise the

Contractor and Design Engineer of any problems. The Resident CQA Engineer shall document any problems in his daily report.

APPENDIX C

1.0 Field Seaming

1.1.1 Seam Layout

Before installation begins, the Installer shall provide the Resident CQA Engineer and the Design Engineer with a panel layout drawing. This drawing shall present all the proposed seams of the lining system at the facility. The Design Engineer and the Resident CQA Engineer shall review the panel layout drawing and verify that it is consistent with the technical specifications and the Division approved plans. No panels may be seamed until the Design Engineer has provided written approval of the panel layout drawing. In addition, panels not specifically shown on the panel layout drawing may not be used without the Design Engineer's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, thus, oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 10 feet (3.0 meter) from the toe or crest of the slope, or areas of potential stress concentrations, unless otherwise authorized by the Design Engineer.

The Resident CQA Engineer and the CQA monitors shall use a seam numbering system compatible with the panel numbering system.

1.1.2 Accepted Seaming Methods

Approved processes for field seaming are fusion welding and extrusion welding. Proposed alternate processes shall be documented and submitted by the Installer to the Design Engineer for approval. Only apparatuses that have been specifically approved by make and model shall be used. The Contractor shall submit all documentation regarding seaming methods to be used to the Resident CQA Engineer for review.

1.1.2.1 *Fusion Process*

The CQA monitor shall log ambient temperature, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the Resident CQA Engineer.

The Resident CQA Engineer shall verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatuses agreed upon at the pre-construction meeting.

2. Equipment used for seaming is not likely to damage the geomembrane.

3. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

4. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs to the geomembrane.

5. A movable protective layer is used as required by the Installer directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between the sheets and to prevent debris from collecting around the pressure rollers.

6. In general, the geomembrane panels are aligned to have an overlap of 4 to 6 inches (100 mm to 150 mm) for fusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

7. No solvent or adhesive is used.

8. The geomembrane is protected from damage in heavy traffic areas.

1.1.2.2 *Extrusion Process*

The CQA monitor shall log ambient temperature, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the Design Engineer.

The Resident CQA Engineer shall verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatuses agreed upon at the pre-construction meeting.

2. Equipment used for seaming is not likely to damage the geomembrane.

3. Prior to beginning a seam, the extruder is purged until all heat-degraded extrudate has been removed from the barrel.

4. Clean and dry welding rods or extrudate pellets are used.

5. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

6. Grinding is completed no more than one hour prior to seaming.

7. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs.

8. The geomembrane is protected from damage in heavy traffic areas.

9. Exposed grinding marks adjacent to an extrusion weld shall be minimized. In no instance shall exposed grinding marks extend more than 1/8 inch (6 mm) from the finished seamed area.

10. In general, the geomembrane panels are aligned to have a nominal overlap of 3 inches (75 mm) for extrusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

11. No solvent or adhesive is used.

12. The procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any temporary welding apparatus is controlled such that the geomembrane is not damaged

1.1.3 Seam Preparation

The CQA monitors shall verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. If seam overlap grinding is required, the CQA monitors must ensure that the process is completed according to the Manufacturer's instruction within one hour of the seaming operation, and in a way that does not damage the geomembrane. The CQA monitors shall also verify that seams are aligned with the fewest number of wrinkles and "fishmouths".

1.1.4 Test Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Trial seams shall be performed in accordance with section 04800 of the technical specifications.

1.1.5 General Seaming Procedures

During general seaming, the CQA monitors shall ensure the following:

1. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches (150 mm) beyond the cut in all directions.

2. If seaming operations are carried out at night, adequate illumination shall be provided.

3. Seaming shall extend to the outside edge of panels placed in the anchor trench.

4. All cross seam tees should be extrusion welded to a minimum distance of 4 inches (100 mm) on each side of the tee.

5. No field seaming shall take place without the Master Seamer being present.

6. A firm substrate may be required to be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.

The Resident CQA Engineer shall verify that the above seaming procedures or any other procedures agreed upon and indicated in the Preconstruction Meeting or construction progress meetings are followed, and shall inform the Design Engineer of any nonconformance.

1.1.6 Seaming Weather Conditions

1.1.6.1 Cold Weather Conditions

To ensure a quality installation, if seaming is conducted when the ambient temperature is below 40°F (5°C), the following conditions shall be met:

1. Geomembrane surface temperatures shall be determined by the Resident CQA Engineer at intervals of at least once per 100 feet (30 meter) of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 41°F (5°C).

2. For fusion welding, preheating may be waived by the Design Engineer based on a recommendation from the Resident CQA Engineer, if the Installer demonstrates to the their satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

3. If preheating is required, the CQA monitors shall observe all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.

4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.

5. The Resident CQA Engineer shall approve all preheating devices prior to use.

6. Additional destructive tests shall be taken at an interval between 250 feet and 500 feet (75 to 150 meter) of seam length, at the discretion of the Resident CQA Engineer.

7. Sheet grinding may be performed before preheating, if applicable.

8. Test seams shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, additional trial seams shall be conducted if the ambient temperature drops by more than 10°F from the

initial trial seam test conditions. Such new seams shall be conducted upon completion of seams in progress during temperature drop.

1.1.6.2 Warm Weather Conditions

At ambient temperatures above 104°F, no seaming of the geomembrane shall be permitted unless the Installer can demonstrate to the satisfaction of the Resident CQA Engineer that geomembrane seam quality is not compromised. Test seams shall be conducted under the same ambient temperature conditions as the production seams. At the option of the Resident CQA Engineer, additional destructive tests may be required for any suspect areas.

1.2 Nondestructive Seam Testing

1.2.1 Concept

The Installer shall nondestructively test all field seams over their full length using an air pressure test (for double fusion seams only), a vacuum test or other approved method. Air pressure testing and vacuum testing are described elsewhere respectively. The purpose of nondestructive tests is to check the continuity of seams. It does not provide quantity information on seam strength. Nondestructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

For all seams, the CQA monitors shall:

1. Observe nondestructive testing procedures.

2. Record location, data, test unit number, name of tester, and outcome of all testing.

3. Inform the Installer and Resident CQA Engineer of any required repairs.

Any seams that cannot be nondestructively tested shall be cap-stripped. The cap-stripping operations shall be observed by the Resident CQA Engineer and Installer for uniformity and completeness.

1.2.2 Air Pressure Testing

Air pressure testing is applicable to double fusion welding which produces a double seam with an enclosed space.

1. The Equipment for air pressure testing shall consist of the following:

    a. An air pump (manual or motor driven), equipped with pressure gauge and capable of generating and sustaining a pressure between 25 and 30 psi (160 and 200 kPa) and mounted on a cushion to protect the geomembrane.

b. A rubber hose with fittings and connections.

c. A sharp hollow needle, or other pressure feed device, approved by the Resident CQA Engineer.

2. The following procedures shall be followed:

a. Seal both ends of the seam to be tested.

b. Insert needle or other approved pressure feed device into the air channel created by the fusion weld.

c. Insert a protective cushion between the air pump and the geomembrane.

d. Pressurize the air channel to a pressure of approximately 30 psi (200 Kpa). Close valve, allow 2 minutes for pressure to stabilize, and sustain pressure for at least 5 minutes. Pressure loss over the 5-minute period should not exceed 3psi.

e. If loss of pressure exceeds the maximum permissible pressure differential as outlined in the project specifications or does not stabilize, locate fault area and repair in accordance with Section 1.4.3.

f. Cut opposite end of tested seam area once testing is complete to verify continuity of the air channel. If air does not escape, locate blockage and retest unpressurized area.

g. Remove needle or other approved pressure feed device and grind and weld or patch the hole in the geomembrane.

1.2.3 Vacuum Testing

Vacuum testing is applicable to extrusion welding.

1. The equipment shall consist of the following:

a. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a porthole or valve assembly, and a vacuum gauge.

b. A pump assembly equipped with a pressure controller and pipe connections.

c. A rubber pressure/vacuum hose with fittings and connections.

d. A soapy solution. (CQA monitors shall ensure solution makes bubbles when air is passed through.)

e. A bucket and wide paintbrush, rag, or other means of applying the soapy solution.

2. The following procedures shall be followed:

a. Wet a strip of geomembrane approximately 12 inches X 48 inches (0.3 m X 1.2 meter) with the soapy solution.

b. Place the box over the wetted area.

c. Close the bleed valve and open the vacuum valve.

d. Ensure that a leak-tight seal is created.

e. Energize the vacuum pump and reduce the applied pressure to approximately 5-psi (10 inches of Hg/35kPa) on the gauge.

f. For a minimum of 10 seconds, apply vacuum with the box placed and maintaining a seal, examine the geomembrane through the viewing window for the presence of soap bubbles.

g. If no bubble appears after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 inches (75 mm) overlap, and repeat the process.

h. All areas where soap bubbles appear shall be marked and repaired in accordance with Section 1.4.3.

1.2.4 Test Failure Procedures

The Installer shall complete any required repairs in accordance with Section 1.4.3. For repairs, the CQA monitor shall:

1. Observe the repair and testing of the repair.

2. Mark on the geomembrane that the repair has been made.

3. Document the repair procedures and test results.

1.3 Destructive Seam Testing

1.3.1 Concept

The purpose of destructive tests is to evaluate seam strength. Destructive seam tests shall be performed at selected locations. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

1.3.2 Location and Frequency

The Resident CQA Engineer shall select where seam samples will be cut out for laboratory testing. The frequency and locations shall be established as follows:

1. A minimum frequency of one test location per 500 feet (150 meter) of seam length shall be performed by each welding machine. This frequency is to be determined as an average taken throughout the entire facility.

2. Test locations shall be determined during seaming at the discretion of the Resident CQA Engineer or the Design Engineer. Special consideration shall be given to locations where the potential for imperfect welding, such as overheating, contamination, and offset welds exists.

1.3.3 Sampling Procedures

Samples shall be cut by the Installer at locations chosen by the Resident CQA Engineer as the seaming progresses so that laboratory test results are available before the geomembrane is covered by another material. The Resident CQA Engineer shall:

1. Observe sample cutting.

2. Assign a number to each sample, and mark it accordingly.

3. Record sample location on layout drawing.

4. Record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be repaired in accordance with repair procedures described in Section 1.4.3 immediately following receipt of successful test results. The continuity of the new seams in the repaired area shall be tested according to Section 1.2.3. All holes in the geomembrane shall be temporarily patched or repaired in accordance with section 1.4.3 before the end of each workday in order to protect the clay liner from inclement weather.

1.3.4 Sampling Procedure

Destructive sampling shall be performed in accordance with section 04800 of the technical specifications.

1.3.5 Field Testing

Destructive field-testing shall be performed in accordance with section 04800 of the technical specifications.

1.3.6 Destructive Test Failure

Destructive test failures shall be handled in accordance with section 04800 of the technical specifications.

1.4 Defects and Repairs

1.4.1 Identification

All seams and non-seam areas of the geomembrane shall be examined by the CQA monitors for identification of defects, holes, blisters, undispersed raw materials, large wrinkles and any sign of contamination by foreign matter. The geomembrane surface shall be cleaned by the Installer prior to examination if the CQA monitor determines that the amount of dust or mud inhibits examination.

1.4.2 Evaluation

Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in Section 1.2. Each location that fails the nondestructive testing shall be marked by the CQA monitor and repaired by the Installer. Work shall not proceed with any materials that will cover locations that have been repaired until successful nondestructive and/or laboratory tests are obtained.

When seaming of the geomembrane is completed, and prior to placing overlying materials, the Resident CQA Engineer shall indicate to the General Contractor any large wrinkles that should be cut and reseamed by the Installer. The number of wrinkles to be repaired should be kept to an absolute minimum. Therefore, wrinkles should be located during the coldest part of the installation period, while keeping in mind the forecasted weather to which the undercover geomembrane may be exposed. Wrinkles are considered to be large when the geomembrane can be folded over onto itself, which is generally a wrinkle that extends 12 inches (0.3 meter) from the subgrade. Seams produced while repairing wrinkles shall be nondestructively tested.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather. In

addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by McGill Associates or a CQA monitor to ensure that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

1.4.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be determined by the Design Engineer and the Resident CQA Engineer.

1. The repair procedures available include:

    a. Patching, used to repair holes, tears, undispersed raw materials, and contamination by foreign matter.

    b. Spot welding used to repair pinholes, or other minor, localized flaws.

    c. Capping, used to repair large lengths of failed seams.

    d. Removing bad seam and replacing with a strip of new material welded into place.

    NOTE: Extrusion welding the flap to repair inadequate fusion seams which have an exposed edge shall not be allowed under any circumstances.

2. For any repair method, the following provisions shall be satisfied:

    a. Surfaces of the geomembrane that are to be repaired using extrusion methods shall be ground no more than one hour prior to the repair.

    b. All surfaces shall be clean and dry at the time of the repair.

    c. All seaming equipment used in repairing procedures shall meet the requirements of this SSCQAP.

    d. Patches or caps shall extend at least 6 inches (150 mm) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 inches (75 mm).

1.4.4 Repair Verification

The CQA monitors shall observe all nondestructive testing of repairs and shall record the number of each repair, date and test outcome. Each repair shall be nondestructively tested using the

method described in Section 1.2 as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Repairs more than 500 feet (50 meter) long require destructive test sampling. Failed tests require that the repair shall be redone and re-tested until a passing test results.

1.5 Geomembrane Protection

The quality assurance procedures indicated in this Section are intended only to assure that the installation of adjacent materials does not damage the geomembrane. The quality assurance of the adjacent materials themselves is covered in separate Sections of this manual.

1.5.1 Soils

1. Placement of soil on the geomembrane shall not proceed at an ambient temperature below 32 degrees F (0 degrees C) nor above 104 degrees F (40 degrees C) unless otherwise specified.

2. Placement of soil on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.

3. Equipment used for placing soil shall not be driven directly on the geomembrane.

4. A minimum thickness of 18 inches of soil shall be maintained between the geocomposite and a light dozer, ground pressure of 5 psi (35 kPa) or lighter, and the geomembrane. Trucks shall have a minimum thickness of 2 feet between them and the geomembrane.

5. In any areas traversed by heavy construction, any vehicles other than low ground pressure vehicles shall be approved by the Design Engineer, and the soil layer shall have a minimum thickness of 3 feet (0.9 meter). This requirement may be waived if provisions are made to protect the geomembrane through an engineered design approved by the Design Engineer. Drivers shall proceed with caution when traveling on the overlying soil and prevent spinning of tires or sharp turns.

6. Methane gas collection pipes shall not be crossed with construction equipment without the full two (2) feet of soil in place. In areas where trucks must repeatedly cross the methane gas piping, a temporary soil road shall be build to bridge over the pipe and maintain a minimum thickness of three (3) feet.

7. Care shall be taken to avoid creating wrinkles in the geomembrane during placement of the soil layer.

1.5.2 Appurtenances

The appurtenances shall be constructed in accordance with the technical specifications and the Resident CQA Engineer shall certify the following:

1. Installation of the geomembrane, equipment, and appurtenant areas has been performed properly, and connections of geomembrane to appurtenances have been made according to project specifications.

2. Extreme care is taken while welding around appurtenances since nondestructive testing will be difficult in these areas.

3. The geomembrane has not been visibly damaged while making connections to appurtenances.

4. The Resident CQA Engineer or his representative shall be present at all times when the Installer is welding geomembrane to appurtenant structures.

The Resident CQA Engineer shall inform the Design Engineer in writing if the above conditions are not fulfilled.

APPENDIX D

1.0 Geotextile

1.1 Definition and Applicability

Geotextile are used in protection and filtering applications in lining systems. This Section does not describe procedures for other applications such as erosion control or reinforcement. This Section is applicable to nonwoven geotextiles made of polyester of polypropylene and not applicable to geotextiles made of other materials or woven geotextiles.

1.2 Manufacturing Plant Inspection

The Owner or an appropriate representative may conduct a periodic inspection of the Manufacturer's plant. In addition, the Design Engineer or his designated representative may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the geotextile rolls for that particular project. The purpose of the plant inspections is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection shall include:

1. Verification that properties of the geotextile guaranteed by the Manufacturer are met and meet the project specifications.

2. Verification that the measurement of properties by the manufacturer is properly documented and test methods used is acceptable.

3. Inspection of the rolls and verification that they are free of imperfections or any sign of contamination by foreign matter.

4. Review of packaging, handling, storage, and transportation procedures and verification that these procedures will not damage the geotextile.

5. Verification that roll packages have a label indicating the name of the manufacturer, type of geotextile, roll number and roll dimensions.

6. Verification that the geotextiles are inspected continuously for the presence of needles using a metal detector.

A report describing the inspection will be retained by the Owner for periodic inspections and by the Design Engineer for project-specific inspections.

1.3 Quality Control Documentation

Prior to the installation of any geotextile, the Manufacturer or Installer shall provide the Design Engineer with the following information:

1.4 Roll Dimensions

The Resident CQA Engineer shall review these documents and shall report any discrepancies with the above requirements to the Design Engineer. The Certifying CQA Engineer shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Roll packages are appropriately labeled.

5. Certified minimum roll properties meet the project specifications.

6. Project specifications and a copy of the QAP were submitted by the Design Engineer to the Installer.

1.5 Geotextile Deployment

During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, moisture, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions. Geotextile rolls shall be shipped and stored in relatively opaque and watertight wrappings. Wrapping shall not be removed until shortly before deployment.

The CQA monitors shall observe rolls upon delivery at the site. Any apparently damaged or improperly wrapped rolls shall be reported to the Resident CQA Engineer.

The installer shall ensure that geotextiles are not damaged during handling. The geotextile shall be deployed as described below:

1. On slopes, the geotextile shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geotextile sheet in tension.

2. In the presence of wind, all geotextiles shall be weighted with sandbags or the equivalent. Such sand bags shall be installed during deployment and shall remain until replaced with cover material.

3. Geotextiles shall be cut using a geotextile cutter (hook blade) only. If in place, special care shall be taken to protect other materials from damage that could be caused by the cutting of the geotextile.

4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile.

5. During placement of geotextile, care shall be taken not to entrap, in or beneath the geotextile, stones, excessive dust, or moisture that could damage the geomembrane, cause clogging of drains or filters, or hamper subsequent seaming.

6. A visual examination of the geotextile shall be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects, such as needles, are present.

The Resident CQA Engineer shall note any noncompliance and report it to the Design Engineer.

1.6 Geotextile Material Specification and Seaming Procedures

Non-woven Filter Geotextile shall be as indicated below:

Non-woven Geotextile

The geotextile used shall be ultraviolet stabilized 1) a non-woven, needlepunched, continuous filament polyester material or, 2) a non-woven, needlepunched continuous filament polypropylene material or, 3) a non-woven, needlepunched staple fiber polypropylene material.

A 6 oz. geotextile will be placed between the geomembrane and the vegetative supportive soil layer via installation of an integrated double-sided drainage net (geocomposite).

The minimum angle of friction between the 6 oz. geotextile geocomposite and the textured geomembrane shall be twenty-four (24) degrees.

The non-woven material shall meet or exceed the following criteria using Minimum Average Values:

		6 oz. Geotextile
Grab Tensile	ASTM D4632	170 lbs.
Puncture Strength	ASTM D4833	90 lbs.
Fabric Weight		6.0 oz.
Apparent Opening Size (AOS)	ASTM D4751	0.212 mm (70 Sieve max.)

Seaming

The geotextile for the cap shall be installed as follows:

1. Panels of geotextile shall be 6' and overlapped continuously sewn along the entire length of the seams.

1.7 Geotextile Protection

All soil materials located on top of a geotextile shall be deployed in such a manner as to ensure:

1. The geotextile and underlying lining materials are not damaged.
2. Minimal slippage of the geotextile on underlying layers occurs.
3. No excess tensile stresses occur in the geotextile.

All noncompliance with these guidelines or the project specifications shall be noted by the Geosynthetic QAC and reported to the Design Engineer.

2.0 Geonets

2.1 Definition and Applicability

Geonets are geosynthetic nets used as a drainage medium in lining systems. This Section is applicable to geonets made of high density polyethylene (HDPE), including "foamed" HDPE products but is not applicable to geonets made of other polymers.

2.2 Manufacturing Plant Inspection

The Owner or appropriate representative may conduct a periodic inspection of the Manufacturer's plant. In addition, the Design Engineer, or his designated representative may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the geonet rolls for that particular project. The purpose of the inspection is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection shall include:

Verification that properties guaranteed by the Manufacturer are met and meet all project specifications.

1. Verification that the measurement of properties by the Manufacturer is properly documented and test methods used are acceptable.

2. Spot inspection of the rolls and verification that they are free of imperfections or any sign of contamination by foreign matter.

3. Review of packaging, handling, storage, and transportation procedures and verification that these procedures will not damage the geonet.

4. Verifications that roll packages have a label indicating the name of the manufacturer, type of geonet, roll number and roll dimensions.

A report describing the inspection will be retained by the Owner for periodic inspections and by the Design Engineer for project-specific inspections.

2.3 Quality Control Documentation

Prior to the installation of any geonet, the Manufacturer or Installer shall provide the Resident CQA Engineer with the following information:

1. The origin (supplier's name and production plant) and identification (brand name and number) of the resin.

2. Copies of dated quality control certificates issued by the resin supplier.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Roll packages are appropriately labeled.

5. Certified minimum properties meet the project specifications.

6. Project specifications and a copy of the QAP were submitted by Design Engineer to the Installer.

2.4 Geonet Installation

1. On slopes, the geonet shall be secured and rolled down the slope in such a manner as to continually keep the geonet sheet in tension. If necessary, the geonet shall be positioned by hand after being unrolled to minimize wrinkles.

2. In the presence of wind, all geonet shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.

3. Unless otherwise specified, geonet shall not be welded to geomembrane.

4. Geonet shall only be cut using scissors or other cutting tools approved by the Resident CQA Engineer that will not damage the underlying geosynthetics. Care shall be taken not to leave tools in the geonet.

5. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geonet.

6. During placement of geonet, care shall be taken not to entrap dirt, excessive dust, or fugitive bentonite clay in the geonet that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geonet, it should be cleaned prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags, to prevent puncturing the sandbag.

The Resident CQA Engineer shall note any noncompliance and report it to the Design Engineer.

2.5 Seams and Overlaps

At a minimum, the following requirements for joining the adjacent geonet shall be met:

1. Adjacent rolls shall be overlapped by at least 4 inch (100 mm).

2. The geonet overlaps shall be tied with plastic fasteners. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.

3. Tying shall be every 5 feet (1.5 meters) along the length at the adjacent rolls, every 6 inches (0.25 meter) in the anchor trench and every 6 in (0.15 meter) along end-to-end seams.

The Resident CQA Engineer shall observe any repair and report any noncompliance with the above requirements in writing to the Design Engineer.

3.0 Geocomposites

3.1 Definition and Applicability

Geocomposites are geosynthetic nets with geotextile heat bonded to the surface. The geocomposite can be single-sided or double-sided depending on the application. They are used as drainage medium in lining systems, where the properties of the geotextile can either serve as a filter media from clogging the geonet or increase stability of the lining system. This Section is applicable to geocomposites where the geonet portion is made of high density polyethylene (HDPE), including "foamed" HDPE products but is not applicable to geocomposites where the geonet is made of other polymers.

3.2 Manufacturing Plant Inspection

The Owner or appropriate representative may conduct a periodic inspection of the Manufacturer's plant. In addition, the Design Engineer, or his designated representative may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the geocomposite rolls for that particular project. The purpose of the inspection is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection shall include:

Verification that properties guaranteed by the Manufacturer is met and meets all project specifications.

1. Verification that the measurement of properties by the Manufacturer is properly documented and test methods used is acceptable.

2. Spot inspection of the rolls and verification that they are free of imperfections or any sign of contamination by foreign matter.

3. Review of packaging, handling, storage, and transportation procedures and verification that these procedures will not damage the geocomposite.

4. Verifications that roll packages have a label indicating the name of the manufacturer, type of geocomposite, roll number and roll dimensions.

A report describing the inspection will be retained by the Owner for periodic inspections and by the Design Engineer for project-specific inspections.

3.3 Production

The geocomposite shall be manufactured by heat bonding the geotextile to the HDPE drainage net on one or both sides. No burn through geotextiles shall be permitted. No glue or adhesive shall be permitted.

The geonet portion of the geocomposite shall be manufactured by extruding two sets of strands to form a three (3) dimensional structure to provide planar water flow.

3.4 Quality Control Documentation

Prior to the installation of any geocomposite, the Manufacturer or Installer shall provide the Resident CQA Engineer with the following information:

1. The origin (supplier's name and production plant) and identification (brand name and number) of the resin used for geonet.

2. Copies of dated quality control certificates issued by the geonet resin supplier.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Roll packages are appropriately labeled.

5. Certified minimum properties meet the project specifications.

6. Project specifications and a copy of the QAP were submitted by Design Engineer to the Installer.

At a minimum, the geotextile used to produce the geocomposite shall be tested in accordance with section 1.0. The geonet used to produce the geocomposite shall be tested in accordance with section 2.0. The bond between the geotextile and the HDPE drainage net shall be tested at a minimum rate of one (1) test per 600 linear feet of geocomposite produced. The bond shall exhibit a minimum average peel strength of 2 lbs per inch, and a typical peel strength of 4 lbs. per inch as per ASTM D-413.

3.5 Geocomposite Installation

1. On slopes, the geocomposite shall be secured and rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

2. In the presence of wind, all geocomposite shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.

3. Unless otherwise specified, geocomposite shall not be welded to geomembrane.

4. Geocomposite shall only be cut using scissors or other cutting tools approved by the Resident CQA Engineer that will not damage the underlying geosynthetics. Care shall be taken not to leave tools in the geocomposite.

5. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

6. During placement of geocomposite, care shall be taken not to entrap dirt, excessive dust, or fugitive bentonite clay in the geocomposite that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags, to prevent puncturing the sandbag.

The Resident CQA Engineer shall note any noncompliance and report it to the Design Engineer.

3.6 Seams and Overlaps

At a minimum, the following requirements for joining the adjacent geocomposite shall be met:

1. Adjacent rolls shall be overlapped by at least 4 inches (100 mm).

2. The geocomposite overlaps shall be tied with plastic fasteners. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.

3. Tying shall be every 5 feet (1.5 meters) along the length at the adjacent rolls, every 6 inches (0.25 meter) in the anchor trench and every 6 in (0.15 meter) along end-to-end seams.

4. Any areas where the geotextile portion of the geocomposite was damaged for the purpose of tying shall be covered by an extra geotextile prior to backfilling. The geotextile used to patch the geocomposite can be thermally bonded to the geotextile on the geocomposite.

The Resident CQA Engineer shall observe any repair and report any noncompliance with the above requirements in writing to the Design Engineer.

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CLOSURE PLAN
MSW LANDFILL
MADISON COUNTY, NORTH CAROLINA

TECHNICAL SPECIFICATIONS

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02202.1 SCOPE

The work of this section consists of locating, hauling, and processing the soil material used to construct the 24-inch vegetative support soil layer as shown on the construction drawings. The purpose of the vegetative soil layer is to protect the geomembrane component of the cap system and to provide a layer for vegetative growth to reduce erosion on the landfill cap. The hydraulic conductivity, or permeability, of the vegetative support soil layer must be a maximum of 1 X 10^{-5} cm/sec. Borrow soils shall meet the requirements of Section 02203 and placement of the select backfill shall be in strict accordance with Section 02200 and the construction drawings.

02202.2 SOIL MATERIALS

The vegetative soil layer will be the soil placed on top of the geosynthetic component of the landfill cap system. This material will have the same preconstruction and testing requirements as the subgrade, with the exception that preconstruction and construction testing will have to be performed to show conformance with the permeability or hydraulic conductivity requirements. The testing requirements are as follows.

Preconstruction Qualification		
Test	**ASTM Method**	**Quantity**
Permeability, Hydraulic Conductivity	D2434, D3385 or D5126	1/5,000 YD^3
*** Preconstruction test samples shall be taken from the borrow source and or stockpile prior to construction.**		
Construction Testing		
Test	**ASTM Method**	**Quantity**
Field Density	D2922, D1556, D2167	1/ACRE
Field Moisture	D2216, D3017, D4643	1/ACRE
Permeability	D5084	1/ACRE
Testing Criteria		
Permeability, Hydraulic Conductivity		Maximum of 1 X 10^{-5} cm/sec

02202.3 EXECUTION

The contractor is required to provide soil material for constructing the vegetative layer of the landfill cap system in accordance with the material requirements described in 2202.2. The vegetative layer shall be placed in accordance with Section 02200.

The friction angle between the structural fill and the geomembrane shall be a minimum of 24 degrees. The Contractor shall verify prior to beginning construction. The test method used to verify the interface friction angle between the 40-mil geomembrane and the structural fill shall be ASTM D5321 *Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by Direct Shear Method*. Test parameters are to provide 3 points to range over minimum and maximum expected normal loads. Maximum will be a construction load of 260 psf.

The friction angle between the vegetative soil layer and the geocomposite shall be a minimum of 24 degrees. The Contractor shall verify prior to beginning construction. The test method used to verify the interface friction angle between the 6-ounce geocomposite and the vegetative soil layer shall be ASTM D5321 *Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by Direct Shear Method*. Test parameters are to provide 3 points to range over minimum and maximum expected normal loads. Maximum will be a construction load of 260 psf.

02202.4 MEASUREMENT AND PAYMENT

See Section 01300.

END OF SECTION

02212.1 SCOPE

The work of this section consists of furnishing, loading, and hauling of borrow material used in the construction of the 24 inch vegetative soil layer, structural fill and the clay liner portion of the landfill cap system, as shown and specified herein.

02212.2 GENERAL

Borrow soils shall be selected to meet the requirements and conditions of the particular fill for which its use is intended. Borrow soils will be required for construction of the 24 inch vegetative soil layer, structural fill and the clay liner portion of the landfill cap system. Borrow area(s) are located on Madison County property and are available to the Contractor. One of the borrow areas is located to the north of the MSW landfill (between the MSW cell and the new C&D cell) and the other is located to the south of the MSW landfill above the cemetery. The locations of the available borrow areas are shown on sheet 2 of the construction drawings. The Owner does not certify the available material will meet the project specifications, but only that the material is available for the Contractor's convenience. The Contractor is responsible for providing borrow material which meets the project specifications. All borrow soils shall be free of roots, trash, and other deleterious material.

A. Borrow shall consist of material obtained from sources provided by the Contractor and shall meet the requirements of the classifications in accordance with USCS listed below:

   1. Acceptable Classifications: SC, CL, OL, CH, MH, OH and ML.

   2. Unacceptable Classifications: SW, SP, SM, and PT.

B. Cohesionless Materials: Cohesionless materials include poorly and well-graded gravels (GP and GW) and poorly and well graded sands (SP and SW). Cohesionless soils are generally regarded as free draining.

C. Cohesive Materials: Clayey gravels (GC), clayey sands (SC), lean clays (CL), fat clays (CH), silts (ML and MH), and organic (GM) and silty sands (SM) will be considered cohesionless only when the fines have a plastic index of 0. Otherwise they will be considered cohesive.

02212.3 RESTORATION

All borrow areas shall be graded to drain properly. The Contractor shall provide the owner with a proposed borrow area grading plan prior to beginning construction. The condition of the borrow areas, after construction has been completed, shall be approved by the Owner.

All borrow areas shall be seeded in accordance with Section 02931 of these specifications. Topsoil replacement will not be required for on-site borrow areas prior to seeding. Erosion control methods used at the borrow areas shall be approved by the Engineer.

02212.4 MEASUREMENT AND PAYMENT

No direct payment will be made for the work covered by this section. Payment at the contract prices for the various items in the contract will be full compensation for all work covered by this section including but not limited to furnishing any borrow areas; any right of access to borrow areas; and dressing and shaping of fill areas.

END OF SECTION

02300.1 Scope of Work

The landfill cap shall include a 18-inch compacted clay liner. The Contractor shall furnish all labor, material, supervision, and equipment to complete the Compacted Clay Liner for the landfill, including hauling, sieving, raking, discing, compacting, drying, wetting, removal of rainwater and removal of all previously placed material rendered unsuitable due to weather conditions or construction operations, final grading and sealing and all necessary and incidental items as detailed or required to complete the compacted liner, all in accordance with the Contract Documents, and the Site Specific Construction Quality Assurance Plan.

02300.2 Materials

Soil that meets the requirements of clay liner fill shall be used for construction of the compacted clay liner. The clay liner material shall have a Plasticity Index (PI) greater than 10. The clay liner material shall be raked or sieved by the Contractor to remove all aggregate greater than 3 inches in the lower 18-inches and 1/4-inch in the top 6-inches. No more than 5 percent material greater than the No. 4 sieve will be allowed in the soil liner. All clay clods will be broken down with tillers and discs to provide a homogeneous clay soil.

The Clay Liner may consist of fill material modified by the addition of powdered bentonite in sufficient quantity to meet the specifications. Clay liner modified with bentonite will be subject to the exact same testing criteria and frequencies as natural clay, with the addition of percentage of bentonite used. If a bentonite admix is used, the mixing procedure shall be approved by the Engineer prior to construction. Material to be placed as part of the landfill cap, either natural or augmented, shall have a minimum effective internal friction angle of twenty-four (24) degrees. The internal friction angle of the clay liner material shall be verified by the Contractor prior to beginning construction. The test method used to verify the internal friction angle of the clay liner material shall be ASTM D4767 *Standard Test Method for Consolidated Undrained Triaxial Compression Test on Cohesive Soils*. The specimens must be compacted to design criteria for dry density and moisture content as determined by preconstruction testing. Test parameters require stepped confinement @ 1, 3, and 5ksf (nominally 5, 15 and 30 psi effective confining pressure.

Continuous and repeated visual inspection of the materials will be performed by the Contractor to ensure proper soils are being used. In addition, the Engineer will make frequent inspections of the clay liner placement operations and materials, and will consult with the site

personnel on suitable liner fill and locations of such. All soil liner fill proposed shall be inspected by the Engineer prior to actual use.

The compacted clay liner material when tested in accordance with ASTM D 5084 shall have a permeability not greater than $1.0x10^{-5}$ cm/sec. Confining pressure during permeability test shall be 3 psi +/- 1 psi. Bulk samples will be taken from stockpile or borrow source at intervals given in the construction quality assurance plan. The samples will be transported to the laboratory for compaction and permeability testing. The samples will be compacted to at least 95 percent of Standard Proctor at moisture contents similar to field conditions.

02300.3 Construction

Test pads 20 ft x 50 ft in area shall be constructed prior to beginning installation of the compacted clay liner and whenever there is a significant change in soil material properties or the borrow source is changed. The equipment used, liner thickness, subgrade slope, and all other conditions shall be representative of full scale construction. For each lift of the test pad, a minimum of three (3) test locations shall be established for testing moisture content and density. At least one (1) shelby tube sample for lab permeability testing and one (1) composite sample for recompacted lab permeability shall be obtained per lift. Compaction and soil moisture content shall be in accordance with Table 1 and the previously approved moisture-density-permeability relationship. Field moisture and density tests and laboratory permeability tests will be performed by the CQA Engineer for each lift placed on the test pads to verify the construction method, equipment, and material necessary to achieve the required permeability not greater than $1.0x10^{-5}$ cm/sec for the clay liner. The Contractor shall allow sufficient time for construction and testing of the test pad prior to placement of the Compacted Clay Liner.

TABLE 1 - QA TESTING FREQUENCIES AND CRITERIA FOR SOIL LINER LAYER

PRECONSTRUCTION QUALIFICATION		
TEST	ASTM METHOD	QUANTITY
Moisture Content	D2216	1/1,000 YD^3
Grain Size	D422 or D1140	1/5,000 YD^3
Atterberg Limits	D4318	1/5,000 YD^3
Laboratory Compaction	D698 - Standard	1/5,000 YD^3
Permeability	D5084	1/5,000 YD^3

TABLE 1 (continued)

CONSTRUCTION TESTING		
TEST	ASTM METHOD	QUANTITY
Field Density	D2922, D1556, D2167	1/10,000 FT^2/LIFT
Field Moisture	D2216, D3017, D4643	1/10,000 FT^2/LIFT
Permeability	D5084	1/40,000 FT^2/LIFT
TESTING CRITERIA		
Classification	CL, CH, ML, or MH	
Maximum Particle Size		3-inch dia. (lower 18 inches) 1/4-inch dia. (top 6 inches)

Construction methods, sampling and testing will be recommended by the Engineer. Typical tests to be included will be moisture content, in-place density, Atterberg limits and permeability testing.

Prior to fill placement, the prepared subgrade shall be proofrolled. Proofrolling shall be conducted at the discretion of the Engineer or his representative. Any soft, saturated or yielding areas exhibited by pumping and/or rutting will require removal and replacement with the appropriate soil at no additional cost to the Owner.

02300.4 Final clay liner lift thickness, after compaction, shall be a maximum of six (6) inches. Thinner lifts are permissible to achieve design grade.

02300.5 Equipment or truck traffic shall not be permitted during the period between scarifying and compaction of a lift unless approved by the Engineer.

02300.6 After the lift to be compacted is conditioned, representative samples will be taken by the Engineer and tested for moisture content prior to any compactive efforts. If the moisture content is within the range specified by the moisture-density-permeability relation, compaction may begin. If the moisture content is outside of this range, the clay liner fill will be wetted or dried and reworked accordingly. The soil fill should be sprinkled or sprayed with water utilizing equipment creating a uniform application and dozed, wind-rowed, and/or disc-plowed to uniformly increase the moisture content of the soil if the material moisture content is too low. The soil fill shall be dozed, wind-rowed, and/or disc-plowed to help air dry the soil if the moisture content is too high.

02300.7 Each lift shall be thoroughly compacted to satisfy moisture and density controls through field testing before a subsequent lift is placed.

02300.8 Compaction of lifts shall be as follows:

1) Compaction of lifts shall be performed with an appropriately heavy, properly ballasted compactor. The compactor used shall be subject to approval of the Engineer. A minimum of four (4) passes will be required on each lift regardless of whether the lift meets density specifications. A pass is defined as one trip of the compacting equipment over the lift and back to the starting point by a single drum roller or one trip across the lift surface from one side to the other if the compacting equipment has front and back compacting rollers. This requirement is to allow thorough remolding of the soil by kneading action. Compaction methods may be modified with prior approval from the Engineer.

2) The daily work area shall extend a distance so as to maintain moist soil conditions (facilitate bonding) and continuous operations. Desiccation and crusting of the lift surface shall be avoided as much as possible. Each lift shall be protected, at all times after placement, from desiccation and crusting.

3) If desiccation and crusting of the lift surface occurs before placement of the next lift, this area shall be scarified to a sufficient depth to mix with moist materials, or sprinkled with water and then scarified at the direction of the Engineer.

4) Dozer equipment shall not be used for primary compaction efforts.

5) The surface of the underlying lift shall be scarified a minimum of 2 inches prior to compaction of each subsequent lift (i.e., Lift 2 to Lift 3) to facilitate bonding of the lifts.

02300.9 During compaction of the soil liner material, the soil moisture content and dry density shall be maintained within the limits specified below.

1) To assure the moisture content and dry density requirements of the compacted soil are being satisfied, field and laboratory tests shall be made at intervals and locations designated by the Engineer.

2) The clay liner shall be compacted to a minimum dry density of 95 percent of the maximum dry density determined from the Standard Proctor Test (ASTM D-698). Where densities less than 95 percent of the maximum dry density determined from the Standard Proctor Test are measured, the soil liner shall be recompacted and/or removed and reworked to meet density objectives.

02300.10 The clay liner, in addition to the other provisions of this section, shall have a permeability not greater than 1.0 $x10^{-5}$ cm/s on thin wall tube samples taken from the completed clay liner. If representative permeability tests do not achieve the required permeability, the clay liner shall be reworked to meet permeability requirements regardless of its previously achieved density. Representative soil samples taken from the clay liner that fail laboratory permeability testing must be re-sampled until passing results are achieved. Each failing sample must be replaced by one successful sample. The Owner will pay for the permeability testing at the frequency required by the site specific Construction Quality Assurance Plan. The Contractor will be responsible for all costs associated with re-sampling and re-testing for failing samples beyond a 5% failure rate by quantity. This includes the cost of lab and Construction Quality Assurance personnel. The minimum charge for re-sampling and re-testing for failing permeability tests exceeding 5% failure rate will be $300.00 per occurrence.

02300.11 Soil fill shall not be placed or compacted during sustained periods with air temperature below 32°F. Soil fill may be placed and compacted during periods of early morning and early evening freezing temperatures with warming trends above 45°F during the day. No fill shall be placed on frozen subgrade. If the clay liner or structural fill freezes or ices the fill section shall be rescarified and recompacted, at the discretion of the Engineer.

02300.12 During construction, finished lifts or sections of compacted clay liner shall be sprinkled with water twice a day if needed.

02300.13 At the end of each construction day's activities, completed lifts or sections of compacted clay liner shall be sealed by rolling with a rubber tired or smooth drum rollers and sprinkled with water as needed.

02300.14 The compacted clay liner shall be a minimum of eighteen (18) inches thick in the cell.

02300.15 The as-built thickness of the compacted clay liner shall be determined by survey methods (non-destructive) as described below. An individual lift may be sampled upon completion (but prior to subsequent lift placement) with an approved sampler or other investigative tool. Any penetration within any portion or lift of the clay liner shall be promptly backfilled by the Contractor with hand tamped soil and bentonite fill. Samples of the in place compacted soil liner shall be tested and evaluated in accordance with provisions of the Construction Quality Assurance Plan. All test locations shall be filled with a homogeneous mixture of one part bentonite and three parts soil.

02300.16 After completion of a segment of compacted clay liner, but before installation of the geomembrane liner, the surface of the clay liner shall be surveyed by the Contractor to ensure the specified thickness of Compacted Clay Liner (18 inches) has been achieved. The survey must be performed and stamped by a registered Professional Land Surveyor in the State of North Carolina. The survey information shall be provided to the Engineer in a format pre-approved by the Engineer and acceptable to the North Carolina Solid Waste Division.

02300.17 The surface of the compacted clay liner shall be smooth drum rolled and maintained free of rocks, organics, voids and sharp edges.

No vehicles other than a smooth-drum roller will be allowed on the clay liner once the clay liner has been approved. This includes equipment used to deploy geomembrane material. Any exceptions should have prior approval from the project engineer.

02300.18 The minimum interface friction angle between the clay liner and the 40 mil textured geomembrane shall be twenty-four (24) degrees. This shall be verified by the Contractor prior to beginning construction.

The test method used to verify the internal friction angle between the clay liner and the 40-mil textured geomembrane shall be ASTM D5321 *Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by Direct Shear Method.* Soil specimens must be compacted to design criteria for dry density and moisture content as determined by preconstruction testing. Test parameters are to provide 3 points to range over minimum and maximum expected normal loads. Minimum will be a construction load of 260 psf.

END OF SECTION

SECTION 02622 GEOCOMPOSITE DRAINAGE LAYER

PART 1: GENERAL

1.01 SCOPE OF WORK

Furnish all labor, equipment, materials and incidentals necessary to install and complete installation of the geocomposite drainage layer for the landfill cap system. This Section includes Specifications and guidelines for manufacturing and installing geocomposite.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)
   1. D 1505-98 Standard Test Method for Density of Plastics by the Density-Gradient Technique
   2. D 1603-94 Standard Test Method for Carbon Black in Olefin Plastics
   3. D 4533-91 (1996) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
   4. D 4595-86 (1994) Standard Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method
   5. D 4632-91 (1997) Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
   6. D 4716-00 Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
   7. D 4751-99 Standard Test Method for Determining Apparent Opening Size of a Geotextile
   8. D 4833-88 (1996) Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
   9. D 5035-95 Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
   10. D 5199-99 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

B. Geosynthetic Research Institute (GRI)
   1. GRI GC-7 Determination of Adhesion and Bond Strength of Geocomposites.

C. Relevant publications from the Environmental Protection Agency (EPA):
   1. Daniel, D.E. and R.M. Koerner, (1993), *Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities,* EPA/600/R-93/182.

1.03 DEFINITIONS

A. Construction Quality Assurance Consultant (CONSULTANT) – Party, Independent from MANUFACTURER and INSTALLER that is responsible for observing and documenting activities related to quality assurance during the lining system construction.

B. ENGINEER- McGill Associates

C. Geocomposite Manufacturer (MANUFACTURER)- The party responsible for manufacturing the geocomposite rolls.

D. Geosynthetic Quality Assurance Laboratory (TESTING LABORATORY)- Party, independent from the MANUFACTURER and INSTALLER, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the OWNER.

E. INSTALLER- Party responsible for field handling, transporting, storing and deploying the geocomposite.

F. Lot- A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geocomposite rolls. The finished rolls will be identified by a roll number traceable to the resin lot.

1.04 QUALIFICATIONS

A. MANUFACTURER
   1. Manufacturer shall be experienced with the manufacture of geocomposite material for a minimum of ten (10) years.

   2. Manufacturer shall have manufactured a minimum of 10,000,000 square feet of polyethylene geocomposite material during the last year.

B. INSTALLER
   1. Installer shall have installed a minimum of 2,000,000 square feet of geocomposite in the last 2 years.

   2. Installer shall have worked in a similar capacity on at least 3 projects similar in complexity to the project described in the contract documents, with at least 150,000 square feet of geocomposite installation on each project.

   3. The Installation Supervisor shall have worked in a similar capacity on at least 3 projects similar in size and complexity to the project described in the Contract Documents.

1.05 MATERIAL LABELING, DELIVERY, STORAGE AND HANDLING

A. Labeling - Each roll of geocomposite delivered to the site shall be wrapped and labeled by the manufacturer. The label will identify:
   1. manufacturer's name
   2. product identification
   3. length
   4. width
   5. roll number

B. Delivery- Rolls of geocomposite will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

C. Storage- The on-site storage location for the geocomposite, provided by the Contractor to protect the geocomposite from abrasions, excessive dirt and moisture shall have the following characteristics:
   1. level (no wooden pallets)
   2. smooth
   3. dry
   4. protected from theft and vandalism
   5. adjacent to the area being lined

D. Handling
   1. The Contractor and Installer shall handle all geocomposite in such a manner as to ensure it is not damaged in any way.
   2. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

1.06 WARRANTY

A. Material shall be warranted for a period of 1-year from the date of the geocomposite installation.

B. Installation shall be warranted against defects in workmanship for a period of 1-year from the date of geocomposite completion.

C. Damage due to foreign matter such as needles shall be warranted against indefinitely.

PART 2: PRODUCTS

2.01 GEOCOMPOSITE PROPERTIES

A. A geocomposite shall be manufactured by extruding two crossing strands to form a bi-planar drainage net structure with a non-woven geotextile bonded to one or both sides.

B. The geocomposite specified shall have properties that meet or exceed the values listed in Table 02622-1.

Table 02622-1

Standard Property Drainage Sheet				
Tested Property	**Test Method**	**MINIMUM AVERAGE VALUES[c]**		
Transmissivity[a], m^2/sec	ASTM D4716-00	$1.0x10^{-4}$	$1.0x10^{-4}$	$1.0x10^{-4}$
Ply Adhesion, lb/in (N/m)	GRI GC-7	1.0 (178) [b]	1.0 (178) [b]	1.0 (178) [b]
Roll Width, ft (m)		14.5 (4.4)	14.5 (4.4)	15.0 (4.5)
Roll Length [d], ft (m)		230 (70.1)	200 (60.9)	190 (58.0)
Net Component [b]				
Transmissivity[a], m^2/sec	ASTM D4716-00	$2x10^{-3}$	$2x10^{-3}$	$2x10^{-3}$
Thickness, mil (mm)	ASTM D 5199	200 (5.0)	200 (5.0)	200 (5.0)
Density, g/cm^3	ASTM D 1505	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	45 (7.9)	45 (7.9)	45 (7.9)
Carbon Black Content, %	ASTM D 1603	2.0	2.0	2.0
Geotextile Component [b]				
Mass Per Unit Area, oz/yd^2 (g/m^2)	ASTM D 5261	6 (200)	8 (270)	10 (335)
AOS, US Sieve (mm)	ASTM D 4751	70 (0.212)	80 (0.180)	100 (0.150)
Flow Rate, gpm/ft^2 (lpm/m^2)	ASTM D 4491	110 (4480)	110 (4480)	85 (3460)
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	70	70	70

(a) Gradient of 0.1, normal load of 10,000 psf, water at 70°, between stainless steel plates and a 15-minute seat time.
(b) Component properties prior to lamination.
(c) These are MARV values that are based on the cumulative results of specimens tested.

C. Resin
1. Resin shall be new first quality, compounded polyethylene resin.
2. Natural resin (without carbon black) shall meet the following additional minimum requirements:

Table 02622-2

Property	Test Method	Value
Density (g/cm3)	ASTM D 1505	>0.94
Melt Flow Index (g/10 min)	ASTM D 1238	$\leq$ 1.0

2.02 MANUFACTURING QUALITY CONTROL

A. The geocomposite shall be manufactured in accordance with the Manufacturer's Quality Control Plan submitted to and approved by the Engineer.

B. The geocomposite shall be continuously inspected for the presence of needles using a metal detector.

C. The geocomposite shall be tested according to the test methods and frequencies listed below:

Manufacturing Quality Control Test Frequencies			
Characteristics	**Test Method**	**Units**	**FREQUENCY**
			Bi-Planar
Resin			
Polymer Density	ASTM D 1505	g/cm^3	Once Per Lot
Melt Flow Index	ASTM D 1238	g/10 min	Once Per Lot
Geonet Test			
Thickness	ASTM D 5199	mil	25,000 ft^2
Carbon Black	ASTM D 4218	%	25,000 ft^2
Tensile Strength, MD	ASTM D 4595	lbs/ ft	25,000 ft^2
Geotextile Tests			
Mass per Unit Area	ASTM D 5261	oz/yd^2	Every 90,000 ft^2
Grab Tensile	ASTM D 4632	lbs.	Every 90,000 ft^2
Puncture	ASTM D 4833	lbs.	Every 90,000 ft^2
AOS, US Sieve	ASTM D 4751	mm	Every 540,000 ft^2
Water Flow Rate	ASTM D 4491	gpm/ft^2	Every 540,000 ft^2
Geocomposite Tests			
Ply Adhesion	GRI GC-7	lbs/ in.	25,000 ft^2
Transmissivity	ASTM D 4716-00	m^2/sec	672,000 ft^2

PART 3: EXECUTION

3.01 FAMILIARIZATION

A. Inspection

1. Prior to implementing any of the work in the Section to be lined, the Installer shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the Section may properly commence without adverse impact.

2. If the Installer has any concerns regarding the installed work of other Sections, he shall notify the Project Engineer.

A. Confirmation Testing

The friction angle between the structural fill and the geomembrane shall be a minimum of 24 degrees. The Contractor shall verify prior to beginning construction. The test method used to verify the interface friction angle between the 40-mil geomembrane and the structural fill shall be ASTM D5321 *Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by Direct Shear Method*. Test parameters are to provide 3 points to range over minimum and maximum expected normal loads. Maximum will be a construction load of 260 psf.

The friction angle between the vegetative soil layer and the geocomposite shall be a minimum of 24 degrees. The Contractor shall verify prior to beginning construction. The test method used to verify the interface friction angle between the 6-ounce geocomposite and the vegetative soil layer shall be ASTM D5321 *Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by Direct Shear Method*. Test parameters are to provide 3 points to range over minimum and maximum expected normal loads. Maximum will be a construction load of 260 psf.

3.02 MATERIAL PLACEMENT

A. The geocomposite roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the Engineer.

B. If the project contains long, steep slopes, special care should be taken so that only full length rolls are used at the top of the slope.

C. In the presence of wind, all geocomposites shall be weighted down with sandbags or the equivalent. Such sandbags shall be used during placement and remain until replaced with cover material.

D. If the project includes an anchor trench at the top of the slopes, the geocomposite shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geocomposite.

E. In applying fill material, no equipment can drive directly across the geocomposite. The specified fill material shall be placed and spread utilizing vehicles with a low ground pressure.

F. The cover soil shall be placed in the geocomposite in a manner that prevents damage to the geocomposite. Placement of the cover soil shall proceed immediately following the placement and inspection of the geocomposite.

3.03 SEAMS AND OVERLAPS

A. Each component of the geocomposite will be secured or seamed to the like component at overlaps.

B. Geonet Components

1. Adjacent edges of the geonet along the length of the geocomposite roll shall be placed with the edges of each geonet butted against each other.

2. The overlaps shall be joined by tying the geonet structure with cable ties. These ties shall be spaced every 3 feet along the roll length.

3. Adjoining geocomposite rolls (end to end) across the roll width should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geocomposite a minimum of 12 inches across the roll width.

4. The geonet portion should be tied every 6 inches in anchor trenches or as specified by the Engineer.

3.04 REPAIR

A. Prior to covering the deployed geocomposite, each roll shall be inspected for damage resulting from construction.

B. Any rips, tears or damaged areas on the deployed geocomposite shall be removed and patched. The patch shall be secured to the original geonet by tying every 6 inches with the approved tying devices. If the area to be

repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out and the two portions of the geonet shall be joined in accordance with Subsection 3.03.

PART 4: MEASUREMENT AND PAYMENT

See Section 01300.

END OF SECTION

02623.1 Scope of Work

The Installer shall furnish all labor, materials, supervision and equipment to complete the LLDPE Geomembrane Liner including, but not limited to, anchor trench excavation and backfill, liner layout, seaming, patching, and all necessary and incidental items required to complete the Work, in accordance with the Contract Drawings and these Specifications.

02623.2 Materials

The geomembrane liner shall be made of linear low density polyethylene (LLDPE) that has an absolute minimum thickness of 40 mils. This means that the geomembrane shall have a thickness of 40 mils at any point measured on the sheet. An average minimum thickness will not be considered. If during conformance testing or on-site testing and inspection, a thickness measurement is found to be less than 40 mils, the material will be rejected for use during construction.

The geomembrane used shall meet, at a minimum, the standards included in Tables 1 and 2 located at the end of this section.

The chemical resistance of the geomembrane liner shall be in keeping with typical properties of high quality polyethylene products currently available through commercial sources.

Geomembrane liner shall be shipped rolled with a protective wrap around each roll, labeled with roll number and manufacturer's batch number. Manufacturer's quality control documentation shall be included with each roll.

The geomembrane shall be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defect shall be repaired in accordance with the geomembrane manufacturer's recommendations. The Engineer may reject all or portions of units (or rolls) of the geomembrane if in his opinion significant quantities of production or transporting flaws are observed.

The Installer shall submit proposed geomembrane panel layouts to the Engineer at least 14 days prior to mobilization of crews (2 copies). Once the panel layout is approved, the Installer may not change the layout without permission of the Engineer.

02623.3 Construction

The geomembrane liner shall be installed by a specialty contractor, and that specialty contractor must have installed a minimum of 2,000,000 square feet of geomembrane liner since January, 2003.

The geomembrane liner shall be constructed as soon as practical after completion and approval of the compacted clay liner or portion thereof. The top of the compacted clay liner will be surveyed to ensure adequate thickness of clay material and proper grades. The Contractor shall be responsible for providing survey information for the purpose of depth verification. The survey must be performed and stamped by a registered Professional Land Surveyor in the State of North Carolina. The survey information shall be provided to the Engineer in a format pre-approved by the Engineer and acceptable to the North Carolina Solid Waste Division. The geomembrane is to cover the bottom of the cell and the side slopes in accordance with the Contract Drawings.

Areas to receive liner installation shall be relatively smooth and even, free of ruts, voids, etc., to the extent required by the Engineer. This shall be accomplished by final dressing of the compacted liner with smooth drum rollers. No vehicles are permitted on final dressed surfaces unless authorized by the Engineer.

A ditch, labeled as liner edge and illustrated on the Contract Drawings, will be required to secure the geomembrane in certain areas of the landfill cap. No loose soil will be allowed to underlie the geomembrane on the liner edges. The time schedule for excavation and backfilling of the liner edges is to be approved by the Engineer so that desiccation of trench soils does not occur prior to backfilling.

02623.4 Installation of the geomembrane shall be as follows:

All geomembrane installed on the landfill cap will be 40 mil textured material.

Unroll only those sections that are to be seamed together in one day. Panels should be positioned with the overlap recommended by the manufacturer, but not less than 4 inches. The side slope geomembrane will be placed in an anchor trench that is then backfilled with soil and compacted as shown on the Contract Drawings.

After panels are initially in place, remove wrinkles as directed by the Engineer. Unroll several panels and allow the liner to "relax" before beginning field seaming. The purpose of this is to make the edges, which are to be bonded, as smooth and free of wrinkles as possible.

Once panels are in place and smooth, commence field seaming operations.

The Installer's Field Superintendent will complete a Daily Report at the end of each day and submit the form daily to the engineer.

Field seaming shall be in accordance with EPA Technical Guidance document: "The Fabrication of Polyethylene FML Field Seams" EPA/530/SW-89/069 or as follows. Where conflicts exist between the two guidance specifications, the most stringent specification prevails or as directed by the Engineer.

02623.6 All foreign matter (dirt, water, oil, etc.) shall be removed from the edges to be bonded. For extrusion welds, the bonding surfaces must be thoroughly cleaned by mechanical abrasion or alternate methods approved by the Engineer to remove surface cure and prepare the surfaces for bonding. All abrasive buffing shall be performed using No. 80 grit or finer sandpaper. The grinding shall be performed so that any and all grind marks are perpendicular to the edge of sheet. No grinding greater than 1/8 inch outside the welds is permitted or the Engineer can require patching. No solvents shall be used to clean the geomembrane liner.

02623.7 As much as practical, field seaming shall start from the top of the slope down. This will minimize large wrinkles from becoming trapped, which requires cutting and patching. Tack welds (if used) shall use heat only; no double sided tape, glue, or other method will be permitted. The geomembrane should be seamed completely to the ends of all panels to minimize the potential of tear propagation along the seam.

The completed liner shall not exhibit <u>any</u> "trampolining" during any daylight hours (6:00 a.m. to 8:00 p.m.). All areas exhibiting trampolining must be repaired as directed by the Engineer.

02623.8 At the end of each day or installation segment, all unseamed edges shall be anchored by sand bags or other approved device. If high winds are expected, boards along the edge of unseamed panels, with weighted sand bags on top, may be used to anchor the geomembrane. Staples, U-shaped rods or other penetrating anchors shall not be used to secure the geomembrane. Any damage to the liner or clay liner including damage due to wind, rain, hail, or other weather shall be the sole responsibility of the Contractor.

02623.9 Field seaming may be extrusion or fusion welding or a combination of these methods. Solvent welding is not acceptable. The Engineer reserves the right to reject any proposed seaming method it believes

unacceptable. Double hot wedge fusion welding shall be the predominant seaming method and shall be used when possible. Additional concepts and requirements of proper field seaming include the following.

02623.10 Extrusion welding applies a molten bead of material to preheated sheets of geomembrane. The sheets are then joined by pressure.

02623.11 The fusion welding process heats the area to be joined to the melting point and then applies pressure to join the melted surfaces.

02623.12 The sheets to be joined shall be overlapped at least four (4) inches after the necessary cleaning, aligning and cutting.

02623.13 The seams should be oriented parallel to the line of maximum slope, i.e., oriented up and down, not across, the slope. In corners and odd shaped geometric locations, the number of field seams shall be minimized.

02623.14 No horizontal seams shall be within ten (10) feet from the toe of the slope.

02623.15 No seaming shall be attempted above 40°C (104°F) ambient air temperature. Below 5°C (41°F) ambient air temperature, preheating of the geomembrane will be required, unless it is demonstrated that this is not necessary (i.e., acceptable test (start-up) seams which duplicate, as closely as possible, actual field conditions can be achieved). Preheating may be achieved by natural and/or artificial means (shelters and heating devices). Ambient temperature is measured 18 inches above the liner surface. The Installer shall supply instrumentation for measurement of ambient temperature.

02623.16 A moveable protective layer of plastic or approved material may be placed directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded. The protective layer must be removed after welding.

02623.17 Seaming will extend to the outside edge of panels to be placed in anchor trenches.

02623.18 If required, a firm substrata should be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.

02623.19 Grinding prior to welding shall be done perpendicular to the sheet edge. Overgrind greater than 1/8 inch beyond the welded seam or improperly ground areas shall be replaced at the Installer's expense.

02623.20 Seams at the Panel Corners

Seams at the panel corners of 3 or 4 sheets shall be completed with a circular patch approximately 12 inches in diameter, extrusion welded to the parent sheets.

02623.21 Quality Control

All geomembrane sheet, seams, and patches will be tested and evaluated prior to acceptance. In general, testing of the sheet will be conducted by the manufacturer. Testing of the seams will be conducted by the Installer under observation by the Engineer. The Engineer or a designated, independent geosynthetics laboratory may perform additional testing, as required by these detailed Specifications or as required in the judgment of the Engineer or Authorized Representative to verify that the LLDPE sheet and seams meet the specifications. The geosynthetics installer will be required to adhere to the requirements of the Site Specific Construction Quality Assurance Plan. Testing requirements are detailed in the following subsections:

02623.22 Pre-shipping Sheet Tests

The Installer or supplier (manufacturer) will be required to submit his Quality Control program to the Owner prior to initiating field work. At a minimum, the Manufacturer will perform the tests, at the frequencies given in Table 3, on the LLDPE sheet prior to shipping LLDPE material to the site.

02623.23 Test Seams (Destructive Tests)

The Installer shall maintain and use equipment and personnel at the site to perform testing of test seams. These seams will be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. At a minimum, test seams shall be made upon each start of work for each seaming crew, upon every four hours of continuous seaming, every time seaming equipment is changed or if significant changes in geomembrane temperature and weather conditions are observed. The technician shall complete the Test Seam Form provided by the Engineer immediately after each test. Requirements for test seams are as follows:

02623.24 The test seam sample will be at least 1.8m (6 feet) long by 0.3m (1 foot) wide with the seam centered lengthwise. Six adjoining specimens 25mm (1 inch) wide each will be cut from the test seam sample. At the Engineer's option, the shear tests may be eliminated for test seams. These specimens will be tested in the field with a tensiometer and/or

manual seam tester for both shear (3 specimens) and peel (3 specimens). For dual wedge both inside and outside welds should be tested in the peel. Test seams will be tested by the Installer under approval of the Engineer. The specimens should not fail in the weld. The Installer shall supply all necessary knowledgeable personnel and testing equipment. Quantitative strength measurements from a calibrated field tensiometer, supplied by the Installer, shall be obtained for all three (3) specimens in shear and peel for the test seams. A passing test seam will be achieved when the criteria described in Table 1 (located at the end of this section) are satisfied. If a test seam fails, the entire operation will be repeated. If the additional test seam fails, the seaming apparatus or seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full test seams are achieved. Test seam failure is defined as failure of any one of the specimens tested in shear or peel.

02623.25 The Engineer will approve all test seam procedures and results. The six (6) test specimens shall be labeled with initials of the technician, date, and A.M. or P.M. as appropriate; bound together with electrical tape; and retained by the Engineer until the project is over. The Engineer will transfer these specimens to the Owner following the Engineer's acceptance of the geomembrane materials and installation.

02623.26 **Production Seams**

One hundred percent of the production seams will be tested by the Installer continuously using non-destructive techniques and at specified intervals using destructive tests.

All areas failing nondestructive test procedures described below shall be clearly marked both on the liner itself and on the Seam Inspection Quality Control Form.

02623.27 **Non-Destructive Testing**

Single Weld Seams: The Contractor shall maintain and use equipment and personnel at the site to perform continuous vacuum box testing on all single weld production seams except those corner seams where vacuum box testing is impossible. The system shall be capable of applying a vacuum of at least 3 psi. The vacuum shall be held for a minimum of 15 seconds for each section of seam. All vacuum boxes to be used at this job site shall have new gaskets installed prior to reaching the job site. The geosynthetics installer shall also be required to have backup vacuum testing equipment at the job site. If the geosynthetics installer fails to provide the backup equipment, and it results in delays of the project, the geosynthetics installer will be liable for all costs associated with the delay.

Double Weld Seams: The Contractor shall maintain and use equipment and personnel to perform air pressure testing of all double weld seams. The system shall be capable of applying a pressure of at least 30 psi for not less than 5 minutes. All channels between the double weld seam must first be verified that the channel is open throughout the entire test area. The air pressure test results shall be documented. Pressure loss tests shall be conducted in accordance with the procedures outlined in "Pressurized Air Channel Test for Dual Seamed Geomembranes," Geosynthetic Research Institute Test Method GM-6. As outlined by the test method, following a 2 minute pressurized stabilization period, pressure losses over a measurement period of 5 minutes shall not exceed 3 psi.

Double weld seams will also be visually inspected on 100 percent of the seam. If necessary, the outside flap can be pulled back to aid in the visual inspection.

02623.28 Destructive Testing

Laboratory destructive testing (LDT) is defined as 12" X 48" samples cut on 500 foot centers for both extrusion and double welded seams. Field destructive testing (FDT) is defined as 3" X 6" samples cut at the end of each seamed area exceeding 200 feet. Both are described below:

Laboratory destructive testing will be performed on an average of every 500 linear feet of production seam. The locations will be selected by the Engineer. Samples will be 12" X 48" in order to provide one sample to the archive, one sample to the Engineer for laboratory testing, and one sample to be retained by the Installer for possible field and/or additional laboratory testing at the option of the Installer.

Before the sample is sent to the laboratory, two specimens, one from each end of the specimen will be tested in peel in a calibrated field tensiometer, supplied by the Installer. Both specimens must meet the qualitative and quantitative criteria listed in Tables 1 and 2. Testing requirements are as follows: Each sample shall be large enough to test five specimens in peel and five specimens in shear. The average values of each set of five specimens must meet the values shown in Tables 1 and 2. If the average of the five specimens is adequate, but one of the specimens is below the required value, values for the specimen must be at least 90% of the values required for the sample to pass. All samples must fail in film tear bond (FTB). Samples which do not pass the shear and peel tests will be re-sampled from locations at least 10 feet on each side of the original location. These two re-test samples must pass both shear and peel testing. If these two samples do not pass, then the entire

seam represented by the test shall be capped. Tests shall be conducted using a calibrated tensiometer and must meet the criteria outlined in Tables 1 and 2 located at the end of this section. The Owner will pay for destructive testing of the original destructive samples. The geosynthetics installer will be responsible for all costs associated with resampling and retesting for failing destructive samples beyond a 5% failure rate by quantity. This includes the cost of lab and CQA personnel. The minimum charge for each destructive re-test exceeding the 5% failure rate will be $500.00 per occurrence.

Field Destructive Testing (FDT) shall be small 2" X 6" samples cut out at the beginning and end of each seam exceeding 200 feet in length. Three 1" X 6" specimens will be tested in peel from each sample using the Installer's Field Tensiometer or qualitative peel tester at the option of the Installer. No qualitative peel strength values need to be determined with the Field Destructive test, but each specimen must be all qualitative criteria listed in Tables 1 and 2.

The Engineer will approve all seam field and laboratory test procedures and results. All laboratory destructive test specimens will be marked with the seam number and letters then bound together for a particular seam and stored in the Owner's archives. The specimens for the FDT need not be retained.

Each sample area will be clearly marked both on the liner itself (LDT or FDT).

All areas cut out for testing shall be immediately patched by the Installer.

02623.29 Repair of Damaged and Sampled Areas

Damaged and sample coupon areas of geomembrane shall be repaired by the Installer by construction of an extrusion welded cap strip. No repairs shall be made to seams by application of an extrusion bead to a seam edge previously welded by fusion or extrusion methods. Repaired areas will be tested for seam integrity as outlined in Section 02623.27 of this specification. Damaged materials are the property of the Contractor and will be removed from the site at the Contractor's expense. The Contractor will retain all ownership and responsibility for the geomembrane until acceptance by the Engineer. The geomembrane shall be accepted by the Engineer after the installation and repair are complete, and after the Engineer has received documentation for the installation.

02623.30 Potentially Damaging Activities

No support equipment of any type, which may be used by the Contractor, shall be allowed on the geomembrane. Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in any activity that could damage the geomembrane. No glass or sharp objects shall be allowed on the geomembrane.

02623.31 Protection of Leading Edges

Between construction of partial sections of the membrane liner, excluding temporary phaselines, leading edges of the membrane may be exposed or buried for extended periods of time prior to their joining to adjacent, subsequent membrane sections. The combined action of abrasive soil and equipment impact stresses may "etch" unprotected membrane surfaces sufficiently to affect seam strengths. Therefore, it is necessary to protect leading edges in high activity areas with sacrificial layers of geotextile and LLDPE sheet until they are ready for final seaming. As a minimum, each leading edge to be seamed that must be buried or which must be exposed for periods of one month or longer shall be continuously covered by a layer of LLDPE sheet. The geotextile shall be nonwoven and have a minimum weight of 8 oz. per square yard. The sacrificial LLDPE sheet shall have a minimum thickness equal to that of the membrane liner to be protected. Both protective layers shall have a minimum width of 2 feet. The protective cover sheets shall be either covered with soil or weighted with sand bags to prevent displacement by wind. The edge of the sheet to be protected shall be approximately centered beneath the overlying protective layers prior to burial or weighing with sandbags. Leading edges located in areas expected to receive direct traffic from construction equipment shall be buried under a minimum thickness of one foot of buffer soil.

Table 1

Required Physical Properties of Textured Membrane Liner (LLDPE) Sheet

Property	Test Method	Required Values (40 Mil. LLDPE)
Thickness	ASTM D-5994	40 mil nominal
Sheet Density	ASTM D-1505	0.939 g/ml max
% Elongation at Break	ASTM D-6693 Type IV	250
Tensile Strength at Break	ASTM D-6693 Type IV	60 lb/in. min
Carbon Black Content	ASTM D-1603	2% min. - 3% max.
Carbon Black Dispersion	ASTM D-5596	1, 2, Category
Puncture Resistance	ASTM D-4833	44 lb. min.
Tear Resistance	ASTM D 1004	22 lb. min.

Seam Strengths

Shear Strength	ASTM D4437, NSF Modified	120 psi
Shear Strain @ Yield	ASTM D4437, NSF Modified	10% (min.)
Peel Strength (Fusion Weld)	ASTM D4437, NSF Modified	90 psi
Peel Strength (Extrusion Weld)	ASTM D4437, NSF Modified	78 psi

Non-Destructive Testing

Single Weld	Continuous Vacuum Box; Impact	Maintain vacuum of 3 psi, hold vacuum for 15 seconds.
Double Weld	Air Testing	Maintain 30 psi for no less than 5 min.; pressure loss not greater than 3 psi for last 3 minutes.

Table 2

Required Pre-Shipping Sheet Testing of Membrane Liner (LLDPE)

Property	Test Method	Frequency
Thickness	ASTM D-5994	Each Roll
Sheet Density	ASTM D-1505	Every 200,000 lb
Tensile Properties	ASTM D-6693 Type IV	Every 20,000 lb
Tear Resistance	ASTM D-1004	Every 45,000 lb
Puncture Resistance	ASTM D-4833	Every 45,000 lb
Carbon Black Content	ASTM D-1603	Every 45,000 lb
Carbon Black Dispersion	ASTM D-5596	Every 45,000 lb

END OF SECTION