TOMOKA FARMS ROAD LANDFILL
NORTH CELL PHASE III EXPANSION
VOLUSIA COUNTY

Area 4 Expansion Permit Application

Construction Quality Assurance (CQA) Plan

WACS ID: 27540
Permit Number: 0078767-030-SO-01

Prepared for:

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March 2018

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AREA 4 EXPANSION

CONSTRUCTION QUALITY ASSURANCE PLAN

1.0 INTRODUCTION

1.1 Purpose and Scope of the Construction Quality Assurance Plan

This Construction Quality Assurance (CQA) Plan addresses the soil and geosynthetic components of the bottom liner system for the Area 4 Expansion of the North Cell Phase II Tomoka Farms Road Landfill (TFRL) . This CQA Plan describes the procedures to be followed for monitoring construction associated with these materials. In addition, it presents CQA procedures for survey control. The scope of this CQA Plan includes the CQA of the soil and geosynthetic components of the bottom liner system. This CQA Plan does not address design guidelines, installation specifications, or selection of soils, geomembranes, and other geosynthetics.

1.2 Units

In this CQA Plan, properties and dimensions are expressed in U.S. units with “approximate equivalent” SI units in parentheses. It should be noted that the conversion is typically only accurate within 10 percent due to rounding. In cases of conflict or clarification, the U.S. units will be deemed to govern.

1.3 References

The CQA Plan includes references to test procedures of the American Society for Testing and Materials (ASTM), Corps of Engineers (COE), the “Standards for Flexible Membrane Liners” of the National Sanitation Foundation (NSF), the Geosynthetics Research Institute (GRI), the American Association of State Highway and Transportation Officials (AASHTO), and the Plastic Pipe Institute (PPI). The Technical Specifications of the Contract Documents shall take precedence in cases where they are more stringent than this CQA Plan. The CQA Plan cites requirements that are in conformance with applicable regulations. However, in some cases, the specific requirements of the Project are more restrictive than the regulations and, therefore, are specified elsewhere in the Contract Documents and shall govern the Work.

1.4 Organization of the Construction Quality Assurance Plan

The remainder of the CQA Plan is organized as follows:

- Section 2 presents definitions relating to CQA;
- Section 3 describes the parties involved with the CQA;

- Section 4 describes site and project control requirements of the CQA;
- Section 5 describes CQA documentation;
- Section 6 describes CQA for high-density polyethylene (HDPE) geomembranes;
- Section 7 describes CQA for geotextile;
- Section 8 describes CQA for geonet;
- Section 9 describes CQA for geocomposite;
- Section 10 describes CQA for geosynthetic clay liners;
- Section 11 describes CQA for HDPE pipe and fittings;
- Section 12 describes CQA for soils; and
- Section 13 describes surveying requirements of the CQA.

2.0 DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE

2.1 Construction Quality Assurance and Construction Quality Control

This CQA Plan is devoted to Construction Quality Assurance. In the context of this plan, Construction Quality Assurance (CQA) and Construction Quality Control (CQC) are defined as follows:

CQA - A planned and systematic pattern of the means and actions designed to provide adequate confidence that items or services meet contractual and regulatory requirements, and will perform satisfactorily in service.

CQC - Those actions which provide a means to measure and regulate the characteristics of an item or service to contractual and regulatory requirements.

2.2 Use of The Terms in This Plan

In the context of this document:

- *CQA* refers to means and actions employed by the CQA Consultant and testing laboratories to assure that the components of the liner system is produced and installed to conform with the requirements of this CQA Plan, the drawings, and the specifications. CQA is provided by a consultant who is independent of the Owner, Contractor, Manufacturer, and Fabricator.

- *CQC* refers to those actions taken by Manufacturers, Fabricators, Installers, Contractors, or Owners to ensure that the materials and the workmanship meet the requirements of the plans and specifications. In the case of soil components, CQC may be combined with CQA and then may be provided by the CQA Consultant; otherwise, CQC of soil components is provided by the Contractor. In the case of the geosynthetic and other non-soil components, CQC is provided by the Manufacturers and Installers of the various geosynthetics.

- This Document was prepared as a Permit document to show intent to the Florida Department of Environmental Protection that the protocols set forth herein will be carried out. Therefore, the Contractor, all Manufacturers, Fabricators, Installers, Suppliers, Transporters, Laboratories, Surveyors and other parties subcontracted by or affiliated with the Contractor shall interpret the term “will” to be “shall”, meaning a requirement.

3.0 PARTIES TO CONSTRUCTION QUALITY ASSURANCE

3.1 Description of the Parties

3.1.1 Engineer

The Engineer is responsible for the design, drawings, CQA plan, and specifications for the liner system.

3.1.2 Contractor

The Contractor is responsible for the preparation of the site and installation of the soil and non-soil components of the liner system. Contractor shall also be responsible for all damage and related repair costs to the liner system, electrical system or LFG management systems associated with general construction activities (e.g., earthwork, geosynthetic deployment).

3.1.3 Soils Supplier

The Soils Supplier excavates and delivers off-site soils to the Contractor.

3.1.4 Pipe Supplier

The Pipe Supplier manufactures and delivers pipe to the site.

3.1.5 Resin Supplier

The Resin Supplier produces and delivers the resin to the Geosynthetics or Pipe Manufacturer.

3.1.6 Geosynthetics Manufacturer

The Geosynthetics (e.g., geomembrane, geotextile, geonet, GCL, geocomposite, in the liner system) Manufacturer (Manufacturer) is responsible for the production of rolls of geosynthetics to be used on this project.

3.1.7 Geosynthetics Fabricator

The Geosynthetics Fabricator (Fabricator) is responsible for the fabrication (if required) of factory panels of geosynthetics from rolls received from the Manufacturer. The Fabricator may also be responsible for the delivery of the factory fabricated panels to the site.

3.1.8 Geosynthetics Installer

The Geosynthetics Installer (Installer) is responsible for field handling, storing, placing, seaming, loading (against wind), and other aspects of the geosynthetics installation. The Installer may

also be responsible for specialized construction tasks (e.g., construction of anchor trenches for the geosynthetics and pipe boots).

3.1.9 Transporter

The Transporter transports the geosynthetics, including rolls of factory panels of geosynthetics and lengths of pipe from the manufacturing facility and/or fabrication facility to the site.

3.1.10 Soils CQA Consultant

The Soils CQA Consultant is a party, independent from the Owner, Contractor, Manufacturer, Fabricator, and Installer, that is responsible for observing, testing, and documenting activities related to the CQA of the earthworks at the site. The Soils CQA Consultant may also be responsible for CQA of other components of the liner system. The Soils CQA Consultant is also responsible for issuing a CQA report.

3.1.11 Geosynthetics CQA Consultant

The Geosynthetics CQA Consultant is a party, independent from the Owner, Contractor, Manufacturer, Fabricator, and Installer, that is responsible for observing and documenting activities related to the CQA of the production and installation of the geosynthetic components of the liner system. The Geosynthetics CQA Consultant will also be responsible for CQA of pipes associated with the landfill liner system. The Geosynthetics CQA Consultant is also responsible for issuing a CQA report.

3.1.12 Soils CQA Laboratory

The Soils CQA Laboratory is independent from the Owner, Contractor, Soils Supplier, and Contractor and is responsible for conducting tests in accordance with ASTM standards on samples of soil in the field and in either an on-site or off-site laboratory.

3.1.13 Geosynthetics Laboratory

The Geosynthetics CQA Laboratory is a party, independent from the Owner, Manufacturer, Fabricator, and Installer, that is responsible for conducting tests in accordance with ASTM standards on samples of geosynthetic materials used in construction of the landfill liner system .

3.1.14 Owner

The Owner owns and operates the Tomoka Farms Road Landfill. In this CQA Plan, the term “Owner” will refer specifically to the Volusia County Solid Waste Division.

3.1.15 Project Manager

The Project Manager will be the official representative of the Owner. In this CQA Plan, the term "Project Manager" will apply equally to "Owner's Representative" (i.e., the individual in charge of coordinating field activities).

3.1.16 Certifying Surveyor

The Certifying Surveyor is responsible for producing as-built documentation of the components of the landfill liner system.

3.2 Qualifications of the Parties

3.2.1 Introduction

The following qualifications are required of all parties involved with the design, manufacture, installation, transportation, and CQA of all components of the landfill liner system.

3.2.2 Engineer

The Engineer shall be a qualified engineer, licensed as a Professional Engineer in the State of Florida and by regulation. The Engineer shall have a history that demonstrates familiarity with the components of the landfill liner system including detailed design methods and procedures.

3.2.3 Contractor

Qualifications of the Contractor are specific to the construction contract. The Contractor shall have a demonstrated history of successful roadway, landfill and earthworks construction and shall have current state and federal licenses as appropriate.

3.2.4 Soils Supplier

The qualifications of the Soils Supplier are specific to the construction contract. The Soils Supplier shall have a demonstrated history of providing soils with consistent properties and should be a licensed contractor in the State of Florida.

3.2.5 Pipe Supplier

The qualifications of the Pipe Supplier are specific to the construction contract. The Pipe Supplier shall have a demonstrated history of providing pipe with consistent properties.

3.2.6 Resin Supplier

Qualifications of the Resin Supplier are specific to the Manufacturer's requirements. The Resin Supplier shall have a demonstrated history of providing resin with consistent properties.

3.2.7 Geosynthetics Manufacturers

The Geosynthetics Manufacturers shall be able to provide sufficient production capacity and qualified personnel to meet the demands of the project. The Geomembrane Manufacturer, in particular, must be pre-qualified and approved by the Project Manager. The qualifications required of the Geomembrane Manufacturer may include:

- corporate background and information; and
- a list of at least 20 completed facilities totaling a minimum of 10,000,000 ft^2 (100,000 m^2), for which the Manufacturer has manufactured a geomembrane of the same material to be used for this project; for each facility, the following information will be provided:
    - name and purpose of facility, its location and date of installation;
    - name of owner, project manager, engineer, fabricator (if any), and installer; and
    - thickness of geomembrane and surface area of geomembrane manufactured.

3.2.8 Geosynthetics Fabricator

The Geosynthetics Fabricator shall be trained and qualified to fabricate geosynthetic panels to be used for this project. The Geosynthetics Fabricator shall be a well-established firm able to provide sufficient fabrication capacity and qualified personnel to meet the demands of the project.

The Geomembrane Fabricator, in particular, shall be approved and/or licensed by the Geomembrane Manufacturer. A copy of the approval letter or license must be submitted by the Geomembrane Fabricator to the Project Manager prior to the fabrication of materials.

Prior to the confirmation of any contractual agreements, the Geomembrane Fabricator must provide the Project Manager with the following written information:

- corporate background and information;
- fabrication capabilities including:
    - information on factory size, equipment, personnel, number of shifts per day and capacity per shift;
    - daily fabrication quantity available for this contract;
    - quality control manual for fabrication; and
    - samples of fabricated seams and certified test results; and

- a list of at least 10 completed facilities, totaling a minimum of 10,000,000 ft^2 (100,000 m^2), for which the Geomembrane Fabricator has fabricated polyethylene geomembrane panels; for each fabrication, the following information will be provided:

    - name and purpose of facility, its location, and date of installation;
    - name of owner, project manager, designer, manufacturer, and installer;
    - thickness of geomembrane and surface area of geomembrane fabricated;
    - type of seaming and type of seaming apparatus used; and
    - available information on the performance of the geosynthetics and the facility.

All personnel performing seaming operations should be qualified by experience or by successfully passing seaming tests. At least one seamer must have experience seaming a minimum of 100,000 linear ft (30,000 linear m) of geomembrane seams using the same method of seaming that will be used on this project. The most experienced seamer, the "master seamer", shall provide direct supervision, as required, over less experienced seamers. No field seaming shall take place without the master seamer being present.

3.2.9 Geosynthetics Installer

The Geosynthetics Installer shall be trained and qualified to install geosynthetics, as well as other liner system components such as pipe. The Geomembrane Installer, in particular, must be approved and/or licensed by the Geomembrane Manufacturer. A copy of the approval letter(s) or license(s) must be submitted by the Geosynthetics Installer to the Project Manager. In addition, prior to confirmation of any contractual agreements, the Geosynthetics Installer must provide the Project Manager with the following written information:

- corporate background and information;

- installation capabilities including:

    - information on installation equipment and personnel;
    - daily anticipated production capabilities;
    - quality control manual for installation of geosynthetic materials, and samples of field seams and certified test results; and

- a list of at least 20 completed facilities, totaling a minimum of 5,000,000 ft^2 (465,000 m^2) for which the Installer has installed a geomembrane of the same material for this project; for each installation, the following information will be provided:

    - name and purpose of facility, its location, and date of installation;
    - name of owner, project manager, engineer, manufacturer, and fabricator (if any);

- name and qualifications of the supervisor of the Installer's crew;
- thickness of geomembrane, surface area of the installed geomembrane;
- type of seaming and/or type of seaming apparatus used; and
- duration of installation.

All personnel performing seaming operations should be qualified by experience. At least one seamer must have experience seaming a minimum of 2,000,000 ft^2 (184,000 m^2) of geomembrane using the same method of seaming that will be used on this project. The most experienced seamer, the "master seamer", will provide direct supervision, as required, over less experienced seamers. No field seaming will take place without the master seamer being present.

The Geosynthetics Installer will provide the Project Manager with a list of proposed seaming personnel and their professional records (i.e., resumes). This documentation will be reviewed by the Project Manager and the Geosynthetics CQA Consultant. Any proposed seaming personnel deemed insufficiently experienced will not be accepted by the Project Manager or will be invited to pass a seaming test.

The Installer will designate one representative as his Superintendent, who will represent the Installer at all site meetings and be responsible for acting as the Installer's spokesman on site. The Superintendent will be qualified by experience. The Superintendent must have supervised the installation of a minimum of 2,000,000 ft^2 (185,000 m^2) of geomembrane and 100,000 ft^2 (10,000 m^2) of geotextile. The Superintendent will also exhibit good management skills. The appointment of the Superintendent will be approved by the Project Manager.

3.2.10 Transporter

All personnel responsible for the loading, transport, and unloading of the geosynthetics must be fully aware of the consequences of damage to the geosynthetics, and familiar with handling and transport constraints required by the Manufacturer and/or Fabricator. The Transporter will ensure that all rolls of polyethylene geomembrane are shipped on open trailers (no enclosed vans) for ease and safety of unloading the material.

3.2.11 Soils CQA Consultant

The Soils CQA Consultant shall be a well-established engineering firm incorporated (or otherwise registered) in the United States. The Soils CQA Consultant will be experienced with soils, including high- and low-permeability soils. The Soils CQA Consultant will be experienced in the preparation of CQA documentation including CQA forms, reports, and plans. The Soils CQA Consultant will provide qualified staff for the project, as necessary; such staff may include a Soils CQA Managing Engineer, a Soils CQA Site Manager, and Soils Field Monitors.

The Soils CQA Consultant will provide the following, in writing, to the Project Manager upon request:

- corporate background and information; and

- CQA capabilities:

    - a summary of the firm's experience with soils;
    - a summary of the firm's experience in CQA, including installation CQA of soils; and
    - a summary of CQA documentation and methods used by the firm, including sample CQA forms, reports, and plans prepared by the firm.

The Soils CQA Managing Engineer, if required, must be licensed as a Professional Engineer in the State of Florida. The Soils CQA Managing Engineer must also comply with the experience requirements listed in the previous paragraphs. The Soils CQA Site Manager will be specifically experienced in the installation of soils and will be trained and certified by the Soils CQA Consultant in the duties of a Soils CQA Site Manager. The Soils Field Monitors will be CQA personnel who have been specifically trained in CQA of soils.

In addition, the Soils CQA Consultant will provide the following, in writing, to the Project Manager upon request:

- resumes of personnel to be involved in the project including Soils CQA Managing Engineer, Soils CQA Manager, and Soils CQA Monitors;

- proof of Professional Engineering registration (or ability to be registered) of the engineer to be designated the Soils CQA Managing Engineer; and

- proof of CQA experience of proposed soils CQA personnel.

3.2.12 Geosynthetics CQA Consultant

The Geosynthetics CQA Consultant shall be a well-established engineering firm incorporated (or otherwise registered) in the United States. The Geosynthetics CQA Consultant will be experienced with geosynthetics, including geomembranes, geocomposites, geotextiles, and geonets, GCLs, as well as polyethylene pipe. The Geosynthetics CQA Consultant shall be experienced in the preparation of CQA documentation including CQA forms, reports, and plans.

In addition, the Geosynthetics CQA Consultant shall provide the following, in writing, to the Project Manager upon request:

- corporate background and information; and
- geosynthetics CQA capabilities including:
- a summary of the firm’s experience with geosynthetics, particularly including geomembranes, geotextiles, geonets and GCLs;
- a summary of the firm’s experience with polyethylene pipe;

- a summary of the firm's experience in geosynthetics CQA, including installation CQA of geomembranes, geotextiles, geonets, pipes; and
- a summary of geosynthetic system CQA documentation and methods used by the firm, including sample Geosynthetics CQA forms, reports, and manuals prepared by the firm.

The Geosynthetics CQA Consultant will provide staff for the project, as necessary. The staff may include a Geosynthetics CQA Managing Engineer, a Geosynthetics CQA Site Manager, and Geosynthetics CQA Field Monitors. The Geosynthetics CQA Managing Engineer must be licensed as a Professional Engineer in the State of Florida. The Geosynthetics CQA Managing Engineer must also comply with the experience requirements listed in the previous paragraph. The Geosynthetics CQA Site Manager will be specifically familiar with the installation of geosynthetics and will be trained and certified by the Geosynthetics CQA Consultant in the duties of a Geosynthetics CQA Site Manager. Geosynthetics CQA Field Monitors will be CQA personnel who have been specifically trained in CQA of geosynthetics and other applicable geosynthetic liner system components.

The Geosynthetics CQA Consultant will provide the following, in writing, to the Project Manager upon request:

- a list of at least 5 completed facilities totaling a minimum of 1,000,000 ft^2 (100,000 m^2) in area, for which the Geosynthetics CQA Consultant has provided CQA monitoring services for the installation of the corresponding geosynthetic material; for each facility, the following information will be provided:
  - name and purpose of facility, its location, and date of installation,
  - name of owner, and
  - type of geosynthetic, surface area of geosynthetic material installed;
- resumes of personnel to be involved in the project including Geosynthetics CQA Managing Engineer, Geosynthetics CQA Site Manager, and Geosynthetics CQA Field Monitors;
- proof of Professional Engineering registration (or ability to be registered) in the State of Florida of the engineer to be designated the Geosynthetics CQA Managing Engineer; and
- proof of Geosynthetics CQA experience of proposed CQA personnel with emphasis on geomembranes as well as geotextiles.

3.2.13 Soils CQA Laboratory

The Soils CQA Laboratory shall have experience in testing soils, meet all regulatory requirements, and be familiar with ASTM and other applicable standards. The Soils CQA Laboratory will be capable of providing test results in accordance with the specifications.

3.2.14 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory shall have experience in testing geosynthetics and be familiar with ASTM, NSF, GRI, and other applicable test standards. The Geosynthetics CQA Laboratory will be capable of providing test results within 24 hours of receipt of samples and will maintain that capability throughout the duration of geosynthetic material installation.

3.2.15 Certifying Surveyor

The Certifying Surveyor must be a registered Land Surveyor in the State of Florida and employed by a well-established surveying firm incorporated (or otherwise registered) in the United States.

3.3 Duties of Construction Quality Assurance Personnel

3.3.1 Introduction

In this CQA Plan, the roles of the Soils CQA Consultant and Geosynthetics CQA Consultant are described separately, however, one consultant may perform both Soils CQA and Geosynthetics CQA, or two or more separate consultants may be used. The personnel of each CQA Consultant will include:

- the CQA Managing Engineer, who operates from the offices of the CQA Consultant's firm and visits the site periodically;
- the CQA Site Manager, who is located at the site; and
- the CQA Monitors, who are located at the site.

The duties of the CQA Personnel are discussed in the following sections.

3.3.2 CQA Managing Engineer

Each CQA Managing Engineer (i.e., for Soils and for Geosynthetics):

- reviews the liner system designs, plans, and specifications;
- reviews site-specific documentation, including bid documents, proposed layouts, soil sampling and analysis reports, and geosynthetics materials manufacturer's and installer's literature; unless otherwise agreed, such reviews are for familiarization and for evaluation of constructibility only and the CQA Managing Engineer will not make comments regarding the feasibility, appropriateness, or comprehensiveness of the design, and the CQA Managing Engineer and his firm will assume no responsibility for any aspect of the design;

- attends the pre-construction and any resolution meeting when requested;
- administers the CQA program (i.e., assigns and manages all CQA personnel, reviews all field reports, and provides engineering review of all CQA related issues);
- provides quality control of the CQA personnel, including site visits;
- reviews changes to the design, plans, and specifications; and
- with assistance from the CQA Site Manager, prepares the final report, including a review of the record drawings.

3.3.3 CQA Site Manager

The CQA Site Manager for soils and/or geosynthetics may be the same, and may also be the CQA Managing Engineer, and:

- acts as the on-site (resident) representative of the CQA Consultant;
- familiarizes the CQA Monitors with the site and the CQA requirements for the project;
- manages the daily activities of the CQA Monitors;
- attends the CQA-related meetings (e.g., resolution, pre-construction, daily, weekly);
- prepares, or oversees the ongoing preparation of the record drawing(s);
- assigns locations for testing and sampling;
- verifies the calibration and condition of on-site CQA equipment;
- reviews the CQA Monitors' daily reports and logs;
- reports to the Project Manager, and logs in his daily report relevant observations reported to him by the CQA Monitors;
- prepares his own daily report;
- oversees the collection and shipping of laboratory test samples;
- reviews and reports results of laboratory testing;

- designates a senior CQA Monitor to act on his behalf whenever he is absent from the site while operations are ongoing;
- reports any unresolved deviations from the CQA Plan to the Project Manager; and
- prepares the final report with the CQA Managing Engineer.

In addition, the Soils CQA Site Manager:

- periodically checks stockpile or borrow pit sources for variability of the soils, and verifies that conformance testing is carried out;
- reviews the work of the Contractor's equipment operators, to verify that care is taken to protect other portions of the work; and
- establishes additional test requirements beyond those in the specifications, when necessary.

In addition, the Geosynthetics CQA Site Manager:

- reviews Supplier, Manufacturer, and Installer certifications and documentation and makes appropriate recommendations;
- reviews the Installer's personnel qualifications for conformance with those pre-approved for work on site; and
- notes on-site activities that could result in damage to the geosynthetics.

3.3.4 CQA Monitors

The duties of the CQA Monitors, as assigned by the CQA Site Manager, include monitoring, logging, and/or documenting appropriate operations.

The duties to be performed, and operations to be monitored by the Soils CQA Monitors specifically include:

- observation and documentation of soils delivery, stockpiling, and placement;
- observation and documentation of soils moisture content, and moisture conditioning, if required;
- observation and documentation of unsuitable materials in the excavation area, if required;

- observation and documentation of collection of soil samples for laboratory testing;
- observation and documentation of operations to protect completed areas before the covering materials are placed;
- examination of the soil surface for signs of excessive wetting, desiccation, or other disturbance prior to placement of any liner materials; and
- observation and documentation of specification, rewetting, recompaction, or proof rolling required to repair deteriorated areas.

The operations to be monitored by the Geosynthetics CQA Monitors include:

- observation and documentation of material delivery;
- observation and documentation of material unloading and on-site transport and storage;
- on-site conformance testing to verify geomembrane thickness;
- observation and documentation of geosynthetic placement operations;
- observation and documentation of joining and/or seaming operations;
- observation and documentation of condition of panels as placed;
- sampling for conformance testing by the Geosynthetics CQA Laboratory;
- marking samples for conformance testing; and
- observation and documentation of repair operations.

Specifically, for geomembranes, the seaming operations to be monitored include:

- trial seaming;
- seam preparation;
- seaming;
- nondestructive seam testing;
- sampling for destructive seam testing;

- field tensiometer testing;
- laboratory sample marking; and
- repair operations.

Specifically, for geotextiles, operations to be performed by Geosynthetics CQA Monitors include visual examination by walkover and, for needlepunched non-woven geotextile only, monitoring for Installer's broken needles (if deemed necessary by the CQA Consultant) using a metal detector or other approved system.

In addition to these specific duties, CQA Monitors will take note of on-site activities that could result in damage to the soils, geosynthetic, or other components of the lining system. This is particularly important during placement and compaction of the initial lift of soil on top of the geosynthetic materials. Observations so noted by the CQA Monitors will be reported as soon as possible to the CQA Site Manager.

4.0 SITE AND PROJECT CONTROL

4.1 Project Coordination Meetings

4.1.1 Overview

Meetings of key project personnel are necessary to assure a high degree of quality during installation, and promote clear, open channels of communication. Therefore, Project Coordination Meetings are an essential element in the success of the project. There are three types of Project Coordination Meetings, including: (i) pre-construction meetings; (ii) progress meetings; and (iii) problem or work difficulty meetings. These meetings are described below.

4.1.2 Resolution Meeting

After award of the contract to the successful bidder, a Resolution Meeting will be held. This meeting will be attended by the Engineer, the CQA Managing Engineer(s), the CQA Site Manager(s), the Project Manager, and the Contractor.

The purpose of the Resolution Meeting is to coordinate construction tasks, anticipate installation problems that might cause difficulties and delays in construction, and, above all, present the CQA Plan to all of the parties involved. It is very important that the criteria stated in the CQA Plan regarding testing, repair, etc., be known and accepted by all parties prior to the installation of geosynthetic materials and construction of the soil components of the landfill liner system The first part of the Resolution Meeting may be devoted to a review of the design drawings and specifications for familiarity. This is different from the peer review of the design, including design calculations, which may have been carried out previously.

The Resolution Meeting shall include the following activities:

- distribute relevant documents to all parties;
- review critical design details of the project;
- review this CQA Plan;
- review the Drawings and project specifications;
- make appropriate modifications to the design criteria, Drawings, and project specifications so that the fulfillment of all design specifications or performance standards can be determined through the implementation of the CQA Plan;
- reach a consensus on the quality control procedures, especially on methods of determining acceptability of the soils and geosynthetic materials comprising the liner system;

- assign the responsibilities of each party;
- establish work area security and safety protocol;
- confirm the methods for documenting observations, reporting, and distributing documents and reports; and
- confirm the lines of authority and communication.

The Project Manager will appoint one of the meeting attendees (typically a representative of the Soils CQA Consultant) to record the discussions and decisions of the meeting. A record of the meeting will be documented by the appointee in the form of meeting minutes, which will be subsequently distributed to the attendees.

4.1.3 Pre-Construction Meeting

A Pre-Construction Meeting will be held at the site prior to installation of the geosynthetic materials and construction of soil components. As a minimum, the meeting will be attended by the Owner, Engineer, the Contractor, the Geosynthetics Installer's Superintendent, the CQA Managing Engineer(s), the CQA Site Manager(s), and the Project Manager. The Resolution Meeting and Pre-Construction Meeting may be held at the same time if so arranged between the Owner, Engineer, the Contractor, the Geosynthetics Installer's Superintendent, the CQA Managing Engineer(s), the CQA Site Manager(s), and the Project Manager.

Specific items for discussion at the geosynthetics pre-construction meeting include the following:

- appropriate modification or clarification to the CQA Plan;
- review the project specifications;
- review the responsibilities of each party;
- review lines of authority and communication;
- establish work area security and safety protocol;
- review methods for documenting and reporting, and for distributing documents and reports;
- communicate to all parties any change in the project documents;
- review critical design details of the project;

- decide the number of spare seaming units for geomembranes to be maintained on site by the Installer (this number depends on the number of seaming crews and on the type of seaming equipment);
- establish protocols for testing;
- establish protocols for handling deficiencies, repairs, and retesting;
- review the time schedule for all operations;
- establish rules for writing on the geomembrane (i.e., who is authorized to write, what can be written and in which color);
- outline procedures for packaging and storing archive samples;
- review panel layout and numbering systems for panels and seams;
- finalize field destructive seam sample size;
- review seam testing procedures;
- review repair procedures;
- conduct a site walk-around to verify that earthwork construction is proceeding on schedule, and to review material storage locations; and
- establish material stockpile locations.

The meeting will be documented by a person designated at the beginning of the meeting. A record of the meeting will be documented by the appointee in the form of meeting minutes, which will be subsequently distributed to the attendees.

4.1.4 Progress Meetings

Weekly progress meetings will be held during construction between the CQA Site Manager(s), the Geosynthetics Installer's Superintendent, the Contractor, the Project Manager, and other concerned parties. This meeting will be used to discuss the current progress of the project, planned activities for the upcoming week, and any new business or revisions to the work. The CQA Site Managers will document any problems, decisions, or questions arising at this meeting in their daily reports. Any matter requiring action raised in this meeting will be reported to the appropriate parties. Minutes of the weekly progress meetings will be recorded by Project Manager or his representative and will be distributed to the appropriate parties.

4.1.5 Problem or Work Deficiency Meeting

A special meeting will be held when and if a problem or deficiency is present or is likely to occur. At a minimum, the meeting will be attended by the affected parties (e.g., contractor(s), the Project Manager, the appropriate CQA Manager(s)). If the problem requires a design modification, the Engineer should either be present, consulted prior to, or notified immediately upon conclusion of this meeting. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions;
- select a suitable solution that is acceptable to all parties; and
- implement an action plan to resolve the problem or deficiency.

The meeting will be documented by the Project Manager and minutes will be transmitted to affected parties.

4.2 Project Control Visits

Periodically, the construction site will be visited by the CQA Managing Engineer and/or the CQA Project Manager (if different from the CQA Managing Engineer) of each of the CQA Consultants. If possible, each such visit should be coordinated with a similar visit by the Engineer. The appropriate regulatory officials should be informed of the dates of the visits.

5.0 DOCUMENTATION

5.1 Introduction

An effective CQA plan depends largely on recognition of all construction activities that should be monitored, and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. Each CQA Consultant will document that the quality assurance requirements have been addressed and satisfied.

Each CQA Site Manager will provide the Project Manager with signed descriptive remarks, data sheets, and logs to verify that the monitoring activities have been carried out. Each CQA Site Manager will also maintain at the job site a complete file of plans and specifications, a CQA plan, checklists, test procedures, daily logs, and other pertinent documents.

5.2 Daily Recordkeeping

5.2.1 Overview

Standard reporting procedures will include preparation of a daily CQA report which, at a minimum, will consist of: (i) field notes, including memoranda of meetings and/or discussions with the Contractor, Installer, or Project Manager; (ii) CQA monitoring logs and testing data sheets; and (iii) construction problem and solution summary sheets. This information will be regularly submitted to and reviewed by the Project Manager.

5.2.2 Memorandum of Discussion with Contractor of Installer

Each CQA Consultant will prepare a memorandum (i.e., daily field report) each day, summarizing their discussions with the Contractor and/or Installer. At a minimum, the memorandum will include the following information:

- date, project name, location, and other identification;
- name of parties to discussion;
- relevant subject matter or issues;
- activities planned;
- constraints or suggestions;
- schedule; and
- signature of the CQA Managing Engineer and/or CQA Site Manager.

5.2.3 Monitoring Logs and Test Data Sheets

Monitoring logs and test data sheets will be prepared daily. At a minimum, these logs and data sheets will include the following information:

- an identifying sheet number for cross referencing and document control;
- date, project name, location, and other identification;
- data on weather conditions;
- a reduced-scale site plan showing the work areas and test locations;
- descriptions and locations of ongoing construction;
- equipment and personnel in each work area, including subcontractors;
- descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- locations where tests and samples were taken;
- a summary of test results;
- calibrations or recalibrations of test equipment, and actions taken as a result of recalibration;
- delivery schedule of off-site materials received, including quality control documentation;
- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality; and
- signature of the respective CQA Site Manager(s) and/or the CQA Monitor(s).

In any case, all logs must be completely filled out with no items left blank.

5.2.4 Construction Problem and Solution Data Sheets

Sheets describing special construction situations will be cross-referenced with specific observation logs and testing data sheets, and must include the following information, where available:

- an identifying sheet number for cross-referencing and document control;

- a detailed description of the situation or deficiency;
- the location and probable cause of the situation or deficiency;
- how and when the situation or deficiency was found or located;
- documentation of the response to the situation or deficiency;
- final results of any responses;
- measures taken to prevent a similar situation from occurring in the future; and
- the signature of the CQA Manager and/or CQA Monitor, and signature of the Project Manager indicating concurrence.

The Project Manager will be made aware of any significant recurring non-conformance with specifications. The Project Manager will then determine the cause of the non-conformance and recommend appropriate changes in procedures or specifications. These changes will be submitted to the Engineer for approval. When this type of evaluation is made, the results will be documented, and any revision to procedures or specifications will be approved by the Owner and the Engineer.

A summary of the supporting data sheets, along with final testing results and the CQA Manager's approval of the work, will be required upon completion of construction.

5.3 Photographic Documentation

Photographs will be taken by the CQA Field Monitors and CQA Site Manager in order to serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain electronic copies and stored in a folder on a daily basis in chronological order. These records will be presented to the Project Manager upon completion of the project. Photographic reporting data sheets, where used, will be cross-referenced with observation and testing data sheet(s), and/or construction problem and solution data sheet(s).

5.4 Design and/or Specifications Changes

Design and/or specifications changes may be required during construction. In such cases, the CQA Manager will notify the Project Manager and the Engineer.

Design and/or specifications changes will be made only with the written agreement of the Project Manager and the Engineer, and will take the form of an addendum to the specifications.

5.5 Progress Reports

Each CQA Consultant will prepare a summary progress report each week, or at time intervals established at the pre-construction meeting. As a minimum, this report will include the following information:

- a unique identifying sheet number for cross-referencing and document control;
- the date, project name, location, and other information;
- a summary of work activities during progress reporting period;
- a summary of construction situations, deficiencies, and/or defects occurring during the progress reporting period;
- photographs and descriptions;
- a summary of test results, failures and retests; and
- the signature of the CQA Site Manager.

5.6 Signatures and Final Report

At the completion of the work, the CQA Consultants will submit to the Project Manager signed and sealed Final Reports. These reports will certify: (i) that the work has been performed in compliance with the drawings and specifications; (ii) physical sampling and testing, except as properly authorized, have been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information.

At a minimum, this report will include: (i) summaries of all construction activities; (ii) observation logs and testing data sheets including sample location plans; (iii) construction problems and solutions data sheets; (iv) changes from design and material specifications; (v) record drawings; and (vi) a summary statement sealed and signed by a Professional Engineer licensed in the State of Florida.

The record drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). All surveying and base maps required for development of the record drawings will be prepared by a qualified land surveyor licensed in the State of Florida. These documents will be prepared and assembled by the appropriate CQA Consultant and included as part of the CQA Final Report.

5.7 Storage of Records

Handwritten data sheet originals, especially those containing signatures, should be stored by the Project Manager or his designee in a safe on-site repository. Other reports may be stored by any standard method which will allow for easy access.

6.0 POLYETHYLENE GEOMEMBRANES

6.1 Introduction

This section discusses the CQA of the high-density polyethylene (HDPE) geomembrane components included in the design of the Area 4 liner system.

6.2 Design Familiarization

A copy of the Drawings and specifications prepared by the Engineer will be given to the Geosynthetics CQA Consultant. The Geosynthetics CQA Consultant will review these items for familiarity. This review should not be considered as peer review of the design, which should have been conducted at an earlier stage of the project. The Geosynthetics CQA Consultant will verify that the specifications include at least all properties listed in Tables 1 and 2, which provide the frequency of testing for the geomembrane.

6.3 Geomembrane Material Conformance

6.3.1 Raw Material

The raw material will be new, first quality polyethylene resin meeting the following specifications given by GRI Test Method GM13:

- Specific Gravity (ASTM D 792 Method A): 0.94, minimum

Compliance testing will be carried out by the Geomembrane Manufacturer to demonstrate that the product meets this Specification.

Prior to the installation of any geomembrane, the Geomembrane Manufacturer will provide the Project Manager and the Geosynthetics CQA Consultant with the following information:

- the origin (Resin Supplier's name and resin production plant), identification (brand name, number) and production date of the resin;
- a copy of the quality control certificates issued by the Resin Supplier;
- reports on the tests conducted by the Geomembrane Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project (at a minimum, these tests should include specific gravity (ASTM D792), percent carbon black (ASTM D 1603) and melt index (ASTM D1238 Condition E 190°C, 2.16 kg)); and
- a statement that no reclaimed polymer is added to the resin.

The Geosynthetics CQA Consultant will review these documents and report discrepancies with the above requirements to the Project Manager.

6.3.2 Geomembrane Manufacturing

Prior to the installation, the Geomembrane Manufacturer will provide the Project Manager and the Geosynthetics CQA Consultant with the following:

- a properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the specifications, or equivalent;
- a list of quantities and descriptions of materials other than the base polymer which comprise the geomembrane;
- the sampling procedure and results of testing; and
- a certification that property values given in the properties sheet are minimum average roll values and are guaranteed by the Geomembrane Manufacturer.

The Geosynthetics CQA Consultant will verify that:

- the property values certified by the Geomembrane Manufacturer meet all of the specifications; and
- the measurements of properties by the Geomembrane Manufacturer are properly documented and that the test methods used are acceptable.

In addition, the Geosynthetics CQA Consultant may, at the request of the Owner, undertake a manufacturing plant visit, preferably during the production of the particular geomembrane for this project, in order to evaluate the manufacturer's quality control procedures.

6.3.3 Rolls

The Geomembrane Manufacturer will provide the Project Manager and the Geosynthetics CQA Consultant with a quality control certificate for each roll of geomembrane shipped to the site. The quality control certificate will be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager. The quality control certificate will include:

- roll numbers and identification; and
- sampling procedures and results of quality control tests - as a minimum, results will be given for thickness and tensile strength evaluated in accordance with the

methods indicated in the specifications or equivalent methods approved by the Engineer.

The Geosynthetics CQA Consultant will:

- verify that the quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it; and

- review the quality control certificates and verify that the certified roll properties meet the specifications.

6.3.4 Conformance Testing

At the Geomembrane Manufacturer's plant or upon delivery of the rolls of geomembrane at the site, the Geosynthetics CQA Consultant or a designated personnel will verify that samples are removed at the specified frequency and forwarded to the Geosynthetics CQA Laboratory for testing to verify conformance to both the design specifications and the list of guaranteed properties. The minimum number of tests to be performed and test procedures will be as indicated in Table 1. Where optional procedures are noted in the test method, the requirements of the specifications will prevail.

Samples will be taken across the entire width of the roll and will not include the first linear 3 ft (1 m). Unless otherwise specified, samples will be 3-ft (1-m) long by the roll width. The Geosynthetics CQA Consultant will mark the machine direction on the samples with an arrow. The required minimum sampling frequencies are provided in Table 1.

The Geosynthetics CQA Consultant will examine the results from laboratory conformance testing and will report non-conformance to the Project Manager.

The following procedure will apply whenever a sample fails a conformance test that is conducted by the Geosynthetics CQA Laboratory:

- the Installer will replace the roll of geomembrane that is in nonconformance with the specifications with a roll that meets specifications;

- the Installer will remove conformance samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll.

These two samples must both conform to specifications. If either of these samples fail, then every roll of geomembrane on site and every roll delivered subsequently must be tested by the Geosynthetics CQA Laboratory for conformance to the specifications. This additional conformance testing will be at the expense of the Installer.

The Geosynthetics CQA Consultant will document actions taken in conjunction with conformance test failures.

6.4 Delivery

6.4.1 Transportation and Handling

Transportation of the geomembrane is the responsibility of the Geomembrane Manufacturer, Fabricator, Installer, or other party as agreed upon. All handling on site is the responsibility of the Installer.

The Geosynthetics CQA Consultant will verify that:

- handling equipment used on the site is adequate and does not pose any risk of damage to the geomembrane; and
- the Installer's personnel handle the geomembranes with care.

Upon delivery at the site, the Installer and the Geosynthetics CQA Consultant will conduct a surface observation of all rolls for defects and for damage. This examination will be conducted without unrolling rolls unless defects or damages are found or suspected. The Geosynthetics CQA Consultant will indicate to the Project Manager:

- rolls, or portions thereof, that should be rejected and removed from the site because they have severe flaws; and
- rolls or factory panels that include minor repairable flaws.

6.4.2 Storage

The Installer will be responsible for the storage of the geomembrane on site. The Project Manager will provide storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible. Storage space should be protected from theft, vandalism, passage of vehicles, etc.

The Geosynthetics CQA Consultant will verify that storage of the geomembrane ensures adequate protection against dirt, shock, and other sources of damage.

6.5 Geomembrane Installation

6.5.1 Earthwork

6.5.1.1 Surface Preparation

The Contractor will be responsible for preparing the supporting soil according to the specifications. The Geosynthetics CQA Consultant will verify that:

- a qualified land surveyor has verified all lines and grades;
- the Soils CQA Consultant has verified that the supporting soil meets the density and moisture content specifications;
- the surface to be covered with geomembrane has been rolled and compacted so as to be free of irregularities, protrusions, loose soil, and abrupt changes in grade;
- the surface of the supporting soil does not contain stones which may be damaging to the geomembrane; and
- there is no area of the subgrade that has been excessively softened by high water content.

The Installer will certify in writing that the surface on which the geomembrane will be installed is acceptable. The certificate of acceptance will be given by the Installer to the Geosynthetics CQA Consultant prior to commencement of geomembrane installation in the area under consideration.

After the supporting soil has been accepted by the Installer, it will be the Installer's responsibility to indicate to the Geosynthetics CQA Consultant any change in the supporting soil condition that may require repair work. If the Geosynthetics CQA Consultant concurs with the Installer, then the Project Manager will ensure that the supporting soil is repaired.

At any time before and during the geomembrane installation, the Geosynthetics CQA Consultant will indicate to the Project Manager any locations that may not provide adequate support for the geomembrane.

6.5.1.2 Anchorage System

Prior to geomembrane placement, anchor trenches will be excavated by the Contractor (unless otherwise specified) to the lines, depths, and widths shown on the drawings. The Geosynthetics CQA Consultant will verify that anchor trenches have been constructed according to drawings.

Slightly rounded corners will be provided in trenches where the geomembrane enters the trench so as to avoid sharp bends in the geomembrane. No loose soil will be allowed to underlie the geomembrane in the trenches.

Backfilling of anchor trenches will be conducted in accordance with Section 6.5.5.

6.5.2 Geomembrane Placement

6.5.2.1 Field Panel Identification

A field panel is the unit area of geomembrane which is to be seamed in the field (i.e., a field panel is a roll or a portion of roll cut in the field).

It will be the responsibility of the Geosynthetics CQA Consultant to ensure that each field panel is given an “identification code” (number or letter-number). This identification code will be agreed upon by the Project Manager, Installer, and Geosynthetics CQA Consultant. This field panel identification code should be as simple and logical as possible. (Note that roll numbers established in the manufacturing plant are usually cumbersome and are not related to location in the field.) It will be the responsibility of the Installer to ensure that each field panel placed is marked with the original roll number. The roll number will be marked at a location agreed upon by the Project Manager, Installer, and Geosynthetics CQA Consultant.

The Geosynthetics CQA Consultant if requested by the Project Manager, will establish a table or chart showing correspondence between roll numbers, factory panels, and field panel identification codes. The field panel identification code will be used for all quality assurance records.

6.5.2.2 Field Panel Placement

Location

The Geosynthetics CQA Consultant will verify that field panels are installed at the location indicated in the proposed panel layout plan, as approved or modified.

Installation Schedule

Field panels will be placed one at a time, and each field panel will be seamed immediately after its placement (in order to minimize the number of unseamed field panels exposed to wind).

It is usually beneficial to "shingle" overlaps in the downward direction to facilitate drainage in the event of precipitation. It is also beneficial to proceed in the direction of prevailing winds. Scheduling decisions must be made during installation, in accordance with varying conditions. In any event, the Installer will be fully responsible for the decision made regarding placement procedures.

The Geosynthetics CQA Consultant will evaluate every change in the schedule proposed by the Installer and advise the Project Manager on the acceptability of that change. The Geosynthetics CQA Consultant and Soils CQA Consultant will verify that the condition of the supporting soil has not changed detrimentally during installation.

The Geosynthetics CQA Consultant will record the identification code, location, and date of installation of each field panel.

Weather Conditions

Geomembrane placement will not proceed at an ambient temperature below 40^0 F (5^0 C) or above 104°F (40°C) or when the wind velocity exceeds 20 miles per hour, unless otherwise authorized by the Engineer. Geomembrane placement will not be done during any precipitation, in an area of ponded water, or in the presence of excessive winds.

The Geosynthetics CQA Consultant will verify that the above conditions are fulfilled. Additionally, the Geosynthetics CQA Consultant will verify that the supporting soil has not been damaged by weather conditions.

The Geosynthetics CQA Consultant will inform the Project Manager if the above conditions are not fulfilled.

Method of Placement

The Geosynthetics CQA Consultant will verify that:

- any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means;

- the prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;

- any geosynthetic elements immediately underlying the geomembrane are clean and free of debris;

- all personnel working on the geomembrane do not smoke, bring glassware on the geomembrane, wear damaging shoes, or engage in other activities that could damage the geomembrane;

- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;

- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);

- adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along the edges of panels to minimize the risk of wind flow under the panels); and

- direct contact with the geomembrane is minimized (i.e., the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected).

- the geomembrane is protected from damage in heavily trafficked areas

The Geosynthetics CQA Consultant will inform the Project Manager if the above conditions are not fulfilled.

Damage

The Geosynthetics CQA Consultant will visually observe each panel, after placement and prior to seaming, for damage. The Geosynthetics CQA Consultant will advise the Project Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the Geosynthetics CQA Consultant. On the landfill base, however, damaged panels or portions of panels may be covered with new panels or portions of panels with the approval of the Engineer. If this work is performed, it will be recorded by the Geosynthetics CQA Consultant. Repairs will be made according to procedures described in Section 6.5.4.

As a minimum, the Geosynthetics CQA Consultant will verify:

- the panel is placed in such a manner that it is unlikely to be damaged; and
- any tears, punctures, holes, thin spots, etc. are either marked for repair or the panel is rejected.

6.5.3 Field Seaming

6.5.3.1 Seam Layout

Prior to installation, the Installer will provide the Project Manager and the Geosynthetics CQA Consultant with a seam layout drawing (i.e., a drawing of the facility to be lined showing all expected seams). The Geosynthetics CQA Consultant will review the seam layout drawing and verify that it is consistent with the accepted state of practice and this CQA Plan. No panels may be seamed in the field without the Project Manager's approval. In addition, no panels not specifically shown on the seam layout drawing may be used without the Project Manager's prior approval.

In general, seams should be oriented parallel to the line of maximum slope (i.e., oriented along, not across, the slope). In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam shall be less than 10 ft (3 m) from the toe of slopes, or areas of potential stress concentrations, unless otherwise authorized by the Engineer.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Pre-Construction Meeting.

6.5.3.2 Requirements of Personnel

All personnel performing seaming operations will be qualified by experience. Seaming personnel must have seamed at least 10,000 lineal ft (3,000 m) of polyethylene geomembrane seams using the same type of seaming apparatus to be used on this project. At least one seamer will have experience seaming a minimum of 2,000,000 ft^2 (186,000 m^2) of polyethylene geomembrane using the same type of seaming apparatus to be used on this site-specific geomembrane. The most experienced seamer, the "master seamer", will provide direct supervision over less experienced seamers.

The Installer will provide the Project Manager and the Geosynthetics CQA Consultant with a list of proposed seaming personnel and their experience records. This document will be reviewed by the Project Manager and the Geosynthetics CQA Consultant.

6.5.3.3 Seaming Equipment and Products

Overview

Approved processes for field seaming are extrusion welding and fusion welding. Proposed alternate processes shall be documented and submitted to the Project Manager. Only apparatus which have been specifically approved by make and model shall be used. The Installer will use a pyrometer to ensure that accurate temperatures are being achieved, supply a calibrated field tensiometer and a manual dye press. The Project Manager will submit all documentation to the Geosynthetics CQA Consultant for his concurrence.

Extrusion Process

The extrusion-seaming apparatus will be equipped with gauges giving the relevant temperatures in the apparatus and at nozzle.

The Installer will provide documentation regarding the extrudate to the Project Manager and the Geosynthetics CQA Consultant, and will certify that the extrudate welding rod is compatible with the specifications, and in any event is comprised of the same resin as the geomembrane sheeting.

The Installer shall log apparatus temperatures, extrudate temperatures, and ambient temperatures at appropriate intervals. Ambient temperatures will be measured between 0 to 6 in. (0 to 150 mm) above the geomembrane surface.

The Geosynthetics CQA Consultant will verify that:

- the Installer maintains on-site the number of spare operable seaming apparatus decided at the Resolution Meeting;
- equipment used for seaming is not likely to damage the geomembrane;

- the extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;

- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane (extra fuel or fuel canisters shall be placed so not to come in direct contact with the geomembrane; i.e., place waste/scrap piece between installed liner and bottom of fuel canister) ;

- a smooth insulating plate or fabric is placed beneath the hot seaming apparatus after usage; and

Fusion Process

The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus will be equipped with gauges giving the applicable temperatures and pressures.

The Geosynthetics CQA Consultant will log ambient seaming apparatus and geomembrane surface temperatures, as well as seaming apparatus pressures.

The Geosynthetics CQA Consultant will also verify that:

- the Installer maintains on-site the number of spare operable seaming apparatus decided at the Resolution Meeting/Pre-Construction Meeting;

- equipment used for seaming is not likely to damage the geomembrane;

- for cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to seaming;

- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane (extra fuel or fuel canisters shall be placed so not to come in direct contact with the geomembrane; i.e., place waste/scrap piece between installed liner and bottom of fuel canister);

- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and

- a movable protective layer may be used directly below each overlap of geomembrane that is to be seamed to prevent build-up of moisture between the sheets.

6.5.3.4 Seam Preparation

The Geosynthetics CQA Consultant will verify that:

- prior to seaming, the seam area is clean and free of moisture dust, dirt, debris of any kind, and foreign material;

- if seam overlap grinding is required, the process is completed according to the Geomembrane Manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane;

- the abrading does not extend more than 0.25 in. (6 mm) on either side of the extrusion seam; and

- seams are aligned with the fewest possible number of wrinkles and "fishmouths".

6.5.3.5 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows:

- unless authorized in writing by the Project Manager, no seaming will be attempted at an ambient temperature below 40°F (5°C) or above 104°F (40°C);

- between ambient temperatures of 32°F (0°C) and 40°F (5°C), seaming is possible if the geomembrane is preheated by either sun or hot air device, and if there is no excessive cooling resulting from wind;

- above an ambient temperature of 40°F (5°C), no preheating is required;

- in all cases, the geomembrane will be dry and protected from wind; and

- the ambient temperatures will be measured between 0 to 6 in. (0 to 150 mm) above the geomembrane surface.

If the Installer wishes to use methods which may allow seaming at ambient temperatures below 40°F (5°C) or above 104°F (40°C), the Installer must demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced at ambient temperatures above 40°F (5°C) and below 104°F (40°C), and that the overall quality of the geomembrane is not adversely affected. Acceptance of the proposed method is the responsibility of the Engineer. In addition, an addendum to the contract between the Owner and the Installer is required which specifically states that the seaming procedure does not cause any physical or chemical modification to the geomembrane that will generate any short or long term damage to the geomembrane. Then, the temperatures in the above quality assurance procedure will be modified accordingly.

The Geosynthetics CQA Consultant will verify that these weather conditions are fulfilled and will advise the Project Manager if they are not. The Project Manager will then decide if the installation will be stopped or postponed.

6.5.3.6 Overlapping and Temporary Bonding

The Geosynthetics CQA Consultant will verify that:

- the panels of geomembrane have a finished overlap of a minimum of 3 in. (75 mm) for extrusion seaming and 5 in. (125 mm) for fusion seaming; and

- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane (in particular, the temperature of hot air at the nozzle of any spot seaming apparatus is controlled such that the geomembrane is not damaged).

The Geosynthetics CQA Consultant will log all appropriate temperatures and conditions, and will log and report to the Project Manager any non-compliance.

6.5.3.7 Trial Seams

Trial seams will be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Such trial seams will be made at the beginning of each seaming period, and at least once every five hours, for each seaming apparatus used in the seaming period. A trial seam will also be made in the event that the ambient temperature varies more than ± 18°F (10°C) since the last passing trial seam. The ambient temperature will be measured between 0 to 6 in. (0 to 150 mm) above the geomembrane. Also, each seamer will make at least one trial seam each seaming period. Trial seams will be made under the same conditions as actual seams. If any seaming apparatus is turned off for any reason, then a new passing trial seam must be completed for that specific seaming apparatus.

The trial seam sample will be at least 3-ft (1-m) long by 1-ft (0.3-m) wide (after seaming) with the seam centered lengthwise for fusion trial seams and at least 10-ft (3-m) long by 1-ft (0.3-m) wide for extrusion trial seams. Seam overlap will be as indicated in Section 6.5.3.6.

Four specimens, each 1 in. (25 mm) wide, and a minimum of 6 in. (150 mm) apart, will be cut from the trial seam sample by the Installer. Two specimens will be tested in shear and two in peel using a field tensiometer, and they should not fail in the seam. If a specimen fails, the entire operation should be repeated. If the additional specimen fails, the seaming apparatus and seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.

The Geosynthetics CQA Consultant will observe the trial seam procedures. The remainder of the successful trial seam sample will be assigned a number and marked accordingly by the Geosynthetics CQA Consultant, who will also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description. The sample itself will be retained in the Owner's archives.

6.5.3.8 General Seaming Procedure

Unless otherwise specified, the general seaming procedure used by the Installer will be as follows:

- For fusion seaming, a movable protective layer of plastic may be placed directly below each overlap of geomembrane that is to be seamed, as directed by the Installer. This is to help prevent any moisture build-up between the sheets to be seamed.

- If required, a firm substrate will be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

- Fishmouths or wrinkles at the seam will first be eliminated by pulling the geomembranes. If this does not work, overlaps will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles will be seamed and any portion where the overlap is inadequate will then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 mm (6 in.) beyond the cut in all directions.

- If seaming operations are carried out at night, adequate illumination will be provided and must be approved by the Engineer.

- Seaming will extend to the outside edge of panels to be placed in the anchor trench.

The Geosynthetics CQA Consultant will verify that the above seaming procedures are followed, and will inform the Project Manager if they are not.

6.5.3.9 Nondestructive Seam Continuity Testing

Concept

The Installer will nondestructively test all field seams over their full length using a vacuum test unit, air pressure test (for double fusion seams only), or other approved method. Vacuum testing and air pressure testing are described in *Vacuum Testing* and the *Air Pressure Testing* of Section 6.5.3.9. The purpose of nondestructive tests is to check the continuity of seams. It does not provide any information on seam strength. Continuity testing will be carried out as the seaming work progresses, not at the completion of all field seaming. Nondestructive testing will not be permitted before sunrise or after sunset unless the Installer demonstrates capabilities to do so.

The Geosynthetics CQA Consultant will:

- observe the continuity testing;

- record location, date, test unit number, name of tester, and outcome of the testing; and
- inform the Installer and Project Manager of any required repairs.

The Installer will complete any required repairs in accordance with Section 6.5.4.

The Geosynthetics CQA Consultant will:

- observe the repair and re-testing of the repair;
- mark on the geomembrane that the repair has been made; and
- document the results.

The following procedures will apply to locations where seams cannot be nondestructively tested.

- Prior to seaming, the seamer will make a new passing trial seam.
- All such seams will be cap-stripped with the same geomembrane.
- If the seam is accessible to testing equipment prior to final installation, then the seam will be nondestructively tested prior to final installation.
- If the seam cannot be tested prior to final installation, then the seaming and cap-stripping operations will be observed by the Geosynthetics CQA Consultant and Installer for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation will be recorded by the Geosynthetics CQA Consultant.

Vacuum Testing

The equipment will be comprised of the following:

- a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge;
- a vacuum tank and pump assembly equipped with a pressure controller and pipe connections;
- a pressure/vacuum hose with fittings and connections;

- an approved applicator; and
- a soapy solution.

The following procedures will be followed:

- if vacuum testing a fusion seam, the flap must be cut off with an approved cutter, prior to testing to expose the seam;
- energize the vacuum pump and reduce the tank pressure to approximately 5 psi (34 kPa) (minimum) gauge;
- with a soapy solution, wet a strip of geomembrane which is 6 in. (150 mm) larger in area than the vacuum box;
- place the box over the wetted area;
- close the bleed valve and open the vacuum valve;
- ensure that a leak tight seal is created;
- for a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles;
- if no bubble appears after 30 seconds, close the vacuum valve and open the bleed valve. Before moving the box over the next adjoining area, place a mark (with a marker that will not damage the geomembrane) on the geomembrane at the leading edge of the viewing window, then move the box over the next adjoining area so that the last mark on the geomembrane is at the rear of the viewing window, and repeat the process; and
- all areas where soap bubbles appear will be marked and repaired in accordance with Section 6.5.4.

Air Pressure Testing (For Double Fusion Seam Only)

The following procedures are applicable to those processes which produce a double seam with an enclosed space.

The equipment will be comprised of the following:

- an air pump equipped with a pressure gauge capable of generating and sustaining a pressure between 25 and 30 psi (175 and 210 kPa) and mounted on a cushion to protect the geomembrane;

- a hose with fittings and connections; and
- a sharp hollow needle, or other approved pressure feed device.

The following procedures will be followed:

- seal both ends of the seam to be tested;
- insert the needle or other approved pressure feed device into the tunnel created by the fusion seam;
- insert a protective cushion between the air pump and the geomembrane;
- energize the air pump to a pressure between 25 and 30 psi (175 and 210 kPa), close the valve, and sustain the pressure for not less than 5 minutes;
- if any loss of pressure exceeds 3 psi (23 kPa) or if the pressure does not stabilize, locate the faulty area and repair it in accordance with Section 6.5.4;
- to verify that there is airflow through the entire tunnel, remove the seal at the end of the tunnel away from the air source and listen for the escaping air, and if it is found that there is a blockage in the channel, the entire seam must be vacuum tested as described previously;
- if upon checking for complete airflow it is found that there is a blockage in the tunnel, the seam will be vacuum tested; and
- remove the needle or other approved pressure feed device and seal the hole.

6.5.3.10 Destructive Testing

Concept

Destructive seam tests will be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing will be done as the seaming work progresses, not at the completion of all field seaming. The seam testing requirements are summarized in Table 2.

Location and Frequency

The Geosynthetics CQA Consultant will select locations where seam samples will be cut out for laboratory testing. Those locations will be established as follows.

- A minimum frequency of one test location per 500 ft (150 m) of seam length. This minimum frequency is to be determined as an average taken throughout the

entire facility. The frequency may be increased to 1000 ft (300 m) if electric leak location testing is performed.

- A maximum frequency will be agreed upon by the Installer, Project Manager and Geosynthetics CQA Consultant at the Resolution and/or Pre-Construction Meeting.

- Test locations will be determined during seaming at the Geosynthetics CQA Consultant's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming.

The Installer will not be informed in advance of the locations where the seam samples will be taken.

Sampling Procedure

Samples will be cut by the Installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The Geosynthetics CQA Consultant will:

- observe sample cutting;

- assign a number to each sample, and mark it accordingly;

- record the sample location on the layout drawing; and

- if necessary, record the 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 will be immediately repaired in accordance with repair procedures described in Section 6.5.4.3. The continuity of the new seams in the repaired area will be tested according to Section 6.5.3.9.

Size and Distribution of Samples

At a given sampling location, two types of samples will be taken by the Installer.

First, two specimens for field testing should be taken. Each of these specimens will be 1-in. (25-mm) wide by 12-in. (300-mm) long, with the seam centered parallel to the width. The distance between these two specimens will be 4 ft (1.2 m). If both specimens pass the field test described in *Field Testing* of Section 6.5.3.10, a sample for laboratory testing will be taken.

The sample for laboratory testing will be located between the two specimens for field testing. The destructive sample will be 1-ft (0.3-m) wide by 3.5-ft (1.1-m) long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one portion to the Installer, 1 ft by 1 ft (0.3 m by 0.3 m);
- one portion to the Owner for archive storage, 1 ft by 1 ft (0.3 m by 0.3 m); and
- one portion for Geosynthetics CQA Laboratory testing, 1 ft by 1.5 ft (0.3 m by 0.45 m).

Final determination of the sample sizes will be made at the Pre-Construction Meeting.

Field Testing

The two 1-in. (25-mm) wide specimens described above will be tested in the field, by hand and tensiometer, for peel and shear respectively, and should not fail at the seam location. If any field test sample fails to pass, then the procedures outlined in *Procedures for Destructive Test Failures* of Section 6.5.3.10 will be followed.

The Geosynthetics CQA Consultant will witness all field tests and mark all samples and portions with their number. The Geosynthetics CQA Consultant will also log the date and time, ambient temperature, number of seaming unit, name of technician, seaming apparatus temperatures and speeds, pass or fail description, and attach a copy to each sample portion.

Geosynthetics CQA Laboratory Testing

Destructive test samples will be packaged and shipped, if necessary, under the responsibility of the Geosynthetics CQA Consultant in a manner which will not damage the test sample. The Project Manager will verify that packaging and shipping conditions are acceptable. The Project Manager will be responsible for storing the archive samples. This procedure will be fully outlined at the Resolution Meeting. Test samples will be tested by the Geosynthetics CQA Laboratory. The Geosynthetics CQA Laboratory will be selected by the Geosynthetics CQA Consultant with the concurrence of the Project Manager.

Testing will include “Seam Strength” (ASTM D 4437) and “Peel Adhesion” (ASTM D 4437). The minimum acceptable values to be obtained in these tests are those indicated in the specifications. At least 5 specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear).

The Geosynthetics CQA Laboratory will provide test results no more than 24 hours after they receive the samples. The Geosynthetics CQA Manager will review laboratory test results as soon as they become available, and make appropriate verbal recommendations to the Project Manager.

The verbal recommendations will be followed by written recommendations.

Should field tensiometer testing be carried out, the following procedure should be followed: if the test passes, the sample qualifies for testing in the laboratory; if it fails, the seam should be repaired in accordance with *Procedures for Destructive Test Failure* of Section 6.5.3.10.

Installer's Laboratory Testing

The Installer's laboratory test results will be presented to the Project Manager and the Geosynthetics CQA Consultant for comments in writing.

Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test is conducted by the Geosynthetics CQA Laboratory, the Installer's laboratory, or by field tensiometer.

The Installer has two options.

- The Installer can reconstruct (e.g., remove the old seam and reseam) the seam between any two passed destructive seam test locations.

- The Installer can trace the seaming path to an intermediate location (at 10 ft (3 m) minimum from the point of the failed test in each direction) and take a small sample for an additional field test at each location. If these additional samples pass tensiometer testing, then full destructive laboratory samples are taken. If these destructive laboratory samples pass the tests, then the seam is reconstructed between these locations by capping. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

If a fusion type seam fails destructive testing and the Installer chooses to cap the seam, then the only acceptable capping method is as described in Section 6.5.4.3. Applying topping is not an approved method of capping long lengths of seam.

All acceptable seams must be bounded by two locations from which destructive samples passing laboratory tests have been taken. In cases exceeding 150 ft (50 m) of reconstructed seam, a sample will be taken from the zone in which the seam has been reconstructed. This sample must pass destructive testing or the procedure outlined in this section must be repeated.

The Geosynthetics CQA Consultant will document all actions taken in conjunction with destructive test failures.

6.5.4 Defects and Repairs

6.5.4.1 Identification

All seams and non-seam areas of the geomembrane will be examined by the Geosynthetics CQA Consultant for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination. The geomembrane surface will be broomed or washed by the Installer if the amount of dust or mud inhibits examination.

6.5.4.2 Evaluation

Each suspect location both in seam and non-seam areas will be non-destructively tested using the methods described in Section 6.5.3.9 as appropriate. Each location which fails the non-destructive testing will be marked by the Geosynthetics CQA Consultant and repaired by the Installer. Work will not proceed with any materials which will cover locations which have been repaired until laboratory test results with passing values are available.

6.5.4.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, will be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be agreed upon between the Project Manager, Installer, and Geosynthetics CQA Consultant.

The procedures available include:

- patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;
- grinding and reseaming, used to repair small sections of extruded seams;
- spot seaming, used to repair minor or localized flaws;
- capping, used to repair large lengths of failed seams; and
- topping, used to repair areas of inadequate seams, which have an exposed edge;

In addition, the following provisions will be satisfied:

- surfaces of the geomembrane which are to be repaired will be abraded no more than one hour prior to the repair;
- all surfaces must be clean and dry at the time of the repair;
- all seaming equipment used in repairing procedures must be approved;

- the repair procedures, materials, and techniques will be approved in advance of the specific repair by the Project Manager, Geosynthetic CQA Consultant, and Installer;

- patches or caps will extend at least 6 in. (150 mm) beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 in. (75 mm); and

- the geomembrane below large caps should be appropriately cut to avoid water or gas collection between the two sheets.

6.5.4.4 Verification of Repairs

Each repair will be numbered and logged. Each repair will be non-destructively tested using the methods described in Section 6.5.3.9 as appropriate. Repairs which pass the non-destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive testing, at the discretion of the Geosynthetics CQA Consultant. Failed tests will require the repair to be redone and retested until a passing test results. The Geosynthetics CQA Consultant should observe all non-destructive testing of repairs and will record the date of the repair and test outcome.

6.5.4.5 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane is completed) and prior to placing overlying materials, the Geosynthetics CQA Consultant will observe the geomembrane wrinkles. The Geosynthetics CQA Consultant will indicate to the Project Manager which wrinkles should be cut and reseamed by the Installer. The seam thus produced will be tested like any other seam.

6.5.5 Backfilling of Anchor Trench

Anchor trenches will be adequately drained, to prevent ponding or otherwise softening of the adjacent soils while the trench is open. Anchor trenches will be backfilled and compacted by the Contractor or the Installer on a timely basis. Care will be taken when backfilling the trenches to prevent any damage to the geosynthetics. The Geosynthetics CQA Consultant will observe the backfilling operation and advise the Project Manager of any problems.

6.5.6 Geomembrane System Acceptance

The Installer and the Manufacturers will retain all ownership and responsibility for the geosynthetics until acceptance by the Owner. The geosynthetic will be accepted by the Owner when:

- the installation is finished;

- verification of the adequacy of all seams and repairs, including associated testing, is complete;

- Installer's representative furnishes the Project Manager with certification that the geomembrane was installed in accordance with the Manufacturer's recommendations as well as the plans and specifications;

- all documentation of installation is completed including the Geosynthetics CQA Consultant's final report; and

- a final report, including record drawings, sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania, have been received by the Project Manager.

The Geosynthetics CQA Consultant will certify that installation has proceeded in accordance with the geosynthetics potion of the CQA Plan for the project except as noted to the Project Manager.

6.5.7 Materials in Contact with the Geomembrane

6.5.7.1 Introduction

The quality assurance procedures indicated in this section are only intended to assure that the installation of these materials does not damage the geomembrane. Additional quality assurance procedures are necessary to assure that systems built with these materials will be constructed in such a way to enable proper performance.

6.5.7.2 Soils

A copy of the Specifications prepared by the Engineer for placement of soils will be given to the Geosynthetics CQA Consultant by the Project Manager. The Geosynthetics CQA Consultant will verify that these Specifications are consistent with the state of practice as described below.

- Placement of soils on the geomembrane shall not proceed at an ambient temperature below 40^0 F (5^0C) nor above 104^0F (40^0C) unless otherwise specified.
- Placement of soils above the geomembrane shall be done in such a manner as not to create waves or wrinkles in the geomembrane of a size that could fold over.
- Soils must be free of objects that could cause damage to the geosynthetics.
- A geotextile or other cushion approved by the Engineer may be installed between angular aggregate and the geomembrane.
- Equipment used for placing soil will not be driven directly on the geomembrane.
- A minimum thickness of 1 ft (0.3 m) of uncompacted soil is specified between a light dozer (such as a wide pad Caterpillar D-3 or lighter) and the geomembrane.
- A minimum thickness of 3 ft (0.9 m) of soil is specified between rubber-tired vehicles and the geomembrane.
- In heavily trafficked areas such as access ramps, soil thickness should be at least 3 ft (0.9 m).

The Geosynthetics CQA Consultant will:

- measure soil thickness and verify that the required thicknesses are present (or, if applicable, verify that required measurements have been completed by the Soils CQA Consultant, if any);

- verify that final thicknesses are consistent with design; and

- verify that placement of soil is done in such a manner that geomembrane damage is unlikely.

The Geosynthetics CQA Consultant will inform the Project Manager if the above conditions are not fulfilled.

6.5.7.3 Appurtenances

A copy of the specifications prepared by the Engineer for appurtenances will be given by the Project Manager to the Geosynthetics CQA Consultant for review.

The Geosynthetics CQA Consultant will verify that:

- installation of the geomembrane in appurtenance areas, and connection of geomembrane to appurtenances have been made according to Specifications;

- extreme care is taken while seaming around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas; and

- the geomembrane has not been visibly damaged while making connections to appurtenances.

The Geosynthetics CQA Consultant will inform the Project Manager if the above conditions are not fulfilled.

7.0 GEOTEXTILES

7.1 Design Familiarization

A copy of the Drawings and specifications prepared by the Engineer will be given to the Geosynthetics CQA Consultant. The Geosynthetics CQA Consultant will review these and verify that they are conceptually consistent with the state of practice, and are clear and complete.
This review is not considered as a peer review of the design.

7.2 Manufacturing Quality Control

The Geotextile Manufacturer will provide the Project Manager with a list of guaranteed "minimum average roll value" properties as defined by GRI Test Method GT 12, for the type of geotextile to be delivered. The Geotextile Manufacturer will also provide the Project Manager with a written certification signed by a responsible party that the materials actually delivered have "minimum average roll values" properties which meet or exceed all property values guaranteed for that type of geotextile.

The Geosynthetics CQA Consultant will examine the manufacturer certifications to verify that the property values listed on the certifications meet or exceed those specified for the particular type of geotextile. Deviations will be reported to the Project Manager.

7.3 Labeling

The Geotextile Manufacturer will identify all rolls of geotextile with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

Additionally, if any special handling of the geotextile is required, it will be so marked on the top surface of the geotextile, e.g., "This Side Up".

The Geosynthetics CQA Consultant will examine rolls upon delivery and any deviation from the above requirements will be reported to the Project Manager.

7.4 Shipment and Storage

During shipment and storage, the geotextile will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls will be shipped and stored in relatively opaque and watertight wrappings.

Geotextiles will not be exposed to precipitation prior to being installed. Wrappings protecting geotextile rolls will be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, the geotextiles will not be exposed to sunlight for more than 30 days, unless otherwise specified and guaranteed by the Geotextile Manufacturer.

The Geosynthetics CQA Consultant will observe rolls upon delivery at the site and any deviation from the above requirements will be reported to the Project Manager. Damaged rolls will be rejected and replaced at no cost to the Owner.

7.5 Conformance Testing

7.5.1 Tests

Geotextile samples shall be taken at the site or at the manufacturer's plant and forwarded to the Geosynthetics CQA Laboratory for testing to ensure conformance to both the Specifications and the Manufacturers list of guaranteed properties.

As a minimum, the following tests will be performed on geotextiles:

- mass per unit area;
- grab strength;
- tear strength;
- puncture strength;
- apparent opening size, when the geotextile is used as a filter; and
- permittivity, when the geotextile is used as a filter.

The conformance tests will be performed in accordance with the test methods specified in the specifications. Other conformance tests may be required by the specifications. Testing frequency for the geotextiles is presented in Table 3.

7.5.2 Sampling Procedures

Samples of the manufactured geotextile components may be taken at the plant or at the site.

Samples will be taken across the entire width of the roll and will not include the first 3 ft (1 m). Unless otherwise specified, samples will be 3-ft (1-m) long by the roll width. Mark the machine direction on the samples with an arrow.

7.5.3 Test Results

The Geosynthetics CQA Consultant will examine the results from laboratory conformance testing and will report non-conformance to the Project Manager.

7.5.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the Geosynthetics CQA Laboratory.

- The Installer will replace the roll of geotextile that is in nonconformance with the specifications with a roll that meets specifications.

- The Installer will remove conformance samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must conform to the specifications. If either of these samples fail, the five numerically closest untested rolls on both sides of the failed sample will be tested by the Geosynthetics CQA Laboratory. These ten samples must conform to the specifications. If any of these samples fail, every roll of geotextile on site and every subsequently delivered roll that is from the same supplier must be tested by the Geosynthetics CQA Laboratory for conformance to the specifications. This additional conformance testing will be at the expense of the Installer.

The Geosynthetics CQA Consultant will document actions taken in conjunction with conformance test failures.

7.6 Handling and Placement

The Installer will handle all geotextiles in such a manner as to ensure they are not damaged in any way, and the following will be complied with:

- on slopes, the geotextiles will be securely anchored in the anchor trench and then rolled down the slope in such a manner as to continually keep the geotextile panel in tension;

- in the presence of wind, all geotextiles will be weighted with sandbags or the equivalent; sandbags installed during placement are to remain in place until replaced with protective cover soils;

- geotextiles will be kept continually under tension to minimize the presence of wrinkles in the geotextile;

- geotextiles will be cut using an approved geotextile cutter only; if in place, then special care must be taken to protect other materials from damage which could be caused by the cutting of the geotextiles;

- the Installer will take any necessary precautions to prevent damage to the underlying layers during placement of the geotextile;

- during placement of geotextiles, care will be taken not to entrap in the geotextile stones, excessive dust, or moisture that could damage the geomembrane, generate clogging of drains or filters, or hamper subsequent seaming;

- a visual examination of the geotextile will be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects, such as needles, are present; and

- if white colored geotextile is used, then precautions will be taken against “snow blindness” of personnel.

The Geosynthetics CQA Consultant will note any noncompliance and report it to the Project Manager.

7.7 Seams and Overlaps

All geotextiles shall be continuously sewn or thermally bonded (i.e., Geo-welded). Geotextiles will be overlapped at a minimum of 6 in. (150 mm) prior to seaming. No horizontal seams will be allowed on side slopes steeper than 10 percent (i.e. seams will be along, not across, slopes steeper than 10H:1V), except as part of a patch.

The Installer will pay particular attention at seams to ensure that no protective cover material could be inadvertently inserted beneath the geotextile.

Sewing will be done using polymeric thread.

7.8 Repair

Holes or tears in the geotextile will be repaired as follows.

- On slopes steeper than 10 percent, a patch made from the same geotextile will be seamed into place no closer than 1 in. (25 mm) from any edge. Should any tear exceed 10 percent of the width of the roll, that roll will be removed from the slope and replaced.

- On slopes flatter than 10 percent, a patch made from the same geotextile will be spot-seamed in place with a minimum of 2-ft (0.6-m) overlap in all directions.

- Care will be taken to remove soil or other material that may have penetrated the torn geotextile.

The Geosynthetics CQA Consultant will observe the repair of geotextiles, note any non-compliance with the above requirements, and report them to the Project Manager.

7.9 Placement of Soil Materials

The Installer will place soil materials located on top of a geotextile in such a manner as to ensure:

- no damage to the geotextile;

- minimal slippage of the geotextile on underlying layers; and

- no excess tensile stresses in the geotextile.

Unless otherwise specified by the Engineer, a minimum thickness of 1 ft (0.3 m) of soil is specified between a low ground-pressure dozer and the geotextile.

Non-compliance will be noted by the Geosynthetics CQA Consultant and reported to the Project Manager.

8.0 GEONETS

8.1 Design Familiarization

A copy of the geonet drawings and specifications prepared by the Engineer will be given to the Geosynthetic CQA Consultant. The Geosynthetic CQA Consultant will review these and verify that the geonets can be installed as indicated. This review is not a peer review of the design (including a review of the calculations) which should have been conducted at an earlier stage of the project. The section apply only if geonet is proposed in the project.

8.2 Manufacturing Quality Control

The Geonet Manufacturer will provide the Project Manager and the Geosynthetic CQA Consultant with a list of guaranteed properties for the type of geonet to be supplied. The Geonet Manufacturer will provide the Project Manager and the Geosynthetics CQA Consultant with a written certification signed by a responsible party that the geonets actually delivered have "minimum average roll values" properties which meet or exceed the guaranteed properties.

The Geosynthetic CQA Consultant will examine the manufacturer's certifications to verify that the property values listed on the certifications meet or exceed those specified. Deviations will be reported to the Project Manager.

8.3 Labeling

The Geonet Manufacturer will identify all rolls of geonet with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

The Geosynthetic CQA Consultant will examine rolls upon delivery and any deviation from the above requirements will be reported to the Project Manager.

8.4 Shipment and Storage

Geonet cleanliness is essential to their performance and geonet rolls should be wrapped in plastic or otherwise protected against dust and dirt during shipping and storage.

The wrapping should be removed less than one hour before placement. The Geosynthetic CQA Consultant will verify that geonets are free of dirt and dust just before installation. The Geosynthetic CQA Consultant will report the outcome of this verification to the Project Manager, and if the geonets are judged dirty or dusty, they will be washed by the Installer prior to installation.

Washing operations will be observed by the Geosynthetic CQA Consultant and improper washing operations will be reported to the Project Manager.

8.5 Conformance Testing

8.5.1 Tests

Geonet samples shall be collected at the site or at the manufacturer's plant and forwarded to Geosynthetic CQA Laboratory for testing, at the frequency indicated in Table 4, to verify conformance to both the design specifications and the list of guaranteed properties.

As a minimum, the following tests will be performed:

- polymer specific gravity;
- carbon black content;
- thickness; and
- hydraulic transmissivity, if required by the Engineer.

8.5.2 Sampling Procedures

Samples of the geonet may be taken at the plant or at the site. Samples will be taken across the entire width of the roll and will not include the first 3 ft (1 m). Unless otherwise specified, samples will be 3-ft (1-m) long by the roll width. Mark the machine direction on the samples with an arrow.

Unless otherwise specified, samples will be taken at a rate of one per lot or one per 100,000 ft^2 (10,000 m^2), whichever yields the greater number of samples, as indicated in Table 4.

8.5.3 Test Results

The Geosynthetic CQA Consultant will examine results from laboratory conformance testing and will report any nonconformance to the Project Manager.

8.6 Handling and Placement

The Installer will handle all geonets in such a manner as to ensure the geonets are not damaged in any way, and comply with the following.

- On sideslopes, the geonets will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geonet sheet in tension. If necessary, the geonet will be positioned by hand after being unrolled to minimize wrinkles. Geonets can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., at the toe of a slope, if an extra layer of geonet is required, this extra layer of geonet can be placed in the horizontal direction). Such locations will be identified by the Designer Engineer on the Drawings. (It should be noted that placement of layers of geonets at 90° angles to each other will result in a partial loss of effective thickness and transmissivity.

- In the presence of wind, all geonets will be weighted with sandbags or the equivalent. Such sandbags will be installed during placement and will remain until replaced with cover material.

- Unless otherwise specified, geonets will not be welded to geomembranes.

- Geonets will only be cut using scissors or hooked blade utility knife.

- The Installer will take any necessary precautions to prevent damage to underlying layers during placement of the geonet.
- During placement of geonets, care will be taken not to entrap in the geonet dirt or excessive dust 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 hosed clean prior to placement of the next material on top of it. In this regard, care should be taken with the handling of sandbags, to prevent rupture or damage of the sandbag.

- Care should be taken not to leave tools on the geonet.

The Geosynthetic CQA Consultant will note noncompliance and report it to the Project Manager.

8.7 Stacking and Joining

When several layers of geonets are stacked, care should be taken to prevent strands from one layer from penetrating the channels of the next layer, thereby significantly reducing the transmissivity. This cannot happen if stacked geonets are placed in the same direction. A stacked geonet will never be laid in perpendicular directions to the underlying geonet (unless otherwise specified by the Engineer). In the corners of side slopes of rectangular landfills, adjacent overlapping geonets are usually perpendicular and special precautions will be taken as discussed below.

Adjacent geonets will be joined according to Drawings and specifications. As a minimum, the following requirements will be met.

- Adjacent rolls will be overlapped by at least 4 in. (100 mm).
- These overlaps will be secured by tying.
- Tying will be achieved by nylon cable ties, plastic fasteners, or polymer braid. Tying devices will be white or yellow for easy observation. Metallic devices are not allowed.
- Tying will be every 5 ft (1.5 m) along the slope, every 2 ft (0.6 m) across the slope, and every 6 in. (150 mm) in the anchor trench and at tie-ins with previously deployed material from a former project. Tying will be every 10 ft (3.0 m) on horizontal surface.
- In the corners of the side slopes of rectangular landfills, where overlaps between perpendicular geonet strips are required, an extra layer of geonet will be unrolled along the slope, on top of the previously installed geonets, from top to bottom of the slope.
- When more than one layer of geonet is installed, joints will be staggered a minimum of 1 ft (0.3 m).

The Geosynthetic CQA Consultant will note noncompliance and report it to the Project Manager.

8.8 Repair

Any holes or tears in the geonet will be repaired by placing a patch extending 2 ft (0.6 m) beyond edges of the hole or tear. The patch will be secured to the original geonet by tying every
6 in. (150 mm). Tying devices will be as indicated in Section 8.7. If the hole or tear width across the roll is more than 50 percent the width of the roll, then the damaged area will be cut out and the two portions of the geonet will be joined as indicated in Section 8.7.

The Geosynthetic CQA Consultant will observe any repair, note any non-compliance with the above requirements and report them to the Project Manager.

8.9 Placement of Soil Materials

Although soil should never be placed in contact with geonets, the Installer will ensure that all soil materials are placed in such a manner as to ensure:

- the geonet and underlying geosynthetic materials are not damaged;
- minimal slippage of the geonet on underlying layers occurs; and
- no excess tensile stresses occur in the geonet.

Noncompliance will be noted by the Geosynthetic CQA Consultant and reported to the Project Manager.

If portions of the geonet are exposed, the Geosynthetic CQA Consultant will periodically place marks on the geonet and the underlying geomembrane and measure the elongation of the geonet during the placement of soil.

9.0 GEOCOMPOSITE

9.1 Design Familiarization

A copy of the Drawings and specifications prepared by the Engineer will be given to the Geosynthetics CQA Consultant. The Geosynthetics CQA Consultant will review these and verify that the geocomposite can be installed as indicated. This review is not a peer review of the design. Peer review should have been conducted at an earlier stage of the project.

9.2 Manufacturing Quality Control

The Geocomposite Manufacturer will provide the Project Manager and the Geosynthetic CQA Consultant with a list of guaranteed properties for the type of geonet to be supplied. The Geocomposite Manufacturer will provide the Project Manager and the Geosynthetics CQA Consultant with a written certification signed by a responsible party that the geocomposites actually delivered have “minimum average roll values” properties which meet or exceed the guaranteed properties.

The Geosynthetic CQA Consultant will examine the manufacturer’s certifications to verify that the property values listed on the certifications meet or exceed those specified. Any deviations will be reported to the Project Manager.

9.3 Labeling

The Geocomposite Manufacturer will identify all rolls of geocomposite with the following:

- manufacturer’s name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

If any special handling is required, it will be so marked on the geotextile component, e.g., “This Side Up”, or “This Side Against Soil To Be Retained”. The Geosynthetic CQA Consultant will examine rolls upon delivery and any deviation from the above requirements will be reported to the Project Manager.

9.4 Shipment and Storage

Geocomposite cleanliness is essential to its performance and geocomposite rolls should be wrapped in plastic or otherwise protected against dust and dirt during shipping and storage.

The wrapping should be removed less than one hour before placement. The Geosynthetic CQA Consultant will verify that geocomposites are free of dirt and dust just before installation. The Geosynthetic CQA Consultant will report the outcome of this verification to the Project Manager, and if the geocomposites are judged dirty or dusty, they will be cleared by the Installer prior to installation.

9.5 Conformance Testing

9.5.1 Tests

Geocomposite samples shall be collected at site or at the manufacturer's plant and sent to Geosynthetic CQA Laboratory for testing, at the frequency indicated in 9.5.2, to verify conformance to both the design specifications and Table 5.

9.5.2 Sampling Procedures

Samples of the geonet and geotextile components of the geocomposite shall be taken at the Geocomposite Manufacturer's plant prior to manufacturing the geocomposite. Samples of the manufactured geocomposite components may be taken at the plant or at the site. Samples of the geotextile component will be obtained as in accordance with *Sampling Procedures* of Section 7.5.2. Samples of the geonet component will be obtained in accordance with *Sampling Procedures* of Section 8.5.2. Samples of the geocomposite will be taken across the entire width of the roll and will not include the first 3 ft (1 m). Unless otherwise specified, samples will be 3-ft (1-m) long by the roll width. The Geosynthetic CQA Consultant will mark the machine direction on the samples with an arrow.

Unless otherwise specified, samples will be taken at a rate of one per lot or one per 100,000 ft^2 (10,000 m^2), whichever yields the greater number of samples.

9.5.3 Test Results

The Geosynthetic CQA Consultant will examine the results from laboratory conformance testing and will report nonconformance to the Project Manager.

9.5.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the Geosynthetic CQA Laboratory.

- The Manufacturer will replace every roll of geocomposite that is in nonconformance with the specifications with a roll that meets specifications.

- The Installer will remove conformance samples for testing by the Geosynthetic CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the specifications. If either of these

samples fail, the five numerically closest rolls on the side of the failed sample that is not tested, will be tested by the Geosynthetic CQA Laboratory. These ten samples must conform to the specifications. If any of these samples fail, every roll of geocomposite on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the Geosynthetic CQA Laboratory for conformance to the specifications. This additional conformance testing will be at the expense of the Manufacturer.

- The Geosynthetics CQA Consultant will document actions taken in conjunction with conformance test failures.

9.6 Handling and Placement

The Installer will handle all geocomposites in such a manner as to ensure the geocomposites are not damaged in any way, and the following will be complied with.

- On sideslopes, the geocomposites will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles.

- In the presence of wind, all geocomposites will be weighted with sandbags or the equivalent. Such sandbags will be installed during placement and will remain until replaced with cover material.

- Geocomposites will only be cut using scissors or a hook blade utility knife.

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

- During placement of geocomposites, care will be taken not to entrap in the geocomposite dirt or excessive dust 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, then it should be cleaned prior to placement of the next material on top of it. In this regard, care should be taken with the handling or sandbags, to prevent rupture or damage of the sandbag.

- Care should be taken not to leave tools in the geocomposite.

The Geosynthetic CQA Consultant will note noncompliance and report it to the Project Manager.

9.7 Seams and Overlaps

Adjacent geocomposites will be joined according to Drawings and specifications. As a minimum, the following requirements will be met.

- Adjacent rolls will be overlapped by at least 4 in. (100 mm).
- Each component of the geocomposite will be secured or seamed to the like component at overlaps.
- The geonet composite overlaps will be secured by tying.
- Tying will be achieved by nylon cable ties, plastic fasteners, or polymer braid. Tying devices will be white or yellow for easy observation. Metallic devices are not allowed.
- Tying will be every 5 ft (1.5 m) along the slope, every 2 ft (0.6 m) across the slope, and every 6 in. (150 mm) in the anchor trench and at tie-ins with previously deployed material from a former project. Tying will be every 10 ft (3 m) on horizontal surface.
- The bottom layers of geotextile will be overlapped.
- The top layers of geotextile will be continuously sewn as described in Section 7.7 of the CQA Plan. The geotextiles may be heat-bonded in lieu of sewing at the discretion of the Design Engineer.

The Geosynthetic CQA Consultant will note noncompliance and report it to the Project Manager.

9.8 Repair

Any holes or tears in the geocomposite will be repaired by placing a patch extending 2 ft (0.6 m) beyond edges of the hole or tear. The patch will be secured by tying approved tying devices every 6 in. (150 mm) through the bottom geotextile and the geonet of the patch, and through the top geotextile and geonet components of the geocomposite needing repair. The top geotextile component of the patch will be heat sealed to the top geotextile of the geocomposite needing repair. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined in accordance with Section 9.7.

The Geosynthetic CQA Consultant will observe each repair, note any non-compliance with the above requirements and report them to the Project Manager.

9.9 Placement of Soil Materials

The Installer will place all soil materials located on top of a geonet composite in such a manner as to ensure:

- the geonet composite and underlying geosynthetic materials are not damaged;

- minimal slippage of the geonet composite on underlying layers occurs; and
- no excess tensile stresses occur in the geocomposite.

Unless otherwise specified by the Engineer, a minimum thickness of 1 ft (0.3 m) of soil is specified between a low ground-pressure dozer and the geocomposite.

Noncompliance will be noted by the Geosynthetic CQA Consultant and reported to the Project Manager.

If portions of the geocomposite are exposed, the Geosynthetic CQA Consultant will periodically place marks on the geocomposite and the underlying geomembrane and measure the elongation of the geonet during the placement of soil.

10.0 GEOSYNTHETIC CLAY LINERS (GCLS)

10.1 Design Familiarization

A copy of the Drawings and specifications prepared by the Engineer will be given to the Geosynthetics CQA Consultant. The Geosynthetics CQA Consultant will review these and verify that they are conceptually consistent with the state of practice, and are clear and complete.
This review is not considered as a peer review of the design. Installation will be in accordance with the GCL Manufacturer's requirements and recommendations.

10.2 Manufacturing Quality Control

The GCL Manufacturer shall provide the Project Manager with a written certification signed by a responsible party that the materials actually delivered have "minimum average roll values" that meet or exceed all property values guaranteed for that type of GCL.

The Geosynthetics CQA Consultant will examine the manufacturer certifications to verify that the property values listed on the certifications meet or exceed those specified for the particular type of GCL. Deviations will be reported to the Project Manager.

10.3 Labeling

The GCL Manufacturer will identify all rolls of GCL with the following:

- manufacturer's name;
- product identification;
- lot number;
- roll number; and
- roll dimensions.

Additionally, if any special handling of the GCL is required, it will be so marked on the top surface of the GCL, e.g., "This Side Up".

The Geosynthetics CQA Consultant will examine rolls upon delivery and any deviation from the above requirements will be reported to the Project Manager.

10.4 Shipment and Storage

During shipment and storage, the GCL will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, GCL rolls will be shipped and stored in relatively opaque and watertight wrappings.

GCLs will not be exposed to precipitation prior to being installed. Wrappings protecting GCL rolls will be removed less than one hour prior to unrolling the GCL. After the wrapping has been removed, the GCLs will not be exposed to sunlight for more than 30 days, unless otherwise specified and guaranteed by the GCL Manufacturer.

The Geosynthetics CQA Consultant will observe rolls upon delivery at the site and any deviation from the above requirements will be reported to the Project Manager. Damaged rolls will be rejected and replaced at no cost to the Owner.

10.5 Conformance Testing

10.5.1 Tests

The GCL samples shall be removed at site or at the plant and forwarded to the Geosynthetics CQA Laboratory for testing to ensure conformance to both the Specifications and the Manufacturers list of guaranteed properties.

As a minimum, the following tests will be performed on GCLs:

- bentonite mass per unit area;
- flux;
- swell index; and
- weight of upper and lower geosynthetic components.

The conformance tests will be performed in accordance with the test methods specified in the specifications. Other conformance tests may be required by the specifications. Testing frequency for the GCLs is presented in Table 6.

10.5.2 Sampling Procedures

Samples of the GCL may be taken at the plant or at the site. Samples will be taken across the entire width of the roll and will not include the first 3 ft (1 m). Unless otherwise specified, samples will be 3-ft (1-m) long by the roll width. The machine direction shall be marked on the samples with an arrow for lab use.

10.5.3 Test Results

The Geosynthetics CQA Consultant will examine the results from laboratory conformance testing and will report non-conformance to the Project Manager.

10.5.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the Geosynthetics CQA Laboratory.

- The Installer will replace the roll of GCL that is in nonconformance with the specifications with a roll that meets specifications.

- The Installer will remove conformance samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must conform to the specifications. If either of these samples fail, the five numerically closest untested rolls on both sides of the failed sample will be tested by the Geosynthetics CQA Laboratory. These ten samples must conform to the specifications. If any of these samples fail, every roll of GCL on site and every subsequently delivered roll that is from the same supplier must be tested by the Geosynthetics CQA Laboratory for conformance to the specifications. This additional conformance testing will be at the expense of the Installer.

The Geosynthetics CQA Consultant will document actions taken in conjunction with conformance test failures.

10.6 Handling and Placement

The Installer will handle all GCLs in such a manner as to ensure they are not damaged in any way, and the following will be complied with:

- on slopes, the GCLs will be securely anchored in the anchor trench and then rolled down the slope in such a manner as to continually keep the GCL panel in tension;

- in the presence of wind, all GCLs will be weighted with sandbags or the equivalent; sandbags installed during placement are to remain in place until replaced with protective cover soils;

- GCLs will be kept continually under tension to minimize the presence of wrinkles in the GCL;

- GCLs will be cut using an approved GCL cutter only; if in place, then special care must be taken to protect other materials from damage which could be caused by the cutting of the GCLs;

- the Installer will take any necessary precautions to prevent damage to the underlying layers during placement of the GCL;

- during placement of GCLs, care will be taken not to entrap in the GCL stones, excessive dust, or moisture that could damage the geomembrane, generate clogging of drains or filters, or hamper subsequent seaming;

- a visual examination of the GCL will be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects, such as needles, are present; and

- if white colored GCL is used, then precautions will be taken against “snow blindness” of personnel.

- no equipment shall be allowed to move on top of GCL.

The Geosynthetics CQA Consultant will note any noncompliance and report it to the Project Manager.

10.7 Seams and Overlaps

All GCL upper geotextiles will be continuously sewn (i.e., spot sewing and thermal bonding are not allowed) at the discretion of the Geosynthetics CQA Consultant, depending on the roll end details. GCLs will be overlapped at a minimum of 24 in. (600 mm) or greater based on the GCL Manufacturer’s recommendations. No horizontal seams will be allowed on side slopes steeper than 10 percent (i.e. seams will be along, not across, slopes steeper than 10H:1V), except as part of a patch.

The Installer will pay particular attention at seams to ensure that no soil material could be inadvertently inserted beneath the GCL.

Sewing, where performed, will be done using polymeric thread.

10.8 Repair

Holes or tears in the GCL will be repaired as follows.

- On slopes steeper than 10 percent, a patch made from the same GCL will be seamed into place no closer than 1 in. (25 mm) from any edge. Should any tear exceed 10 percent of the width of the roll, that roll will be removed from the slope and replaced.

- On slopes flatter than 10 percent, a patch made from the same GCL will be placed with a minimum of 2-ft (0.6-m) overlap in all directions.

- Care will be taken to remove soil or other material that may have penetrated the torn GCL.

The Geosynthetics CQA Consultant will observe the repair of GCLs, note any non-compliance with the above requirements, and report them to the Project Manager.

11.0 PIPE AND FITTINGS

11.1 Material Requirements

11.1.1 Polyethylene Compound

Polyethylene (PE) resin must conform to the requirements of ASTM Designation D 1248, Type III, Class C, Grade P34, Category 5, ASTM D 3350 (Cell Classification PE 345464C), and have a Plastic Pipe Institute (PPI) rating of PE 3408. The pipe compound will be protected against ultraviolet light and the resin compound will contain no additives, adulterants, extenders, or reworked compounds, but will contain an effective antioxidant.

The resin compound will have a minimum resistance of 125 hours when tested for environmental stress crack in accordance with requirements of ASTM-D1693.

Compliance with the above requirements must be certified by the pipe supplier.

11.1.2 Pipe and Fittings

The pipe and fittings shall have a cell classification of PE 345464C under ASTM D3350 and meet or exceed all the requirements of ASTM D3350. Pipes will be of uniform color and thickness.

The pipe and fittings will comply with the requirements of ASTM F714. Pipes will be of uniform color and thickness. Each length of pipe will be suitably marked as to its pressure rating for water at 73.4°F (23°C). Pipe will have a Standard Dimension Ratio (SDR) stated on the Drawings.

All pipe fabrications and perforations shall be performed in the factory. Interior beads of all HDPE pipes upon completion of fusion welding shall removed to achieve a smooth interior surface at the weld location.

Compliance with the above requirements must be certified by the pipe supplier.

11.1.3 Joints

Lengths of pipe will be assembled into suitable installation lengths by the butt-fusion process. Butt-fusion means the butt-joining of the pipe by softening the aligned faces of the pipe ends in a suitable apparatus and pressing them together under controlled pressure. This process will be applied by personnel experienced with the process. Certification will be provided that the person performing this work is qualified by experience and instruction in the procedure. All pipe so joined will be made from the same class and type of raw material made by the same raw material supplier.

Installation lengths will be joined by the use of stub ends. All stub ends for attachment to the polyethylene pipe will be made from the same type and grade of polyethylene, from the same raw material supplier as the pipe, and will be butt-fused to the pipe ends.

The polyethylene stub ends at joints will be backed up by nylon-coated steel flanges conforming to ANSI B16.1 and shaped as necessary to suit the outside dimensions of the pipe. The stub ends will be connected with corrosion resisting bolts and nuts of Type 316 Stainless Steel as specified in ASTM A 726 and ASTM A 307. Flat gaskets of 1/8 in. (3-mm) black reinforced rubber conforming to ANSI B16.21 will be installed between the opposing ends of the stub ends.

In no case will threaded male or female adapters of any plastic material be used for adapting polyethylene pipe to systems, fitting or auxiliary equipment of other materials, or for joining the installation lengths to each other.

Termination to pipes, valves, or fittings made of other material will be by the flanged joints outlined above. The pipe adjacent to these joints and to the joints themselves must be rigidly supported for a distance of one pipe diameter beyond the flange.

11.2 Manufacturer

Prior to the installation of PE pipe, the PE Pipe Manufacturer will provide to the Geosynthetic CQA Consultant:

- a properties' sheet including, at a minimum, all specified properties, measured using test methods indicated in the specifications, or equivalent;
- a list of quantities and descriptions of materials other than the base polymer which comprise the pipe;
- the sampling procedure and results of testing; and
- a certification that property values given in the properties sheet are minimum values and are guaranteed by the PE Pipe Manufacturer.

The Geosynthetic CQA Consultant will verify that:

- the property values certified by the PE Pipe Manufacturer meet all of the specifications; and
- the measurements of properties by the PE Pipe Manufacturer are properly documented and that the test methods used are acceptable.

Prior to shipment, the PE Pipe Manufacturer will provide the Project Manager and the Geosynthetics CQA Consultant with a quality control certificate for each lot/batch of PE pipe provided. The quality control certificate will be signed by a responsible party employed by the

PE Pipe Manufacturer, such as the Production Manager. The quality control certificate will include:

- lot/batch numbers and identification; and
- sampling procedures and results of quality control tests.

The Geosynthetics CQA Consultant will:

- verify that the quality control certificates have been provided at the specified frequency for all lots/batches of pipe, and that each certificate identifies the pipe lot/batch related to it; and
- review the quality control certificates and verify that the certified properties meet the specifications.

11.3 Conformance Testing

If deemed necessary by the Engineer, the CQA Consultant will select one sample of each size of pipe, at least 3 ft (0.9 m) in length, and forward that sample to the CQA Laboratory for conformance testing. The samples will be taken from sections of pipe which are predetermined to have excess lengths. Samples failing to conform to the original specifications will result in rejection of all pipe of that size.

11.4 Handling and Laying

Care will be taken during transportation of the pipe such that it will not be cut, kinked, or otherwise damaged.

Ropes, fabric, or rubber-protected slings and straps will be used when handling pipes. Chains, cables, or hooks inserted into the pipe ends will not be used. Two slings spread apart will be used for lifting each length of pipe. Pipe or fittings will not be dropped onto rocky or unprepared ground.

Pipes will be stored on level ground, preferably turf or sand, free of sharp objects which could damage the pipe. Stacking of the polyethylene pipe will be limited to a height of four pipes to prevent excessive deformation of pipes under the anticipated temperature conditions. The pipe will be stored on wooden sleepers, spaced suitably and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between support. The pipes should be stored out of direct sunlight.

The handling of the joined pipe line will be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Slings for handling the pipeline will not be positioned at butt-fused joints. Sections of the pipes with deep cuts and gauges will be removed and the ends of the pipeline rejoined.

Butt-fusion of pipes and fittings will be performed in accordance with the pipe manufacturer's recommendations as to equipment and technique. Depending on site conditions, butt-fusion joining will be performed in or outside of the excavation.

Care will be exercised when lowering pipe into the trench to prevent damage or twisting of the pipe.

When pipes penetrate through the geomembrane, an effective seal will be established in accordance with the details shown on the Drawings.

11.5 Nondestructive Testing of Joints

All solid wall HDPE pipe with thermal butt-fusion type joints must be nondestructively tested. These pipe joints will be tested using the pressure test, as specified in ASTM F1417. Other nondestructive test methods may be used only when:

- the Installer can prove its effectiveness;
- the method is approved by the Pipe Manufacturer; and
- the method is approved by the Engineer.

The Engineer and the Geosynthetic CQA Consultant will verify the effectiveness and validity of the test method. Nondestructive testing of perforated or slotted pipe is not required.

The Geosynthetic CQA Consultant will report nonconformance of testing methods to the Project Manager.

12.0 SOILS

12.1 Introduction

This section discusses the CQA of the soil components for the construction of Area 4 liner system.

12.2 Soil Components

12.2.1 Overview

In this section of the Soils CQA Plan, a description of the soil components for the liner system and the procedures that will be used to construct each component is provided. Each of the soil components to be used must first be accepted for use by the Engineer based on a review pre-qualification data submitted by the Contractor for each proposed source. The Engineer will confirm acceptance of the soil components to the Contractor, the Soils CQA Consultant, and the Owner. The Contractor will be responsible for performing field and laboratory quality control testing in accordance with the Project Specifications during construction. The Soil CQA Consultant will be responsible for performing field quality assurance testing during construction.

12.2.2 Subbase

The subbase will be a 6 in. (150 mm) minimum thick layer of compacted soil. The cell bottom may have 1-ft minimum subbase as illustrated in the drawings. The subbase will consist of relatively homogenous natural soils that are free of debris, foreign objects, excess silt, rocks, plant materials, and organics. The subbase will have no particles larger than 1 in. (25 mm). The in-place compacted subbase must exhibit a hydraulic conductivity of 1 x 10^{-5} cm/s (1 x 10^{-7} m/s) or less, as determined in the laboratory following the ASTM D 5084 standard test method. The maximum effective stress during the test shall be 5 psi. If a GCL is used permeability requirement shall be ignored.

The Contactor will construct the subbase to the lines, grades, and elevations shown on the Construction Drawings and in accordance with the Project Specifications. The subbase will be constructed on a prepared subgrade meeting the requirements of the Project Specifications and as shown on the Construction Drawings. The Soils CQA Consultant will confirm that a qualified land surveyor has verified lines and grades prior to and after construction of the subbase.

The subbase materials will be placed and compacted in one lift. The final thickness of the subbase will be within 0 to plus 0.2 ft (0.06 m). The subbase will be compacted to the required minimum dry density within the range of moisture contents established by the pre-qualification tests, which will be confirmed based on the results of a test pad constructed in accordance the Project Specifications. The dry density and moisture content of the subbase measured in the field will be used only as an indicator of the degree of compaction. Acceptance of the subbase will be based on the results of laboratory hydraulic conductivity tests performed on undisturbed samples of the subbase. Subsequent soil or geosynthetic layers cannot be placed over

subbase that has not been compacted to at least 95 percent of the maximum dry unit weight determined from the standard Proctor compaction test (ASTM D 698) and within the range of acceptable moisture contents. It should be noted that if a GCL is used, acceptability is based on minimum compaction requirement irrespective of moisture content.

12.2.3 Leachate Collection Gravel

The leachate collection gravel will be placed directly on top of a geocomposite as shown on the Construction Drawings. The gravel will consist of hard, strong, durable, non-carbonate particles that are free of foreign objects, organics, and other deleterious materials. The gravel will have a gradation meeting the requirements of the American Association of State Highway and Transportation Officials (AASHTO) No. 3 coarse aggregate, and will have a hydraulic conductivity of 1×10^{-1} cm/s (1×10^{-3} m/s) or greater. In addition, the gravel will have less than five percent loss of weight, when tested in accordance with ASTM D3042.

Placement of the gravel will be performed using low-ground pressure construction equipment in accordance with the Project Specifications. The equipment will operate only over previously placed gravel or protective cover in accordance with the Project Specifications. No construction equipment will be allowed to operate directly on the geotextile or geocomposite. Hand shovels used to place the gravel will be fitted with a fiberglass reinforced plastic blade. The gravel will be placed within plus or minus 0.1 ft (0.03 m).

12.2.4 Protective Cover

Sand shall be imported clean, excavated, natural sand, free from roots, sharp objects, or organic material, with a maximum size of 1/4 inch or 5% maximum by weight passing the No. 200 Sieve. The sand shall be classified as SW or SP by the Unified Soil Classification System. The sand drainage layer shall have a laboratory permeability not less than 1×10^{-3} cm/sec at 90% relative compaction (ASTM D 698). The material shall not be calcareous or of any other material that would interact with leachate. The sand shall be less than 10 percent loss of weight when tested in accordance with ASTM D3042 (Calcium Carbonate).

12.2.5 Structural Fill

Structural fill will be used to construct berms, cell base fill, and embankments and for other purposes as shown on the Construction Drawings. The structural fill will consist of relatively homogenous natural soils that are free of debris, foreign objects, organics and other deleterious materials. The soil will be classified as GW, GM, GC, SW, SM, SC, ML, or CL in accordance with USCS and will have no particles larger than 4 in. (100 mm).

The structural fill will be placed and compacted in lifts to the lines and grades shown on the Construction Drawings. The compacted thickness of each lift shall be 6 in. (150 mm). Each lift will be compacted to at least 95 percent of the standard Proctor maximum dry density.

12.2.6 Low Permeability Soil

Low permeability soil (<1 x 10^{-6} cm/s) will be used in the perimeter anchor trench and as otherwise shown on the Drawings. The material will consist of relatively homogenous, natural soils that are free of debris, foreign objects, excess silt, rock, plant material, and organics. The soil will be classified as MH, ML, CL, or CH in accordance with uses and will have no particles larger than 1 in. (25 mm). The soil will have a plasiticity index between 10 and 40.

The soil will be placed and compacted in lifts to the lines and grades shown on the Drawings. The average compacted thickness lift will be no less than 6 in. (150 mm). Each lift will be compacted to at least 95 percent of the Standard Proctor maximum dry density.

12.3 Soils Testing

12.3.1 Test Methods

The test method that will be used to evaluate the suitability or conformance of soils materials will be carried out in accordance with the procedures cited in the current versions of the ASTM book(s) of standards. The test methods presented in Table 7 are those which will be used for this testing unless the test methods are updated or revised prior to construction. Any revisions to the test methods will be reviewed and approved by the Engineer prior to their use.

12.3.2 Soils Testing Requirements

Nuclear moisture/density testing devices will be used to monitor the in-place moisture content and dry density of compacted soils. Other field moisture/density tests (i.e., sand cone and drive cylinder) may be used in cases of uncertainty, or as a means to verify the nuclear gage. Any conflict over the results will be resolved by the Engineer.

The minimum frequencies for evaluation of soil materials are presented in Table 8. The actual testing frequency will be determined by the Soils CQA Consultant taking into consideration the natural variability of materials.

The minimum frequencies for soil construction quality assurance testing are presented in Table 9. The actual testing frequency will be determined by the Soils CQA Consultant taking into consideration the natural variability of materials.

Sampling locations will be selected by the Soils CQA Consultant. The location of routine in-place density tests will be determined using a non-biased sampling plan.

A special testing frequency will be used at the discretion of the Engineer or the Soils CQA Consultant when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- the rollers slip during rolling operations;

- the lift thickness is greater than specified;
- the fill material is at improper and/or variable moisture content;
- fewer than the specified number of roller passes are made;
- soil-clogged rollers are used to compact the material;
- the rollers may not have used optimum ballast;
- the soil materials differ substantially from those specified; or
- the degree of compaction is doubtful.

During construction, the frequency of testing may also be increased in the following situations:

- adverse weather conditions;
- breakdown of equipment;
- at the start and finish of grading;
- if the material fails to meet Project Specifications; or
- the work area is reduced.

12.4 Soils Construction Quality Assurance

12.4.1 Introduction

Soils CQA will be performed on all soil materials used in construction. General CQA procedures are outlined below.

12.4.2 Monitoring

12.4.2.1 General

The Soils CQA Consultant will monitor and document the construction of the soil components of the liner system. In general, monitoring soil construction will include:

- reviewing Contractor submittals and prequalification test results to verify that the proposed materials and construction methods conform to the Project Specifications;
- reviewing Contractor quality control test results;

- inspecting the subgrade and other soil layer surfaces for compliance with the Project Specifications before additional materials are placed;
- monitoring soil placement to verify that no deleterious material is present, no frozen material is placed, and no soil is placed on frozen ground;
- sampling and conformance testing of the materials used in construction and notifying the Contractor of non-complying results;
- documenting that the soil components are constructed using the specified equipment and procedures;
- documenting construction equipment used;
- documenting that each soil component is constructed to the lines and grades and to the specified thickness shown on the Drawings;
- monitoring each soil construction activity to verify that no damage is caused to underlying geosynthetics;
- recording field density and field moisture content measurements and test locations on test logs to verify uniform achievement of specified compaction parameters for each lift;
- monitoring the final thickness of each soil component;
- performing quality assurance testing (as required) to determine the acceptability of the work during construction; and
- monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking, etc.).

Additional CQA monitoring activities specific to each of the major soils components of the Area 4 liner system are presented in the following sections.

12.4.2.2 Subbase

Additional CQA monitoring activities specific to the subbase include:

- monitoring compaction activities to verify uniform coverage;
- recording field density and field moisture content measurements and test location on test logs to verify uniform achievement of specified compaction parameters;

- monitoring the compaction procedures to verify that the final surface is compacted, smooth, and uniform;
- obtaining undisturbed samples of the compacted soil for laboratory hydraulic conductivity testing;
- monitoring procedures used to protect the finished surface from desiccation or erosion;
- monitoring procedures used to restore the finished surface damaged by desiccation or erosion so that the geomembrane may be deployed over a smooth surface;
- monitoring construction to verify that completed sections are protected from damage; and
- documenting weather conditions and verifying that construction proceeds only during weather conditions that will not cause completed areas to be damaged, contribute to areas of non-compliance in construction, or impede CQA efforts.

12.4.2.3 Low Permeability Soil

Additional CQA monitoring activities specific to the low permeability soil used in anchor trenches include:

- backfill the anchor trench using low permeability soil when the geomembrane is at its most contracted state; preferably during the morning or an extended period of overcast skies. Take care when backfilling the trenches to prevent any damage to the geosynthetics.
- compact anchor trench in two lifts
- compact by wheel rolling with light, rubber-tired or other light compaction equipment.
- monitoring the compaction procedures to verify that the final surface is compacted, smooth, and uniform;
- monitoring procedures used to protect the finished surface from desiccation or erosion;

12.4.2.4 Protective Cover

Additional CQA monitoring activities specific to the protective cover include:

- monitoring the removal of objects that would damage the underlying geosynthetics; and
- monitoring placement operations to verify the equipment used does not damage the underlying geosynthetics.

12.4.2.5 Leachate Collection Gravel

Additional CQA monitoring activities specific to the leachate collection gravel include:

- monitoring placement to verify that contamination of the gravel with other soils is prevented; and
- monitoring placement and compaction procedures of the gravel to verify that the leachate collection and detection pipes are not damaged.

12.4.2.6 Perforations

Perforations that must be filled will include, but not limited to, the following:

- nuclear density test probe locations;
- sand cone or drive cylinder test locations;
- hydraulic conductivity sampling locations; and
- test pit locations

Hydraulic conductivity samples will be taken such that the sample tube is inserted into the subbase normal to the plane of the constructed surface.

Unless otherwise needed in the project specifications, or as directed by the Engineer, all perforations of the subbase layer by probe or sample tube shall be backfilled with a minimum of a ten percent bentonite powder mixture. The mixtures will be compacted in-place with a tamping rod, hammer, or hand tamper, depending on the size of the perforations.

12.4.3 Deficiencies

If a defect is discovered in the earthwork product, the Soils CQA Consultant will immediately evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the Soils CQA Consultant will evaluate the extent of the deficient area by additional tests, observations, a review of records, or other means that the Soils CQA Consultant deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the Soils CQA Consultant will define the limits and nature of the defect.

12.4.3.1 Notification

After determining the extent and nature of a defect, the Soils CQA Consultant will notify the Project Manager (or Owner) and Contractor and schedule appropriate retests when the work deficiency is corrected.

12.4.3.2 Repairs and Retesting

At locations where the field testing indicates densities below the requirements of the Project Specifications, the failing area will be reworked. For the subbase and low-permeability soil where the field testing indicates the moisture content is below the requirements, the area will be scarified, moisture-conditioned, and recompacted. Alternatively, at the Soils CQA Consultant and Project Manager's (or Owner's) option, undisturbed samples of in-place material will be obtained and hydraulic conductivity and/or strength tests will be conducted as appropriate. Unless specified otherwise, the density requirements may be waived if the hydraulic conductivity and strength tests reveal acceptable results.

The Contractor will correct the deficiency to the satisfaction of the Soils CQA Consultant. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the Soils CQA Consultant will develop and present to the Engineer and/or Project Manager suggested solutions for approval.

All retests recommended by the Soils CQA Consultant must verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency.
The Soils CQA Consultant will also verify that installation requirements are met and that submittals are provided.

12.5 Soils CQA Records

Records will be kept for soils-related activities will be completed by the Soils CQA Consultant. The information will be recorded as testing is performed in the field or as results are received from the laboratory. The records will be available for review on site, and copies will be issued as part of the Final Report. The relevant forms are briefly described below.

Field and Laboratory Compaction Test Log (ASTM D 698 Method A, B, C, D)

The results of field laboratory compaction tests will be recorded on a Field Laboratory Compaction Test Log. Separate forms will be used for each test method.

Field Sand Cone Density or Drive Cylinder Test Log

The results of the sand cone or drive cylinder in-situ density test on soils, if performed, will be recorded on a Field Sand Cone Density Test Log or a Field Drive Cylinder Density Test Log. The results will

be used for comparison or calibration with nuclear density test results, at the discretion of the Soils CQA Consultant.

Summary of Sieve Analysis Test Data

This form will provide a summary of sieve analysis test results for soils.

Summary of Field Density Test

This form will provide a summary of field nuclear density, sand cone, and drive cylinder test results for soils.

Summary of Index Laboratory Test Data

This form will provide a summary of index test results performed in the field laboratory as required for soils.

13.0 SURVEYING

13.1 Introduction

Surveying of lines and grades will be conducted on an ongoing basis during construction of the soil layers, aggregate and placement of the geosynthetics. Certification surveying will be performed to provide documentation for record drawings, to verify quantities of soils and geosynthetics, to verify that the geometric requirements of the placement have been met, and to verify that the full thickness of the various soil and aggregate layers have been met. The Contractor will coordinate his work with the work of the Surveyor. The Surveyor may assist the Contractor in complying with the required grades. Surveying conducted at the site will be part of the CQA program.

13.2 Survey Control

At least three control monuments will be established for the current phase of the work by the Surveyor at locations convenient for daily tie-in. The vertical and horizontal controls for these control points will be established within normal land surveying standards. The Surveyor will communicate horizontal and vertical data for these control points to the Contractor, for the Contractor's used in laying out and providing ongoing geometric control of the work. The control monuments will be shown on all as-built record drawings.

13.3 Surveying Personnel

Surveying will be performed under the direct supervision of a qualified Land Surveyor, who may also be the Senior Surveyor on site. The survey crew will consist of the Senior Surveyor and as many Surveying Assistants as are required to satisfactorily undertake the work. Surveying personnel will be experienced in the provision of these services, including detailed, accurate documentation.

13.4 Precision and Accuracy

The survey instruments used for this work will be sufficiently precise and accurate to meet the needs of the project. Survey instruments shall be capable of reading to a precision of 0.01 ft (3.1 mm) and with a setting accuracy of 10 seconds. Calibration certificates for survey instruments will be submitted to the Project Manager prior to the initiation of surveying activities.

13.5 Lines and Grades

The following surfaces will be surveyed to determine the lines and grades achieved during construction on a 50-ft by 50-ft (15-m by 15-m) grid of the landfill. The survey shall include the following:

- original ground surface after clearing and grubbing;
- surface prepared for subgrade (including edges, bottom, and limits of pipe trenches and sump);
- surface prepared for top of subbase (including edges, bottom, and limits of pipe trenches and sump);
- surface prepared for protective cover (including edges, bottom, and limits of pipe trenches and sump);
- surface and limits of secondary and primary geomembrane, including locations of seam samples and major repairs;
- leachate collection and detection piping and structures, including sumps, cleanouts, gravity transmission pipes and forced main pipes;
- access roads, access ramps, drainage channels, and culverts;
- surface and limits of geosynthetics;
- anchor trench;
- alignment and inverts of piping (both inside and outside the landfill);
- profiles and cross sections; and
- items requested by the Owner.

13.6 Frequency and Spacing

Surveying will be performed as soon as possible after completion of a given installation to facilitate progress and avoid delaying the next installation.

The Surveyor will submit to the Soils CQA Consultant, a minimum of 7 days before surveying activities begins, a Survey Plan describing the methods to be used to evaluate conformance of the work to the geometric requirements of the contract documents. At a minimum, the Survey Plan will be prepared in sufficient detail to demonstrate that:

- all slopes have maximum inclinations as shown on the plans;
- required to have minimum slopes for drainage have at least the required slope; and
- geosynthetics anchor trenches have the required cross-section and are correctly located.

In general, the spacings and locations for survey points should be on a 50-ft by 50-ft (15-m by 15-m) grid and as follows:

- surfaces with slopes less than 10 percent will be surveyed on a square grid not wider than 50-ft (15-m);
- on slopes greater than 10 percent, a square grid not wider than 50-ft (15-m) will be used, but in any case, a line at the crest, midpoint, and toe of the slope will be taken;
- a line of survey points no farther than 50-ft (15-m) apart will be taken along any slope break (this will include the inside edge and outside edge of any terrace on a slope); and
- along linear features, survey sections or points should be at 50-ft (15-m).

The Soils CQA Consultant will review the Survey Plan and will promptly indicate approval or submit a request for additional detail to the Surveyor. Accuracy of the Survey Plan will be the sole responsibility of the Surveyor.

The Surveyor will survey the landfill as described in the Survey Plan. In addition, the Surveyor will provide assurance that uniform grades have been maintained between survey points.

Acceptable tolerance for the horizontal location of breaks in grade will be 0.5 ft (0.15 m).

Deviation from these tolerances will not be permitted unless approved in writing by the Engineer.

The tolerances listed above notwithstanding, all permit conditions, regulatory requirements, and thickness requirements must be adhered to. It is the Contractor's sole responsibility to control the work so that all of the geometric requirements of the project are met. The Contractor will notify the Project Manager 24 hours in advance of the time when any portion of the work will be completed and be ready for surveying by the Surveyor. The Surveyor will immediately notify the Contractor, the Project Manager, and the Soils CQA Consultant of any discrepancy found in the work. It is the Owner's sole prerogative to seek approval for work which is not within the tolerances listed above, but which, in the Owner's sole opinion, may nevertheless meet the intention of the project documents.

13.7 Documentation

Original field survey notes will be retained by the Senior Surveyor. A copy of these notes will be given to the Soils CQA Consultant at the end of each day or surveying task, whichever is shorter.

The Surveyor should produce record plans for the CQA Consultant as the job progresses. The results from the field surveys will be documented on a set of record plans. At the minimum, these plans will show the final elevations of the surfaces on a scale of 1 in. equals 100 ft (30 m), with contour intervals no greater than 2 ft, based on the 50-ft (15-m) grid pattern.

13.8 Certification

Survey as-built drawings will be certified by a registered Land Surveyor and submitted to the Project Manager.

TABLES

TABLE 1

GEOMEMBRANE CONFORMANCE TESTING REQUIREMENTS

Area 4 Expansion
Tomoka Farms Road Class I North Cell Phase II Landfill

TEST NAME	TEST METHOD	MINIMUM FREQUENCY OF TESTING
Specific Gravity	ASTM D792	1 test per 100,000 ft^2 (9,290 m^2)
Thickness	ASTM D 5994	1 test per 100,000 ft^2 (9,290 m^2)
Tensile Strength at Yield	ASTM D638	1 test per 100,000 ft^2 (9,290 m^2)
Tensile Strength at Break	ASTM D638	1 test per 100,000 ft^2 (9,290 m^2)
Elongation at Yield	ASTM D638	1 test per 100,000 ft^2 (9,290 m^2)
Elongation at Break	ASTM D638	1 test per 100,000 ft^2 (9,290 m^2)
Tear Resistance	ASTM D1004, Die C	1 test per 100,000 ft^2 (9,290 m^2)
Puncture Resistance	ASTM D4833	1 test per 100,000 ft^2 (9,290 m^2)
Carbon Black Content	ASTM D1603	1 test per 100,000 ft^2 (9,290 m^2)
Carbon Dispersion	ASTM D5596	1 test per 100,000 ft^2 (9,290 m^2)

TABLE 2

GEOMEMBRANE SEAM TESTING REQUIREMENTS

Area 4 Expansion
Tomoka Farms Road Class I North Cell Phase II Landfill

TEST NAME	TEST METHOD	MINIMUM FREQUENCY OF TESTING
Peel Adhesion	ASTM D4437 (as modified in NSF 54, Appendix A)[1, 3,4]	1 test every 500 ft (150 m)of seam length
Bonded Seam Strength	ASTM D4437 (as modified in NSF 54, Appendix A)[2, 3,4]	1 test every 500 ft (150 m) seam length
Vacuum Testing	---	100 percent of extrusion welded seams
Air Testing	---	100 percent of wedge welded seams

Notes:

1. For peel adhesion, seam separation will not extend more than 10 percent into the seam interface. Testing will be discontinued when the sample has visually yielded.
2. For shear tests, the sheet will yield before failure of the seam.
3. For either test, sample failure will be a Film Tear Bond (FTB) as outlined in NSF 54, Appendix A.
4. Minimum frequency shall be extended up to 1000 feet if electrical leak location survey method is used

TABLE 3

GEOTEXTILE CONFORMANCE TESTING REQUIREMENTS

Area 4 Expansion
Tomoka Farms Road Class I North Cell Phase II Landfill

TEST NAME	TEST METHOD	MINIMUM FREQUENCY OF TESTING
Mass per Unit Area	ASTM D5261	1 test per 100,000 ft^2 (9,290 m^2)
Grab Strength	ASTM D4362	1 test per 100,000 ft^2 (9,290 m^2)
Mullen Burst	ASTM D3786	1 test per 100,000 ft^2 (9,290 m^2)
Puncture Resistance	ASTM D4833	1 test per 100,000 ft^2 (9,290 m^2)
Permeability	ASTM D4491	1 test per 100,000 ft^2 (9,290 m^2)
Apparent Opening Size	ASTM D4751	1 test per 100,000 ft^2 (9,290 m^2)
Trapezoidal Tear Strength	ASTM D4533	1 test per 100,000 ft^2 (9,290 m^2)
Thickness	ASTM D5199	1 test per 100,000 ft^2 (9,290 m^2)

Note: Testing will be carried out at a frequency of one per lot or at listed frequency, whichever is less.

TABLE 4

GEONET CONFORMANCE TESTING REQUIREMENTS

Area 4 Expansion
Tomoka Farms Road Class I North Cell Phase II Landfill

TEST NAME	TEST METHOD	MINIMUM FREQUENCY OF TESTING
Density	ASTM D1505	1 test per 100,000 ft^2 (9,290 m^2)
Thickness	ASTM D5199	1 test per 100,000 ft^2 (9,290 m^2)
Carbon Black Content	ASTM D1603	1 test per 100,000 ft^2 (9,290 m^2)
Tensile Strength	ASTM D1682	1 test per 100,000 ft^2 (9,290 m^2)

Note: Testing will be carried out at a frequency of one per lot or at listed frequency, whichever is less.

TABLE 5

GEOCOMPOSITE CONFORMANCE TESTING REQUIREMENTS

Area 4 Expansion
Tomoka Farms Road Class I North Cell Phase II Landfill

Properties	Qualifiers	Units	Values	Test Method	CQA
Geonet Component					
Resin Polymer Melt Index	maximum	g/10 min.	1.0	ASTM D1238	n/a
Polymer Density (geonet)	Minimum	g/cc	0.94	ASTM D 1505	1/100,000 SF
Carbon Black Content	range	%	2.0 - 3.0	ASTM D 1603	1/100,000 SF
Thickness	minimum	mils	300 +/-15%	ASTM D 5199	1/100,000 SF
Tensile Strength (MD and TD)	minimum	lb/in	100	ASTM D 5035	1/100,000 SF
Geotextile Component					
Polymer Composition	minimum	%	95 polyester or polypropylene	-	n/a
Mass Per Unit Area	minimum	oz/yd^2	6	ASTM D 3776	1/100,000 SF
Apparent Opening Size	maximum	US Sieve	#70	ASTM D 4751	1/100,000 SF
Flow Rate(4)	minimum	$gal/min./ft^2$	110	ASTM D 4491	n/a
Permittivity(4)	minimum	sec^{-1}	1.2	ASTM D 4491	1/100,000 SF
Grab Strength	minimum	lb	160	ASTM D 4632	1/100,000 SF
CBR Puncture Strength	minimum	lb	435	ASTM D 6241	1/100,000 SF
UV Resistance	minimum	% retained	70	ASTM D 4355 (after 300 hours)	n/a
Geocomposite					
Transmissivity@10,000 psf(2)	minimum	m^2/s	2.0×10^{-3}	ASTM D 4716	1/500,000 SF
Ply Adhesion	minimum	lb/in.	1	ASTM F 904(3)	1/100,000 SF

Notes:

(1) All values represent minimum average roll values (i.e., test results for samples collected from any roll in a lot should meet or exceed these values).

(2) Transmissivity @ 100hour: Measure transmissivity using water at 68 DegF with a normal compressive load of 10,000 psf and a hydraulic gradient of 0.02 (ASTM D 4716). Boundary conditions are provided in Section 2.3. Measurements shall be taken 100 hour after application of confining pressure if satisfies the requirements given in Part 2.3A.

(3) Minimum of values measured in machine and cross machine directions with 1 in. clamp on Constant Rate of Extension (CRE) machine.

(4) Either flow rate requirement or permittivity requirement shall be met.

TABLE 6

GCL CONFORMANCE TESTING REQUIREMENTS

Area 4 Expansion
Tomoka Farms Road Class I North Cell Phase II Landfill

TEST NAME	TEST METHOD	MINIMUM FREQUENCY OF TESTING
Bentonite Mass per Unit Area	ASTM D5993	1 test per 100,000 ft^2 (9,290 m^2)
Flux	ASTM D5887	1 test per 100,000 ft^2 (9,290 m^2)
Swell Index	ASTM D5890	1 test per 100,000 ft^2 (9,290 m^2)
Weight of Upper and Lower Geosynthetic Components	ASTM D3776	1 test per 100,000 ft^2 (9,290 m^2)

Note: Testing will be carried out at a frequency of one per lot or at listed frequency, whichever is less.

TABLE 7

TEST PROCEDURES FOR THE EVALUATION OF SOILS

Area 4 Expansion
Tomoka Farms Road Class I North Cell Phase II Landfill

TEST STANDARD	TO DETERMINE	TEST METHOD
Laboratory Test Procedures		
Classification	Classification of Soils	ASTM D2487
Moisture Content	Moisture Content	ASTM D2216
Standard Proctor	Moisture/Density Relationship of Soil (5.5-lb (2.49-kg) rammer and 12-in. (305-mm) drop)	ASTM D698
Atterberg Limits	Liquid Limit and Plastic Limit	ASTM D4318
Hydrometer Analysis	Particle Size Distribution of Fine Fraction of Soils	ASTM D422
Sieve Analysis	Particle Size Distribution of Coarse Fraction of Soils	ASTM D422
Sieve Analyses	Particle Size Distribution of Fine and Coarse Aggregates	ASTM C136
Permeability (Flexible Wall Permeameter)	Permeability of Soils	ASTM D5084
Permeability (Rigid Wall Permeameter)	Permeability of Aggregates	ASTM D2434
Calcium Carbonate Content	Percent of Calcium Carbonate in Soils	ASTM D4373
Field Test Procedures:		
Classification	Classification of Soils	ASTM D2488
Nuclear Densometer	In Situ: Soil Density / Moisture Content	ASTM D2922 / ASTM D3017

TABLE 8

MINIMUM SOILS TESTING FREQUENCIES FOR MATERIALS EVALUATION (CONFORMANCE) BEFORE CONSTRUCTION

Area 4 Expansion
Tomoka Farms Road Class I North Cell Phase II Landfill

TEST	SUBBASE	LEACHATE COLLECTION GRAVEL	PROTECTIVE COVER	STRUCTURAL FILL
Moisture Content	1 per 2,500 yd^3 (minimum 1 per source)	---	---	1 per 2,500 yd^3 (minimum 1 per source)
Sieve Analysis	1 per 6,500 yd^3 (minimum 1 per source)	1 per 6,500 yd3 (minimum1 per source)	1 per 6,500 yd^3 (minimum 1 per source)	1 per 6,500 yd^3 (minimum 1 per source)
Atterberg Limits	1 per 6,500 yd^3 (minimum 1 per source)	---	---	1 per 6,500 yd^3 (minimum 1 per source)
Standard Proctor	1 per 6,500 yd^3 (minimum 1 per source)	---	---	1 per 6,500 yd^3 (minimum 1 per source)
Hydraulic Conductivity	1 per 13,000 yd^3 (minimum 1 per source)	1 per 10,000 yd^3 (minimum 1 per source)	1 per 10,000 yd^3 (minimum 1 per source)	---

TABLE 9

MINIMUM SOILS TESTING FREQUENCIES DURING CONSTRUCTION

Area 4 Expansion
Tomoka Farms Road Class I North Cell Phase II Landfill

TEST	LOW PERMEABILITY SOIL	SUBBASE	STRUCTURAL FILL
In-Situ Moisture Content	1 per 100 lineal ft or 1 per acre per lift	1 per acre per lift	1 per acre per lift
In-Situ Density	1 per 100 lineal ft or 1 per acre per lift	1 per acre per lift	1 per acre per lift
Hydraulic Conductivity	1 per source discretionary	-----	-----

Note 1. Hydraulic conductivity of subbase is not required since GCL is used.

FIELD CQA FORMS

Date _____

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TRIAL SEAM REPORT

PROJECT NAME	TECHNICIAN
PROJECT NO.	GEOMEMBRANE TYPE
INSTALLER	

Date/ Time	Ambient Temp.	Seamer Name	Machine Number	Extrusion Welds				Fusion Welds					Peel/Shear Values Lbs/Inch			Pass/ Fail	Comments
				Barrel Temp.		Preheat Temp.		NIP Roller Spacing	Wedge Temp.		Measured Speed Ft/Min.	Speed Setting					
				Set	Actual	Set	Actual		Set	Actual							

Date _____
Page ____ Of ____

GEOMEMBRANE REPAIRS

Repair Number	Date Repaired	Seam Panel or Repair	Location	Defect Type	Size of Repair	Date Tested

DEFECT TYPES

BO = fusion welder burn out
MD = manufacturer damaged
DS-# = fusion weld destruct
T = three panel intersection
FM = fishmouth
WS = welder restart
IO = insufficient overlap
D = installation damage
SI = soil surface irregularity
EXT = liner extension
WR = wrinkle
CR = crease
PT = pressure test cut
DX - #:extrusion weld destruct
VL = vacuum test leak
FS = failed seam length

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Date _____

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REPORT OF IN-PLACE DENSITY TESTS

PROJECT NAME	TECHNICIAN
PROJECT NO.	ASTM Field Test Method Used
Compaction Requirement	ASTM Laboratory Test Method Used

Test No.	Field Location of Test	Depth or Elevation	Lab Test Results			Field Test Results					Remarks
			Sample No.	Max. Dry Density (pcf)	Opt. Moisture (%)	Wet Density (pcf)	Dry Density (pcf)	Lab Moisture (%)	Compaction (%)	Pass/ Fail	

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GEOMEMBRANE DESTRUCTIVE SAMPLE LOCATIONS

Destructive Sample Number	Date Sampled	Date Seamed	Seam Number	Location	Welder	Unit Number	Results		
							Third-Party Lab	Installers Lab	Comment

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PROJECT NAME	TECHNICIAN
PROJECT NO.	GEOMEMBRANE TYPE
INSTALLER	

Date/ Time	Ambient Temp.	Seamer Name	Machine Number	Temperature Setting	Machine Speed	Peel/Shear Values Lbs/Inch					Pass/ Fail	Comments

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CQA PANEL INSPECTION FORM

PROJECT NAME	PANEL NO.
PROJECT NO.	GEOMEMBRANE TYPE
CONTRACTOR	INSTALLER
DATE PLACED	SUBGRADE CONDITION
WEATHER CONDITIONS	
DEPLOYMENT METHOD	

SHOW PROJECT NORTH

Panel No.: _____

Date	Defect	Defect Description	Repair Date	Repair Type	Approved By

Panel Length	Technician Comments
Panel Width	
Panel Area	
Roll Number	

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DESTRUCTIVE SEAM EVALUATION

PROJECT NAME	**TECHNICIAN**
PROJECT NO.	**GEOMEMBRANE TYPE**
INSTALLER	**DATE SAMPLED**
DESTRUCTIVE SAMPLE NO.	**SEAM NO.**
SEAM TYPE	**DATE TESTED**

PEEL ADHESION					BONDED SHEAR RESISTANCE				
Specimen Number	Load at Yield (lbs/in)	Failure Description	Pass/ Fail	Retest	Specimen Number	Load at Yield (lbs/in)	Failure Description	Pass /Fail	Retest
AVERAGE					AVERAGE				

Checked by: _____	Checked by: _____
Check One: ☐ Seam Qualified ☐ Seam Disqualified	Check One: ☐ Seam Qualified ☐ Seam Disqualified

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CQA SEAM INSPECTION FORM

PROJECT NAME	SEAM NO.
PROJECT NO.	SEAM LENGTH
CONTRACTOR	COMMENTS
INSTALLER	
WELDING TECH.	
TYPE OF WELDER	WELDING UNIT NO.
DATE WELDED	TIME WELDED

QUALITY ASSURANCE SUMMARY

1. VACUUM BOX TEST

Zone	Length	Date Tested	QC Technicians Initials	Number of Defects Found	Date Repairs Made	Date Retested	Date Inspected and Approved

2. AIR PRESSURE TESTING

Start	Start Pressure (psi)	End Time	End Pressure (psi)	Zone	Length (feet)	Pressure Loss (psi)	Approved (Y/N)	If No, Corrective Action	Approved By

LEGEND

	Zone 1 Air Pressure Zone
	Repair Needed
	Repair Completed
	Repair Tested
	Repair Approved
	Destructive Sample
	Cap Strip Repair

3. SEAM REPAIRS (PATCHES)

Repair No.	Defect Type	Date/NDT Type	Approved By

Panel No. ____ Panel No. ____

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CQA SEAM INSPECTION FORM

PROJECT NAME	SEAM NO.
PROJECT NO.	SEAM LENGTH
CONTRACTOR	COMMENTS
INSTALLER	
WELDING TECH.	
TYPE OF WELDER	WELDING UNIT NO.
DATE WELDED	TIME WELDED

QUALITY ASSURANCE SUMMARY

1. VACUUM BOX TEST

Zone	Length	Date Tested	QC Technicians Initials	Number of Defects Found	Date Repairs Made	Date Retested	Date Inspected and Approved

2. AIR PRESSURE TESTING

Start	Start Pressure (psi)	End Time	End Pressure (psi)	Zone	Length (feet)	Pressure Loss (psi)	Approved (Y/N)	If No, Corrective Action	Approved By

LEGEND

	Zone 1 Air Pressure Zone
	Repair Needed
	Repair Completed
	Repair Tested
	Repair Approved
	Destructive Sample
	Cap Strip Repair

3. SEAM REPAIRS (PATCHES)

Repair No.	Defect Type	Date/NDT Type	Approved By

Panel No. ____ Panel No. ____

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(*Soils Engineer or Testing Service Letterhead)*

Subgrade Acceptability Certification No.

Project Name:	Regulatory Agency Project No. (if applicable):
Project Owner:	Subgrade Location:
HDR Project No.:	Date:
Owner's Project No. (if applicable)	Time:

I, _____, having examined the subgrade area referenced above, do certify that said area is properly prepared and is in suitable condition for construction to continue.

Comments:

_____

Designated Soils Lab Representative

Date _____

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GEOMEMBRANE PANEL PLACEMENT SUMMARY

Date	Time	Panel Number	Roll Number	Length (feet)	Width (feet)	Thickness (Mils)					Comments

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Date _____

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GEOMEMBRANE SEAMING SUMMARY

Seam Number	Date Seamed	Panel Numbers	Seam Length (Ft)	Seamer Initials	Machine Number	Temp. Setting	Time		Ambient Temp.		Comments
							Start	Finish	Start	Finish	

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