

**CONSTRUCTION QUALITY ASSURANCE PLAN
FOR THE
CONSTRUCTION OF
THE
CORRECTIVE ACTION MANAGEMENT UNIT
BASIC REMEDIATION COMPANY
HENDERSON, NEVADA**

Prepared for:



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C O M P A N Y

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1. INTRODUCTION

1.1 Terms of Reference

Geosyntec Consultants (Geosyntec) has prepared this Construction Quality Assurance (CQA) Plan for the construction of the Corrective Action Management Unit (CAMU) for Basic Remediation Company (BRC) located in Henderson, Nevada. Hereinafter, the CAMU construction is referred to as the Project.

This CQA Plan was prepared by Ms. Rebecca Flynn of Geosyntec Consultants (Geosyntec) under the direction of Mr. Gregory T. Corcoran, P.E. in general accordance with the peer review policies of the firm.

1.2 Purpose and Scope of the Construction Quality Assurance Plan

The purpose of the CQA Plan is to address the CQA procedures and monitoring requirements for construction of the Project. The CQA Plan is intended to: (i) define the responsibilities of parties involved with the construction; (ii) provide guidance in the proper construction of the major components of the Project; (iii) establish testing protocols; (iv) establish guidelines for construction documentation; and (v) provide the means for assuring that the Project is constructed in conformance to the *Technical Specifications*, permit conditions, applicable regulatory requirements, and *Construction Drawings*.

This CQA Plan addresses the soils and geosynthetic components of the liner and cover systems, the placement of the waste within the CAMU, and the installation of storm water controls for the project. The soils, geosynthetic, and appurtenant components include engineered fill, prepared subgrade, operations layer material, drainage aggregate, geosynthetic clay liner, geomembrane, geotextile, geocomposite, polyethylene pipe, cover soil, and corrugated polyethylene (CPE) pipe. It should be emphasized that care and documentation are required in the placement and compaction of the soils and aggregate and in the production and installation of the geosynthetic materials placed during construction. The storm water controls include subgrade preparation, pipe trench excavation and backfill, and cast-in-place concrete installation. The CQA Plan, therefore, delineates the procedures to be followed for monitoring construction of these materials.

The CQA protocols applicable to manufacturing, shipping, handling, and installing all geosynthetic materials are also included. However, this CQA Plan does not specifically address either installation specifications or specification of soils, geosynthetic materials, or cast-in-place concrete as these requirements are addressed in the *Technical Specifications*.

1.3 References

The CQA Plan includes references to test procedures in the latest editions of the American Society for Testing and Materials (ASTM), American Concrete Institute (ACI), and American Association of State Highway and Transportation Officials (AASHTO).

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 the responsibilities of the CQA personnel;
- Section 5 describes site and project control requirements;
- Section 6 presents CQA documentation;
- Section 7 presents CQA of earthworks and waste placement;
- Section 8 presents CQA of the drainage aggregates;
- Section 9 presents CQA of the pipe and fittings;
- Section 10 presents CQA of the geomembrane;
- Section 11 presents CQA of the geotextile;
- Section 12 presents CQA of the geosynthetic clay liner;
- Section 13 presents CQA of the geocomposite;
- Section 14 presents CQA of the cast-in-place concrete; and
- Section 15 presents CQA surveying.

2. DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE

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

Construction Quality Assurance (CQA) - A planned and systematic pattern of means and actions designed to assure adequate confidence that materials and/or services meet contractual and regulatory requirements and will perform satisfactorily in service.

Construction Quality Control (CQC) - Those actions which provide a means to measure and regulate the characteristics of an item or service in relation to contractual and regulatory requirements.

In the context of this document:

- CQA refers to means and actions employed by the CQA Consultant to assure conformity of the Project “Work” with this CQA Plan, the *Construction Drawings*, and the *Technical Specifications*.
- Construction Quality Control refers to those actions taken by the Contractor, Manufacturer, or Geosynthetic Installer to verify that the materials and the workmanship meet the requirements of this CQA Plan, the *Construction Drawings*, and the *Technical Specifications*. In the case of soil components, CQC is combined with CQA and is provided by the CQA Consultant. In the case of the geosynthetic components and piping of the Work, CQC is provided by the Manufacturer and Geosynthetic Installer and the Contractor. CQA testing of soil, pipe, and geosynthetic components is provided by the CQA Consultant.

3. PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE

3.1 Engineer

Responsibilities

The Engineer is responsible for the design, *Construction Drawings*, and *Technical Specifications* for the Project Work. In this CQA Plan, the term “Engineer” refers to Geosyntec.

Qualifications

The Engineer of Record shall be a qualified engineer, registered as required by Nevada state regulations. The Engineer should have expertise, which demonstrates significant familiarity with piping, geosynthetics and soils, as appropriate, including design and construction experience related to landfill liner systems.

3.2 Construction Manager

Responsibilities

The Construction Manager is responsible for implementing the construction, and overseeing subcontractors. In this CQA Plan, the term “Construction Manager” refers to a Weston Solutions, Inc (Weston).

Qualifications

The Construction Manager shall be a qualified engineer having familiarity with earthwork construction and installation of geosynthetic materials.

3.3 **Contractor**

Responsibilities

In this CQA Plan, Contractor refers to an independent party or parties, contracted by the Owner, performing the Work in general accordance with this CQA Plan, the *Construction Drawings*, and the *Technical Specifications*. The Contractor will be responsible for the installation of the soils and geosynthetic components of the liner systems, as well as the placement of the waste within the CAMU. This work will include excavation, placement and compaction of engineered fill and prepared subgrade, placement of drainage aggregate and operations layer material, installation of piping, installation of temporary erosion control features, and coordination of work with the Geosynthetic Installer and other subcontractors.

The Contractor will be responsible for constructing the liner system and appurtenant components in general accordance with the *Construction Drawings* and complying with the quality control requirements specified in the *Technical Specifications*.

Qualifications

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

3.4 **Resin Supplier**

Responsibilities

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

Qualifications

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

3.5 Geosynthetics Manufacturer

Responsibilities

The Manufacturer is responsible for the production of finished material (geomembrane, geotextile, geosynthetic clay liner, geocomposite, pipe, and other specified material) from appropriate raw materials.

Qualifications

The Manufacturer(s) will be able to provide sufficient production capacity and qualified personnel to meet the demands of the project. The Manufacturer(s) must be a well established firm(s) that meet the requirements identified in the *Technical Specifications*.

3.6 Geosynthetic Installer

Responsibilities

The Geosynthetic Installer is responsible for field handling, storage, placement, seaming, loading or anchoring against wind uplift, and other aspects of the geosynthetic material installation. The Geosynthetic Installer may also be responsible for specialized construction tasks (i.e., including construction of anchor trenches for the geosynthetic materials).

Qualifications

The Geosynthetic Installer will be trained and qualified to install the geosynthetic materials of the type specified for this project. The Geosynthetic Installer shall meet the qualification requirements identified in the *Technical Specifications*.

3.7 **CQA Consultant**

Responsibilities

The CQA Consultant is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, who is responsible for observing, testing, and documenting activities related to the CQC and CQA of the earthwork, piping, and the geosynthetic components used in the construction of the Project. The CQA Consultant will also be responsible for issuing a CQA report at the completion of the Project construction, which details the earthworks, piping, and geosynthetic installation activities and associated CQA activities. The CQA report will be signed and sealed by the CQA Officer who will be a Professional Engineer registered in the State of Nevada.

The CQA Consultant will be responsible for obtaining and testing representative samples of all components used in construction of the Project as required by this CQA Plan and *Technical Specifications*. All tests will be conducted in general accordance with ASTM or other applicable state or federal standards. Test results must be submitted to the Construction Manager within a reasonable timeframe, which will not impede or delay construction of the Project. The CQA Consultant will be responsible for inspecting all earthwork, piping, geosynthetic, and cast-in-place concrete operations to verify that the components are installed in general accordance with this CQA Plan and *Technical Specifications*.

Qualifications

The CQA Consultant is a well established firm specializing in geotechnical and geosynthetic engineering and possess the equipment, personnel, and licenses necessary to conduct the geotechnical and geosynthetic tests required by the project plans and *Technical Specifications*. The CQA Consultant will provide qualified staff for the project, as necessary, which will include, at a minimum, a CQA Officer, and a CQA Site Manager. The CQA Officer will be a professionally licensed engineer as required by Nevada State regulations.

The CQA Consultant will be experienced with earthwork construction, the installation of geosynthetic materials, and cast-in-place concrete installation similar to

those materials used in construction of the Project. The CQA Consultant will be experienced in the preparation of CQA documentation including CQA Plans, field documentation, field testing procedures, laboratory testing procedures, construction specifications, construction drawings, and CQA reports.

The CQA Site Manager will be specifically familiar with the construction of earthworks, piping, and the installation of geosynthetic materials and will be trained by the CQA Consultant in the duties of a CQA Site Manager.

3.8 Surveyor

Responsibilities

The Surveyor is a party, independent from the Contractor, Manufacturer, and Geosynthetic Installer, that is responsible for surveying, documenting, and verifying the location of all significant components of the Work. The Surveyor's work is coordinated and employed by the Contractor. The Surveyor is responsible for issuing record drawings of the construction.

Qualifications

The Surveyor will be a well established surveying company with at least 3 years experience in the profession of surveying services in the State of Nevada. The Surveyor will be a licensed professional as required by the State of Nevada regulations. The Surveyor shall be fully equipped and experienced in the use of total stations and AutoCAD Version 2004. All surveying will be performed under the direct supervision of the Contractor.

3.9 CQA Laboratory

Responsibilities

The CQA Laboratory is a party, independent from the Contractor, Manufacturer and Geosynthetic Installer, that is responsible for conducting tests in general accordance with ASTM and other applicable test standards on samples of

geosynthetic materials, soil, and in the field and in either an on-site or off-site laboratory.

Qualifications

The CQA Laboratory will have experience in testing soils and geosynthetic materials and will be familiar with ASTM and other applicable test standards. The CQA Laboratory will be capable of providing test results within a maximum of seven days of receipt of samples and will maintain that capability throughout the duration of earthworks construction and geosynthetic materials installation. The CQA Laboratory will also be capable of transmitting geosynthetic destructive test results within 24 hours of receipt of samples and will maintain that capability throughout the duration of geosynthetic material installation.

4. CQA CONSULTANTS PERSONNEL ORGANIZATION AND DUTIES

4.1 Overview

The CQA Officer will provide supervision within the scope of work of the CQA Consultant. The scope of work for the CQA Consultant includes monitoring of construction activities including the following:

- excavation and screening of materials;
- placement and compaction of engineered fill, prepared subgrade, operations layer material, and cover soil;
- installation of geotextile;
- installation of geosynthetic clay liner;
- installation of geomembrane;
- installation of drainage aggregate;
- installation of geocomposite;
- installation of concrete;
- installation of piping; and
- placement and compaction of waste materials within the CAMU.

The duties of the CQA personnel are discussed in the remainder of this section.

4.2 **CQA Personnel**

For construction of the Project, the CQA Consultant's personnel will include:

- the CQA Officer, who operates from the office of the CQA Consultant and who conducts periodic visits to the site as required; and
- the CQA Site Manager, who is located at the site.

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

4.2.1 **CQA Officer**

The CQA Officer shall supervise and be responsible for monitoring and CQA activities relating to the construction of the earthworks, piping, installation of the geosynthetic materials, and cast-in-place concrete of the Project. Specifically, the CQA Officer:

- reviews the project design, this CQA Plan, *Construction Drawings*, and *Technical Specifications*;
- reviews other site-specific documentation; unless otherwise agreed, such reviews are for familiarization and for evaluation of constructability only, and hence the CQA Officer and the CQA Consultant assume no responsibility for the liner system design;
- reviews and approves the Geosynthetic Installer's QC Plan;
- attends resolution and/or pre-construction meetings as needed;
- administers the CQA program (i.e., provides supervision of and manages on-site CQA personnel, reviews field reports, and provides engineering review of CQA related activities);

- provides quality control of CQA documentation and conducts site visits;
- reviews the record drawings;
- **is a licensed engineer in the State of Nevada and shall stamp the final CQA report;** and
- with the CQA Site Manager, prepares the CQA report documenting that the project was constructed in general accordance with the Construction Documents.

4.2.2 CQA Site Manager

The CQA Site Manager:

- acts as the on-site representative of the CQA Consultant;
- attends CQA-related meetings (e.g., resolution, pre-construction, daily, weekly (or designates a representative to attend the meeting));
- prepares or oversees the ongoing preparation of the record drawings;
- reviews test results provided by Contractor;
- assigns locations for testing and sampling;
- oversees the collection and shipping of laboratory test samples;
- reviews results of laboratory testing and makes appropriate recommendations;
- reviews the calibration and condition of on-site CQA equipment;
- prepares a daily summary report for the project;

- reviews the Manufacturer's QC documentation;
- reviews the Geosynthetic Installer's personnel Qualifications for conformance with those pre-approved for work on site;
- notes in the daily summary report and reports to the CQA Officer and Construction Manager on-site activities that could result in damage to the geosynthetic materials or other completed work;
- reports unresolved deviations from the CQA Plan, *Construction Drawings*, and *Technical Specifications* to the Construction Manager; and
- assists with the preparation of the CQA report.

5. SITE AND PROJECT CONTROL

5.1 Project Coordination Meetings

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. Several types of Project Coordination Meetings are described below, including: (i) resolution meetings; (ii) pre-construction meetings; (iii) progress meetings; and (iv) problem or work deficiency meetings.

5.1.1 Resolution Meeting

Following the completion of the design, *Construction Drawings*, and *Technical Specifications* for the project and prior to the start of construction, a Resolution Meeting will be held. This meeting may include the CQA Officer, the CQA Site Manager, the Engineer, and the Construction Manager.

The purpose of this meeting is to begin planning for coordination of construction tasks, anticipate installation problems which might cause difficulties and delays in construction, and, above all, present the CQA Plan to the parties involved. It is very important that the criteria regarding testing, repair, and other CQA activities be known and accepted by the parties involved in the work prior to the installation of geosynthetic materials and construction of the soil components for the Project.

The first part of the Resolution Meeting may be devoted to a review of the *Construction Drawings* and *Technical Specifications* for familiarity. This is different from the peer review of the design, including design calculations, which will have been carried out previously.

The Resolution Meeting may include the following activities:

- distribute relevant documents to all parties;
- review critical design details of the project;

- review this CQA Plan;
- review the *Construction Drawings* and *Technical Specifications*;
- make appropriate modifications to the design criteria, *Construction Drawings*, and *Technical Specifications* so that the fulfillment of the 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 evaluating acceptability of the soils and geosynthetic materials;
- assign the responsibilities of each party;
- establish work area security and health and safety protocol;
- confirm the methods for documenting observations, reporting, and distributing documents and reports; and
- confirm the lines of authority and communication.

The Construction Manager will appoint one of the meeting attendees to record the discussions and decisions of the Resolution Meeting. The record of the meeting will be documented by the appointee in the form of meeting minutes, which will be subsequently distributed to all attendees.

5.1.2 Pre-Construction Meeting

A Pre-Construction Meeting will be held at the site prior to construction of the Project. As a minimum, the Pre-Construction Meeting will be attended by the Contractor, the Geosynthetic Installer's Superintendent, the CQA Consultant, the Engineer, and the Construction Manager.

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

- appropriate modifications or clarifications to the CQA Plan;
- the Construction Drawings and Technical Specifications;
- the responsibilities of each party;
- lines of authority and communication;
- methods for documenting and reporting, and for distributing documents and reports;
- acceptance and rejection criteria;
- protocols for testing;
- protocols for handling deficiencies, repairs, and re-testing;
- the time schedule for all operations;
- procedures for packaging and storing archive samples;
- panel layout and numbering systems for panels and seams;
- seaming procedures;
- repair procedures; and
- soil stockpiling locations.

The Construction Manager will conduct a site tour to observe the current site conditions and to review construction material and equipment storage locations. A person in attendance at the meeting will be appointed by the Construction Manager to record the discussions and decisions of the meeting in the form of meeting minutes. Copies of the meeting minutes will be distributed to all attendees.

5.1.3 Progress Meetings

Progress meetings will be held between the CQA Site Manager, the Contractor, Construction Manager, and other concerned parties participating in the construction of the project. This meeting will include discussions on the current progress of the project, planned activities for the next week, and revisions to the work plan and/or schedule. The meeting will be documented in meeting minutes prepared by a person designated by the CQA Site Manager at the beginning of the meeting. Within 2 working days of the meeting, draft minutes will be transmitted to representatives of parties in attendance for review and comment. Corrections and/or comments to the draft minutes shall be made within 2 working days of receipt of the draft minutes to be incorporated in the final meeting minutes.

5.1.4 Problem or Work Deficiency Meeting

A special meeting will be held when and if a problem or deficiency is present or likely to occur. The meeting will be attended by the Contractor, the Construction Manager, the CQA Site Manager, and other parties as appropriate. If the problem requires a design modification, the Engineer should either be present at, consulted prior to, or notified immediately upon conclusion of this meeting. The purpose of the work deficiency 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 agreeable to all parties; and
- implement an action plan to resolve the problem or deficiency.

The Construction Manager will appoint one attendee to record the discussions and decisions of the meeting. The meeting record will be documented in the form of meeting minutes and copies will be distributed to all affected parties. A copy of the minutes will be retained in facility records.

6. DOCUMENTATION

6.1 Overview

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. The CQA Consultant will document that all quality assurance requirements have been addressed and satisfied.

The CQA Site Manager will provide the Construction Manager with signed descriptive remarks, data sheets, and logs to verify that monitoring activities have been carried out. The CQA Site Manager will also maintain, at the job site, a complete file of *Construction Drawings* and *Technical Specifications*, a CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

6.2 Daily Recordkeeping

Preparation of daily CQA documentation will consist of daily reports prepared by the CQA Site Manager which may include CQA monitoring logs, and testing data sheets. This information may be regularly submitted to and reviewed by the Construction Manager.

The CQA Site Manager will prepare daily reports that document the activities observed during each day of activity. The daily reports may include monitoring logs and testing data sheets. At a minimum, these logs and data sheets will include the following information:

- the date, project name, location, and other identification;
- a summary of the weather conditions;
- a summary of locations where construction is occurring;
- equipment and personnel on the project;

- a summary of meetings held and attendees;
- a description of materials used and references of results of testing and documentation;
- identification of deficient work and materials;
- results of re-testing corrected “deficient work;”
- an identifying sheet number for cross referencing and document control;
- descriptions and locations of construction inspected;
- type of construction and inspection performed;
- description of construction procedures and procedures used to evaluate construction;
- a summary of test data and results;
- calibrations or re-calibrations of test equipment and actions taken as a result of re-calibration;
- decisions made regarding acceptance of units of work and/or corrective actions to be taken in instances of substandard testing results;
- a discussion of agreements made between the interested parties which may affect the work; and
- signature of the respective CQA Site Manager.

6.3 **Construction Problems and Resolution Data Sheets**

Construction Problems and Resolution Data Sheets, to be submitted with the daily reports prepared by the CQA Site Manager, describing special construction situations will be cross-referenced with daily reports, specific observation logs, and testing data sheets and will 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 responses;
- measures taken to prevent a similar situation from occurring in the future; and
- signature of the CQA Site Manager and a signature indicating concurrence by the Construction Manager.

The Construction Manager will be made aware of significant recurring nonconformance with the *Construction Drawings*, *Technical Specifications*, or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications will be recommended. 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 Contractor and Engineer.

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

6.4 Photographic Documentation

Photographs will be taken and documented in order to serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints. Electronic records will be presented to the Construction 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). Photographs used for documentation will be identified with the date, time, and location of the photograph.

6.5 Design and/or Specifications Changes

Design and/or specifications changes may be required during construction. In such cases, the CQA Site Manager will notify the Construction Manager. Design and/or specification changes will be made with the written agreement of the Construction Manager and the Engineer and will take the form of an addendum to the *Construction Drawings* and *Technical Specifications*.

6.6 CQA Report

At the completion of the Project, the CQA Consultant will submit to the Construction Manager the CQA report signed and sealed by the Professional Engineer licensed in the State of Nevada. The CQA report will acknowledge: (i) that the work has been performed in **substantial** compliance with the *Construction Drawings* and *Technical Specifications*; (ii) physical sampling and testing has been conducted at the appropriate frequencies; and (iii) that the summary document provides the necessary supporting information. At a minimum, this report will include:

- Manufacturers' quality control documentation;
- a summary report describing the CQA activities and indicating compliance with the *Construction Drawings* and *Technical Specifications* which is signed and sealed by the CQA Officer;
- a summary of CQA/CQC testing, including failures, corrective measures, and retest results;
- contractor personnel resumes and qualifications;
- documentation that the geomembrane trial seams were performed in general accordance with the CQA Plan and *Technical Specifications*;
- documentation that field seams were non-destructively tested using a method in general accordance with the applicable test standards;
- documentation that nondestructive testing was monitored by the CQA Consultant, that the CQA Consultant informed the Geosynthetic Installer of any required repairs, and that the CQA Consultant inspected the seaming and patching operations for uniformity and completeness;
- records of sample locations, the name of the individual conducting the tests, and the results of tests;
- record drawings as provided by the Surveyor;
- documentation showing that piping was tested in general accordance with the *Technical Specifications*; and
- daily inspection reports.

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). Base maps required for

development of the record drawings and the record drawings will be prepared by a qualified Professional Land Surveyor registered in the State of Nevada. These documents will be reviewed by the CQA Consultant and included as part of the CQA Report.

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7. EARTHWORKS AND WASTE PLACEMENT

7.1 Introduction

This section prescribes the CQA activities to be performed to monitor that earthwork components are constructed in general accordance with *Construction Drawings* and *Technical Specifications*. In addition, this section describes the CQA activities to be performed to monitor that waste materials are placed appropriately. The earthworks construction procedures to be monitored by the CQA Consultant include:

- excavation and stockpiling;
- engineered fill placement;
- anchor trench excavation and backfill;
- storm water pipe excavation and backfill;
- subgrade preparation;
- operations layer material placement;
- waste placement; and
- cover soil placement.

7.2 Testing Activities

Soil testing will be performed for material qualification, material conformance, and construction quality control (CQC). These three stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed soil source to the material specifications for qualification of the source prior to construction.
- Soils conformance testing is used to evaluate the conformance of a particular batch of soil from a qualified source to the material specifications prior to installation of the soil.
- CQC tests are performed on completed portions of the earthwork and waste placement during construction to demonstrate that the

placement procedures are resulting in a product that meets or exceeds both material and performance specifications.

The Contractor will be responsible for submitting material qualification test results to the Construction Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing, ~~and CQC testing~~. Soil and waste testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) and American Association of State Highway and Transportation Officials (AASHTO) test procedures. The test methods indicated in Table 1 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

7.2.1 Sample Frequency

The frequency of soils testing for material qualification will conform to the minimum frequencies presented in Table 2. The frequency of soils testing for material conformance will conform to the minimum frequencies presented in Table 3. The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

7.2.2 Sample or Test Location Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make soil available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed soil materials.

CQC sample and test locations will be selected by the CQA Site Manager at the minimum test frequency specified in Table 4. Samples and test locations will

generally be selected at random, however a special testing frequency will be used at the discretion of the CQA Site Manager when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- rollers slip during rolling operation;
- lift thickness is greater than specified;
- fill is at improper and/or variable moisture content;
- less than specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- rollers may not have used optimum ballast;
- fill materials differ substantially from those specified;
- the degree of compaction is doubtful; and
- as directed by the Construction Manager or the CQA Site Manager.

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;
- material fails to meet specifications; and
- the work area is reduced.

7.3 CQA Monitoring Activities

7.3.1 Earthwork and Waste Placement

The CQA Site Manager will monitor and document the earthworks required for the Project. In general, monitoring the construction for earthwork includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;

- monitoring the prepared subgrade and subgrade surfaces for compliance with the *Technical Specifications* before geosynthetic materials are placed;
- sampling and testing for conformance of the materials to the *Technical Specifications*;
- documenting that the earthwork is constructed using the specified equipment and procedures;
- documenting that the earthwork is constructed to the lines and grades shown on the *Construction Drawings*;
- monitoring that the construction activities do not cause damage to underlying geosynthetic materials;
- quality control testing to determine the acceptability of the work during construction;
- monitoring that waste placement, grading, compaction, and moisture condition meet the requirements outlined in the *Technical Specifications*; and
- monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking, etc.).

The specific activities required for CQA of each of the major soil components of the Liner System are presented in the following sections.

7.3.2 Engineered Fill Material

Monitoring the earthwork for the engineered fill material specifically includes the following:

- reviewing documentation of the qualification and conformance test results;
- monitoring soil for maximum particle size and deleterious materials;
- monitoring the thickness of lifts during placement of the materials;
- monitoring compaction operations; and
- measuring and recording the field density and the field moisture content of the in-place material.

7.3.3 Prepared Subgrade

During construction, the CQA Site Manager will monitor the prepared subgrade to document that the prepared subgrade soil characteristics are consistent with those specified in the *Technical Specifications*. The CQA Site Manager will monitor the construction activities to document that sharp rocks and other undesirable materials are removed and that the subgrade is prepared using the procedures and equipment specified in the *Technical Specifications*.

The upper portion of the subgrade can be damaged by excess moisture (causing softening) or insufficient moisture (causing desiccation and shrinkage). At a minimum, the CQA Site Manager will determine the suitability of the subgrade for geomembrane placement by:

- documenting that the surface is free of sharp rocks, debris and other undesirable materials;
- documenting that the surface is smooth, uniform, and free from desiccation cracks by visually monitoring proof rolling activities; and
- documenting that the subgrade surface meets the lines and grades shown on the *Construction Drawings* by reviewing certified survey results.

7.3.4 Operations Layer Material

The CQA Site Manager will monitor the earthwork of the operations layer material for the following:

- the Contractor's submittals and qualification test results for consistency between the proposed methods and the approved methods;
- the conformance testing of the material and notifying the Contractor of results for compliance with material specifications;
- the thickness of lifts during placement;
- the placement equipment operation on the sideslopes is in general accordance with the *Technical Specifications*;
- placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials;
- the construction procedures to monitor that completed sections of liner and geomembrane are protected from damage; and
- the survey data to monitor that operations layer material is constructed to the proposed lines and grades and to the specified thickness.

7.3.5 Waste Material

The CQA Site Manager will monitor the waste placement and daily slit trench cover soil material for the following:

- monitoring the type and size of waste materials being placed;
- monitoring the moisture content of the waste materials being placed;

- monitoring the thickness of lifts during placement of the materials;
- **monitor the distance between slit trench wastes and debris and the both the base and side slope liner system;**
- monitoring compaction operations; and
- measuring and recording the field density and the field moisture content of the in-place waste materials.

7.3.6 Interim Cover Soil Material

The CQA Site Manager will monitor the earthwork for the interim cover soil material for the following:

- reviewing documentation of the qualification and conformance test results;
- monitoring soil for maximum particle size and deleterious materials;
- monitoring compaction operations; and
- measuring and recording the field density and the field moisture content of the in-place material.

7.3.7 Cover Soil Material

The CQA Site Manager will monitor the earthwork for the cover soil material for the following:

- reviewing documentation of the qualification and conformance test results;
- monitoring soil for maximum particle size and deleterious materials;

- monitoring the thickness of lifts during placement of the materials;
- monitoring compaction operations; and
- measuring and recording the field density and the field moisture content of the in-place material.

7.3.8 Aggregate Base

The CQA Site Manager will monitor the earthwork for the aggregate base material for the following:

- reviewing documentation of the qualification and conformance test results;
- monitoring soil for maximum particle size and deleterious materials;
- monitoring the thickness of lifts during placement of the materials;
- monitoring compaction operations; and
- monitoring soil for maximum particle size and deleterious materials.

7.4 Deficiencies

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

7.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Construction Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

7.4.2 Repairs and Re-Testing

At locations where the field testing indicates densities below the requirements of the specification, the failing area will be reworked. **Additional tests shall be taken at half the distance to the next passing test. If the retest has failed, half the distance from the retest to the passing test shall be tested, and continue until the test passes. If a test passes, half the distance from the passing retest to the failed test shall be considered failed.**

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

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

8. DRAINAGE AGGREGATE

8.1 Introduction

This section prescribes the CQA activities to be performed to monitor that drainage aggregates are constructed in general accordance with *Construction Drawings* and *Technical Specifications*. The drainage aggregates construction procedures to be monitored by the CQA Consultant include drainage aggregate placement.

8.2 Testing Activities

Aggregate testing will be performed for material qualification and material conformance. These two stages of testing are defined as follows:

- Material qualification tests are used to evaluate the conformance of a proposed aggregate source to the material specifications for qualification of the source prior to construction.
- Aggregate conformance testing is used to evaluate the conformance of a particular batch of aggregate from a qualified source to the material specifications prior to installation of the aggregate.

The Contractor will be responsible for submitting material qualification test results to the Construction Manager and to the CQA Site Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Aggregate testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in Table 5 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

8.2.1 Sample Frequency

The frequency of aggregate testing for material qualification will conform to the minimum frequencies presented in Table 6. The frequency of aggregate testing for material conformance will conform to the minimum frequencies presented in Table 7. The actual frequency of testing required will be increased by the CQA Site Manager as necessary if variability of materials is noted at the site, during adverse conditions, or to isolate failing areas of the construction.

8.2.2 Sample Selection

With the exception of qualification samples, sampling locations will be selected by the CQA Site Manager. Conformance samples will be obtained from borrow pits and/or stockpiles of material. The Contractor must plan the work and make aggregate available for sampling in a timely and organized manner so that the test results can be obtained before the material is installed. The CQA Site Manager must document sample locations so that failing areas can be immediately isolated. The CQA Site Manager will follow standard sampling procedures to obtain representative samples of the proposed aggregate materials.

8.3 CQA Monitoring Activities

8.3.1 Drainage Aggregate

The CQA Site Manager will monitor and document the installation of the drainage aggregates. In general, monitoring the installation of the drainage aggregates includes the following activities:

- reviewing documentation of the material qualification test results provided by the Contractor;
- sampling and testing for conformance of the materials to the *Technical Specifications*;
- documenting that the drainage aggregates are installed using the specified equipment and procedures;

- placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials and leachate collection pipes.
- documenting that the drainage aggregates are constructed to the lines and grades shown on the *Construction Drawings*; and
- monitoring that the construction activities do not cause damage to underlying geosynthetic materials.

8.4 Deficiencies

If a defect is discovered in the drainage aggregates, the CQA Site Manager will evaluate the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Site Manager will determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA Site Manager deems appropriate.

8.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Construction Manager and Contractor and schedule appropriate re-tests when the work deficiency is to be corrected.

8.4.2 Repairs and Re-testing

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

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

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9. PIPES AND FITTINGS

9.1 Material Requirements

HDPE and CPE pipe and fittings must conform to the requirements of the *Technical Specifications*. The CQA Consultant will document that the HDPE and CPE pipe and fittings meet those requirements through manufacturer's quality control certificates, conformance testing, and visual examination of materials arriving on site.

9.2 Manufacturer

9.2.1 Submittals

Prior to the installation of HDPE and CPE pipe, the Manufacturer will provide to the CQA Consultant:

- a properties' sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent; and
- a certification that property values given in the properties sheet are minimum values and are guaranteed by the Manufacturer.

The CQA Consultant will document that:

- the property values certified by the Manufacturer meet the *Technical Specifications*; and
- the measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

9.2.2 Identification

Prior to shipment, the Manufacturer will provide the Construction Manager and the CQA Site Manager with a quality control certificate for each lot/batch of HDPE and CPE pipe provided. The quality control certificate will be signed by a responsible

party employed by the 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 CQA Site Manager will:

- document 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 document that the certified properties meet the *Technical Specifications*.

9.3 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 handled and stored in general accordance with the Manufacturer's recommendation. The handling of joined pipe will be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Slings for handling the pipe 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 pipe rejoined.

9.4 Joints

Lengths of HDPE pipe will be assembled into suitable installation lengths by the butt-fusion process. Butt-fusion means the butt-joining of the HDPE pipe by

softening by heat the aligned faces of the HDPE 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 HDPE pipe so joined will be made from the same class and type of raw material made by the same raw material supplier.

Lengths of CPE pipe will be assembled into suitable installation lengths by a manufacturer-recommended method.

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10. GEOMEMBRANE

10.1 General

This section discusses and outlines the CQA activities to be performed for high density polyethylene (HDPE) geomembrane installation. The CQA Site Manager will review the *Construction Drawings*, and the *Technical Specifications*, and any approved Addenda regarding this material.

10.2 Geomembrane Material Conformance

10.2.1 Introduction

The CQA Site Manager will document that the geomembrane delivered to the site meets the requirements of the *Technical Specifications* prior to installation. The CQA Site Manager will:

- review the manufacturer's submittals for compliance with the *Technical Specifications*;
- document the delivery and proper storage of geomembrane rolls; and
- conduct conformance testing of the rolls before the geomembrane is installed.

The following sections describe the CQA activities required to verify the conformance of geomembrane.

10.2.2 Review of Quality Control

10.2.2.1 Material Properties Certification

The Manufacturer will provide the Construction Manager and the CQA Site Manager with the following:

- a properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the *Technical Specifications*, or equivalent;
- the sampling procedure and results of testing; and
- a certification that property values given in the properties sheet are guaranteed by the Manufacturer.

The CQA Site Manager will document that:

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

10.2.2.2 Resin Certification

The Manufacturer will also provide the Construction Manager with the following information concerning the resin used to manufacture the geomembrane:

- the origin (Resin Supplier's name and resin production plant), identification (brand name, lot number), and production date of the resin; and
- the raw material quality control certificates.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to it; and
- review the quality control certificates and evaluate that the certified properties meet the specifications.

10.2.2.3 Geomembrane Roll QC Certification

Prior to shipment, the Manufacturer will provide the Construction Manager and the CQA Site Manager with a quality control certificate for every roll of geomembrane provided. 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
- results of quality control tests - as a minimum, results will be given for thickness, specific gravity, carbon black content, carbon black dispersion, tensile properties, tear resistance, puncture resistance, and single point stress rupture evaluated in general accordance with the methods indicated in the specifications or equivalent methods approved by the Engineer.

The CQA Site Manager will:

- evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to the roll represented by the test results; and
- review the quality control certificates and evaluate that the certified roll properties meet the specifications.

10.2.3 Conformance Testing

CQA personnel will sample the geocomposite either during production at the manufacturing facility or after delivery to the construction site. Upon delivery of the rolls of geomembrane, the CQA Site Manager will document that the rolls are unloaded and stored on site as required by the *Technical Specifications*. Damage caused by unloading will be documented by the CQA Site Manager and the damaged material will not be installed. The CQA Site Manager shall obtain conformance samples at the specified frequency and forward them to the Geosynthetics CQA Laboratory for testing to monitor conformance to both the *Technical Specifications* and the list of properties certified by the Manufacturer. The test procedures will be as indicated in Table 8. Where optional procedures are noted in the test method, the requirements of the *Technical Specifications* will prevail.

Samples will be taken across the width of the roll and will not include the first linear 3 ft (1 m) of material. Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow along with the date and roll number. The required minimum sampling frequencies are provided in Table 8.

The CQA Site Manager will examine results from laboratory conformance testing and will report any non-conformance to the Construction Manager and the Geosynthetic Installer. The procedure prescribed in the *Technical Specifications* will be followed in the event of a failing conformance test.

10.3 Delivery

10.3.1 Transportation and Handling

The CQA Site Manager will document that the transportation and handling does not pose a risk of damage to the geomembrane.

Upon delivery at the site, the Geosynthetic Installer and the CQA Site Manager will conduct a surface observation of the rolls for defects and damage. This

inspection will be conducted without unrolling unless defects or damages are found or suspected. The CQA Site Manager will indicate to the Construction Manager:

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

10.3.2 Storage

The Geosynthetic Installer will be responsible for the storage of the geomembrane on site. The Contractor will provide storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible.

The CQA Site Manager will document that storage of the geomembrane provides adequate protection against sources of damage.

10.4 Geomembrane Installation

10.4.1 Introduction

The CQA Consultant will document that the geomembrane installation is carried out in general accordance with the *Construction Drawings, Technical Specifications* and Manufacturer's recommendations.

10.4.2 Earthwork

~~10.4.2.1 Surface Preparation~~

~~The CQA Site Manager will document that:~~

- ~~• a qualified land surveyor has verified lines and grades;~~
- ~~• that the supporting prepared subgrade or subgrade meets the *Technical Specifications* and has been approved; and~~

- ~~placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials.~~

~~The Geosynthetic 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 Geosynthetic Installer to the Construction Manager prior to commencement of geomembrane installation in the area under consideration. The CQA Site Manager will be given a copy of this certificate by the Construction Manager.~~

~~After the supporting subgrade has been accepted by the Geosynthetic Installer, it will be the Geosynthetic Installer's responsibility to indicate to the Construction Manager any change in the supporting soil condition that may require repair work. If the CQA Site Manager concurs with the Geosynthetic Installer, then the Construction Manager will document that the supporting soil is repaired.~~

~~At any time before and during the geomembrane installation, the CQA Site Manager will indicate to the Construction Manager locations that may not provide adequate support to the geomembrane.~~

~~10.4.2.1~~ ~~10.4.2.2~~ *Geosynthetic Termination*

~~The CQA Site Manager will document that the geosynthetic terminations have been constructed in general accordance with the *Construction Drawings*. Backfilling above the terminations will be conducted in general accordance with the *Technical Specifications*.~~

10.4.3 Geomembrane Placement

10.4.3.1 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 CQA Site Manager to document that each field panel is given an "identification code" (number or letter- number) consistent with the layout plan. This

identification code will be agreed upon by the Construction Manager, Geosynthetic Installer and CQA Site Manager. This field panel identification code will be as simple and logical as possible. Roll numbers established in the manufacturing plant must be traceable to the field panel identification code.

The CQA Site Manager will establish documentation showing correspondence between roll numbers, and field panel identification codes. The field panel identification code will be used for all quality assurance records.

10.4.3.2 Field Panel Placement

Location

The CQA Site Manager will document that field panels are installed at the location indicated in the Geosynthetic Installer's layout plan, as approved or modified by the Engineer.

Installation Schedule

Field panels may be installed using one of the following schedules:

- all field panels are placed prior to field seaming in order to protect the subgrade from erosion by rain;
- field panels are placed one at a time and each field panel is seamed after its placement (in order to minimize the number of unseamed field panels exposed to wind); and
- any combination of the above.

If a decision is reached to place all field panels prior to field seaming, it is usually beneficial to begin at the high point area and proceed toward the low point with "shingle" overlaps to facilitate drainage in the event of precipitation. It is also usually beneficial to proceed in the direction of prevailing winds. Accordingly, an early decision regarding installation scheduling should be made if and only if weather conditions can be predicted with reasonable certainty. Otherwise, scheduling decisions

must be made during installation, in general accordance with varying conditions. In any event, the Geosynthetic Installer is fully responsible for the decision made regarding placement procedures.

The CQA Site Manager will evaluate every change in the schedule proposed by the Geosynthetic Installer and advise the Construction Manager on the acceptability of that change. The CQA Site Manager will document that the condition of the supporting soil has not changed detrimentally during installation.

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

Weather Conditions

Geomembrane placement will not proceed unless otherwise authorized:

- when the ambient temperature is below 40°F or above 104°F;
- when the geomembrane sheet temperature is below 40°F or above 104°F; or
- when wind gusts are in excess of 20 mph.

Geomembrane placement will not be performed during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds (i.e., wind gusts in excess of 20 mph).

The CQA Site Manager will document that the above conditions are fulfilled. Additionally, the CQA Site Manager will document that the supporting soil has not been damaged by weather conditions. The Geosynthetics Installer will inform the Construction Manager if the above conditions are not fulfilled.

Method of Placement

The CQA Site Manager will document the following:

- equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;
- the surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;
- geosynthetic elements immediately underlying the geomembrane are clean and free of debris;
- personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;
- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;
- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels); and
- 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 edges of panels to minimize risk of wind flow under the panels).

The CQA Site Manager will inform the Construction Manager if the above conditions are not fulfilled.

Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the CQA Site Manager. Repairs will be made in general accordance with procedures described in Section 10.4.5.

10.4.4 Field Seaming

This section details CQA procedures to document that seams are properly constructed and tested in general accordance with the Manufacturer's specifications and industry standards.

10.4.4.1 Seam Layout

The Geosynthetic Installer will provide the Construction Manager and the CQA Site Manager with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The CQA Site Manager will review the seam layout drawing and evaluate that it is consistent with the preliminary geomembrane panel layout. No panels may be seamed in the field without the Construction Manager's approval. In addition, panels not specifically shown on the seam layout drawing may be used without the Construction 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 should be less than 5 ft (1.5 m) from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized.

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

10.4.4.2 Requirements of Personnel

All personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests, as outlined in the *Technical Specifications*. The most experienced seamer, the "master seamer", will provide direct supervision over less experienced seamers.

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

10.4.4.3 Seaming Equipment and Products

Approved processes for field seaming are fillet extrusion welding and fusion welding.

Fillet Extrusion Process

The fillet extrusion-welding apparatus will be equipped with gauges giving the temperature in the apparatus.

The Geosynthetic Installer will provide documentation regarding the extrudate to the Construction Manager and the CQA Site Manager, and will certify that the extrudate is compatible with the specifications, and in any event is comprised of the same resin as the geomembrane sheeting.

The CQA Site Manager will log apparatus temperatures, ambient temperatures, and geomembrane surface temperatures at appropriate intervals.

The CQA Site Manager will document that:

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

- the geomembrane is protected from damage in heavily trafficked areas.

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 CQA Site Manager will log ambient, seaming apparatus, and geomembrane surface temperatures as well as seaming apparatus pressures.

The CQA Site Manager will also document that:

- the Geosynthetic Installer maintains on-site the number of spare operable seaming apparatus decided at the Resolution Meeting;
- production welding settings are consistent with settings used during trial seams;
- 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 welding;
- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;
- a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage;
- the geomembrane is protected from damage in heavily trafficked areas; 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.

10.4.4.4 Seam Preparation

The CQA Site Manager will document that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris, and foreign material; and
- seams are aligned with the fewest possible number of wrinkles and “fishmouths.”

10.4.4.5 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows unless authorized in writing by the Construction Manager:

- seaming will only be approved between ambient temperatures of 40°F (4°C) and 104°F (40°C); and
- seaming will not be approved if sustained wind speed is in excess of 20 mph (32 km/hr).

If the Geosynthetic Installer wishes to use methods that may allow seaming at ambient temperatures below 40°F (4°C) or above 104°F (40°C), the Geosynthetic Installer will demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced within acceptable temperature and wind requirements, and that the overall quality of the geomembrane is not adversely affected.

The CQA Site Manager will document that these seaming conditions are fulfilled and will advise the Construction Manager if they are not. The Construction Manager will then decide if the installation will be stopped or postponed.

10.4.4.6 Overlapping and Temporary Bonding

The CQA Site Manager will document that:

- the panels of geomembrane have a finished overlap of a minimum of 3 in. (75 mm) for both extrusion and fusion welding;
- no solvent or adhesive bonding material are to be used; and
- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane.

The CQA Site Manager will log appropriate temperatures and conditions, and will log and report to the Construction Manager non-compliances.

10.4.4.7 Trial Seams

Trial seams will be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams will be made at the beginning of each seaming period, beginning of the day and after lunch, for each seaming apparatus used that day. Also, each seamer will make at least one trial seam each day. Trial seams will be made under the same conditions as actual seams.

Extrusion welded trial seam samples will be at least 3 ft (0.9 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Fusion welded trial seam samples will be at least 5 ft (1.5 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap will be as indicated in Section 10.5.3.6.

Four specimens, each 1 in. (25 mm) wide, will be cut from the trial seam sample by the Geosynthetic Installer. One specimen will be tested for shear strength and three specimens will be tested for peel adhesion using a gauged tensiometer. All specimens tested will exhibit a Film Tear Bond (FTB) and will not fail in the seam. In addition, all specimens will meet or exceed the minimum strength requirements described in the *Technical Specifications*. If any of the four specimens fails, the entire trial seaming operation will be repeated. If any of the four additional specimens fails, the seaming apparatus and seamer will not be approved for production seaming until the

deficiencies are corrected and two consecutive trial seam tests achieve the FTB requirements outlined above.

The CQA Site Manager will observe trial seam procedures. Trial seam samples will be assigned a number. The CQA Site Manager, will log the date, time, machine temperature(s), number of the seaming unit, name of the seamer, and pass or fail description for each trial seam sample tested.

10.4.4.8 General Seaming Procedure

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

- Fishmouths or wrinkles at the seam 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 6 in. (150 mm) beyond the cut in all directions.
- If seaming operations are carried out at night, adequate illumination will be provided at the Geosynthetic Installer's expense.
- Seaming will extend to the outside edge of panels to be placed in the anchor trench.

The CQA Site Manager will document that the above seaming procedures are followed, and will inform the Construction Manager if they are not.

10.4.4.9 Nondestructive Seam Continuity Testing

Concept

The Geosynthetic Installer will non-destructively test field seams over their length using a vacuum test unit, air pressure test (for double fusion seams only), or other approved method. The purpose of nondestructive tests is to check the continuity

of seams. It does not provide information on seam strength. Continuity testing will be carried out as the seaming work progresses, not at the completion of field seaming.

The CQA Site Manager will:

- observe continuity testing;
- record location, date, test unit number, name of person conducting the test, and the results of tests; and
- inform the Geosynthetic Installer and Construction Manager of required repairs.

The Geosynthetic Installer will complete any required repairs in general accordance with Section 10.4.5.

The CQA Site Manager 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 non-destructively tested:

All such seams will be cap-stripped with the same geomembrane.

- If the seam is accessible to testing equipment prior to final installation, the seam will be non-destructively tested prior to final installation.
- If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations will be observed by the CQA Site Manager and Geosynthetic 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 CQA Site Manager.

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 steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections;
- a rubber pressure/vacuum hose with fittings and connections;
- an approved applicator; and
- a soapy solution.

The following procedures will be followed:

- energize the vacuum pump and reduce the tank pressure to approximately 5 psi (35 kPa) (10 in. of Hg.) gauge;
- wet a strip of geomembrane approximately 12 in. by 48 in. (0.3 m by 1.2 m) with the soapy solution;
- place the box over the wetted area;
- close the bleed valve and open the vacuum valve;
- document that a leak tight seal is created;
- for a period of not less than ten seconds, examine the geomembrane through the viewing window for the presence of leaks indicated by soap bubbles;

- if no leaks appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. (75 mm) overlap, and repeat the process;
- areas where soap bubbles appear will be marked and repaired in general accordance with Section 10.4.5 and retested using the vacuum testing method.

Air Pressure Testing (For Double-Track Fusion Seam Only)

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

The equipment will be comprised of the following:

- an air pump (manual or motor driven) equipped with pressure gauge capable of generating and sustaining a pressure of 30 psi (200 kPa) and mounted on a cushion to protect the geomembrane;
- a rubber hose with fittings and connections;
- 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 needle or other approved pressure feed device into the tunnel created by the fusion weld;
- insert a protective cushion between the air pump and the geomembrane;
- energize the air pump to a pressure of 25 to 30 psi (170 to 204 kPa), close valve, and sustain pressure for not less than 5 minutes;

- if loss of pressure exceeds 3 psi (20 kPa) or does not stabilize, locate faulty area and repair in general accordance with Section 10.4.5;
- cut end of tested seam area, opposite the location of the pressure gauge, after completion of the five minute pressure hold period to verify complete testing of the seam. If the pressure gauge does not indicate a release of pressure, locate blockage of the air channel and retest until entire seam is tested; and
- remove needle or other approved pressure feed device and repair any holes in the geomembrane resulting from the air pressure testing procedure in general accordance with Section 10.4.5.

10.4.4.10 Destructive Testing

Concept

Destructive seam testing will be performed on site and at the independent CQA laboratory in general accordance with the *Construction Drawings* and the *Technical Specifications*. 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.

Location and Frequency

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

- The frequency of geomembrane seam testing is a minimum of one destructive sample per 500 feet of weld, or as modified in accordance with the Technical Specifications. The minimum frequency is to be evaluated as an average taken throughout the entire facility.
- A minimum of one test per seaming machine used on the project over the duration of the project phase.

- Test locations will be evaluated during seaming at CQA Site Manager's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Geosynthetic 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 Geosynthetic Installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The CQA Site Manager will:

- observe sample cutting;
- assign a number to each sample, and mark it accordingly;
- record sample location on layout drawing; and
- record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

Holes in the geomembrane resulting from destructive seam sampling will be immediately repaired in general accordance with repair procedures described in Section 10.4.5. The continuity of the new seams in the repaired area will be tested in general accordance with Section 10.4.4.9.

Size and Distribution of Samples

The destructive sample will be 12 in. (0.3 m) wide by 42 in. (1.1 m) long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one portion, measuring 12 in. × 12 in. (0.30 m × 0.30 m), to the Geosynthetic Installer for field testing;

- one portion, measuring 12 in. × 18 in. (30 cm × 45 cm), for CQA Laboratory testing; and
- one portion, measuring 12 in. × 12 in. (30 cm × 30 cm), to the Contractor for archive storage.

Final evaluation of the destructive sample sizes and distribution will be made at the Pre-Construction Meeting.

Field Testing

Field testing will be performed by the Geosynthetic Installer using a gauged tensiometer. Prior to field testing the Geosynthetic Installer shall submit a calibration certificate for gauge tensiometer to the CQA Consultant for review. Calibration must have been performed within one year of use on the current project. Five 1 in. (25 mm) wide strips will be taken for peel. The specimens shall not fail in the seam and shall meet the strength requirements outlined in the *Technical Specifications*. If any field test specimen fails, then the procedures outlined in *Procedures for Destructive Test Failures* of this section will be followed.

The CQA Site Manager will witness field tests and mark samples and portions with their number. The CQA Site Manager will also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description.

CQA Laboratory Testing

Destructive test samples will be packaged and shipped same day with next day delivery, if necessary, under the responsibility of the CQA Site Manager in a manner that will not damage the test sample. ~~Destructive test samples will be packaged and shipped, if necessary, under the responsibility of the CQA Site Manager in a manner that will not damage the test sample.~~ The Construction Manager will document that packaging and shipping conditions are acceptable. The Construction Manager will be responsible for storing the archive samples. This procedure will be outlined at the Resolution Meeting. Samples will be tested by the CQA Laboratory. The CQA

Laboratory will be selected by the CQA Site Manager with the concurrence of the Construction Manager.

Testing will include “Bonded Seam Strength” and “Peel Adhesion.” The minimum acceptable values to be obtained in these tests are given in the *Technical Specifications*. At least five specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear...). A passing test will meet the minimum required values in at least four out of five specimens.

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

Geosynthetic Installer’s Laboratory Testing

The Geosynthetic Installer’s laboratory test results will be presented to the Construction Manager and the CQA Site Manager for comments.

Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test conducted by the CQA Laboratory, the Geosynthetic Installer’s laboratory, or by gauged tensiometer in the field. The Geosynthetic Installer has two options:

- The Geosynthetic Installer can reconstruct the seam between two passed test locations.
- The Geosynthetic Installer can trace the welding 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 the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is reconstructed between these locations.

If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

Acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken. In cases where the failed seam segment exceeds 150 ft (50 m), a destructive sample will be taken from the zone in which the seam has been reconstructed. Repairs will be made in general accordance with Section 10.4.5.

The CQA Site Manager will document actions taken in conjunction with destructive test failures.

10.4.5 Defects and Repairs

This section prescribes CQA activities to document that defects, tears, rips, punctures, damage, or failing seams shall be repaired.

10.4.5.1 Identification

Seams and non-seam areas of the geomembrane will be examined by the CQA Site Manager for identification of defects, holes, blisters, undispersed raw materials and signs 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.

10.4.5.2 Evaluation

Each suspect location both in seam and non-seam areas will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate. Each location that fails the nondestructive testing will be marked by the CQA Site Manager and repaired by the Geosynthetic Installer. Work will not proceed with any materials that will cover locations which have been repaired until laboratory test results with passing values are available.

10.4.5.3 Repair Procedures

Portions 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 at the discretion of the CQA Consultant with input from the Construction Manager and Geosynthetic Installer. The procedures available include:

- patching, used to repair large holes ($\geq 1/8$ -in), tears ($\geq 1/2$ -in), undispersed raw materials, and contamination by foreign matter;
- grinding and re-welding, used to repair small sections of extruded seams;
- spot welding or seaming, used to repair small tears ($< 1/2$ -in), pinholes, or other minor, localized flaws;
- capping, used to repair large lengths of failed seams;
- removing bad seam and replacing with a strip of new material welded into place (used with large lengths of fusion seams).

In addition, the following provisions will be satisfied:

- surfaces of the geomembrane which are to be repaired will be abraded no more than 20 minutes prior to the repair;
- 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 by the CQA Consultant with input from the Construction Manager and Geosynthetic 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.

10.4.5.4 Verification of Repairs

Each repair will be numbered and logged. Each repair will be non-destructively tested using the methods described in Section 10.4.4.9 as appropriate. Repairs that 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 test sampling, at the discretion of the CQA Site Manager. Failed tests indicate that the repair will be redone and re-tested until a passing test results. The CQA Site Manager will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

10.4.5.5 Large Wrinkles

When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane liner is completed) and prior to placing overlying materials, the CQA Site Manager will observe the geomembrane wrinkles. The CQA Site Manager will indicate to the Construction Manager which wrinkles should be cut and re-seamed by the Geosynthetic Installer. The seam thus produced will be tested like any other seam.

10.4.6 Lining System Acceptance

The Contractor, Geosynthetic Installer, and the Manufacturer(s) will retain all responsibility for the geosynthetic materials in the liner system until acceptance by the Owner.

The geosynthetic liner system will be accepted by the Owner when:

- the installation is finished;

- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- all documentation of installation is completed including the CQA Site Manager's acceptance report; and
- CQA report, including "as built" drawing(s), sealed by a registered professional engineer has been received by the Construction Manager.

The CQA Site Manager will document that installation has proceeded in general accordance with the *Technical Specifications* for the project except as noted to the Construction Manager.

11. GEOTEXTILE

11.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geotextile installation. The CQA Consultant will review the *Construction Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

11.2 Manufacturing

The Manufacturer will provide the Construction Manager with a list of guaranteed “minimum average roll value” properties (defined as the mean less two standard deviations), for each type of geotextile to be delivered. The Manufacturer will also provide the Construction Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property “minimum average roll values” which meet or exceed all property values guaranteed for that type of geotextile.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- grab strength (filtration geotextiles only);
- tear strength (filtration geotextiles only);
- puncture strength (filtration geotextiles only);
- wide width tensile strength (UV protection geotextile only);
- permittivity (filtration geotextile only); and
- apparent opening size (filtration and UV protection geotextiles only).

Quality control tests must be performed, in general accordance with the test methods specified in Table 9, on geotextile produced for the project. The Manufacturer will also provide a written certification that the nonwoven, needle-punched geotextiles are continuously inspected and found to be needle-free.

The CQA Site Manager will examine Manufacturer certifications to evaluate that the property values listed on the certifications meet or exceed those specified for the particular type of geotextile and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Construction Manager.

11.3 Labeling

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

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

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Construction Manager.

11.4 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.

Protective wrappings will be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, a geotextile will not be exposed to sunlight for more than 15 days, except for UV protection geotextile, unless otherwise specified and guaranteed by the Manufacturer.

The CQA Site Manager will observe rolls upon delivery at the site and deviation from the above requirements will be reported to the Construction Manager.

11.5 Conformance Testing

11.5.1 Tests

Upon delivery of the rolls of geotextiles, the CQA Site Manager will document that samples are removed and forwarded to the Geosynthetics CQA Laboratory for testing to evaluate conformance to *Technical Specifications*. Required test and testing frequency for the geotextiles are presented in Table 9.

These conformance tests will be performed in general accordance with the test methods specified in the *Technical Specifications*.

11.5.2 Sampling Procedures

Samples will be taken across the width of the roll and will not include the first three feet (linear meter). Unless otherwise specified, samples will be 3 ft (1 m) long by the roll width. The CQA Site Manager will mark the machine direction on the samples with an arrow.

Unless otherwise specified, samples will be taken at a rate as indicated in Table 9 for geotextiles.

11.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Construction Manager.

11.5.4 Conformance Sample Failure

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

- The Manufacturer will replace every roll of geotextile that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.

- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of geotextile on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

11.6 Handling and Placement

The Geosynthetic Installer will handle all geotextiles in such a manner as to document 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 sheet in tension.
- In the presence of wind, all geotextiles will be weighted with sandbags or the equivalent. Such sandbags will be installed during placement and will remain until replaced with earth cover material.
- Geotextiles will be cut using an approved geotextile cutter only. If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geotextiles.
- The Geosynthetic Installer will take all necessary precautions to prevent damage to 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 geotextile, 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 document that no potentially harmful foreign objects, such as needles, are present.

The CQA Site Manager will note non-compliance and report it to the Construction Manager.

11.7 Seams and Overlaps

All liner geotextiles will be continuously sewn in accordance with *Technical Specifications*. Liner geotextiles will be overlapped 6 in. (0.15 m) prior to seaming. No horizontal seams will be allowed on side slopes (i.e. seams will be along, not across, the slope), except as part of a patch. Cover geotextiles will be overlapped a minimum of 12 in. (0.3 m) prior to seaming.

Sewing will be done using polymeric thread with chemical and ultraviolet resistance properties equal to or exceeding those of the geotextile.

11.8 Repair

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

- On liner slopes: A patch made from the same geotextile will be double seamed into place. Should a tear exceed 10 percent of the width of the roll, that roll will be removed from the slope and replaced.
- Liner and Cover Non-slopes: A patch made from the same geotextile will be spot-seamed in place with a minimum of 6 in. (0.60 m) overlap in all directions.

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

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

11.9 Placement of Soil or Aggregate Materials

The Contractor will place all soil or aggregate materials located on top of a geotextile, in such a manner as to document:

- no damage of the geotextile;
- minimal slippage of the geotextile on underlying layers; and
- no excess tensile stresses in the geotextile.

Unless otherwise specified by the Engineer, all lifts of soil material will be in conformance with the following guidelines:

Equipment Ground Pressure		Minimum Loose Lift Thickness	
Psi	kPa	in.	m
<10	< 68	12	0.30
<20	< 138	24	0.60
>20	> 138	36	0.90

If portions of the geotextile are exposed, the CQA Site Manager will periodically place two (or more, at his discretion) marks on the geotextile 10 ft (3 m) apart along the slope and measure the elongation of the geotextile during the placement of soil. This elongation will be related, by the Engineer, to the tensile stress in the geotextile.

Non-compliance will be noted by the CQA Site Manager and reported to the Construction Manager.

12. GEOSYNTHETIC CLAY LINER (GCL)

12.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geosynthetic clay liner (GCL) installation. The CQA Consultant will review the *Construction Drawings*, and the *Technical Specifications*, and approved addenda or changes.

12.2 Manufacturing

The Manufacturer will provide the Construction Manager with a list of guaranteed “minimum average roll value¹” properties for the GCL to be delivered. The Manufacturer will also provide the Construction Manager with a written quality control certification signed by a responsible party employed by the Manufacturer that the materials actually delivered have property “minimum average roll values” which meet or exceed all property values guaranteed for that GCL.

The quality control certificates will include:

- roll identification numbers; and
- results of quality control testing.

The Manufacturer will provide, as a minimum, test results for the following:

- mass per unit area; and
- index flux.

Quality control tests must be performed, in general accordance with the test methods specified in Table 10, on GCL produced for the project.

¹ Minimum average roll value defined as the property value calculated as typical minus two standard deviations. Statistically, it yields a 97.7 percent degree of confidence that any sample taken during quality assurance testing will exceed value reported.

The CQA Site Manager will examine Manufacturer certifications to verify that the property values listed on the certifications meet or exceed those specified for the GCL and the measurements of properties by the Manufacturer are properly documented, test methods acceptable and the certificates have been provided at the specified frequency properly identifying the rolls related to testing. Deviations will be reported to the Construction Manager.

12.3 Labeling

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

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

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Construction Manager.

12.4 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.

The CQA Site Manager will observe rolls upon delivery at the site and any deviation from the above requirements will be reported to the Construction Manager.

12.5 Conformance Testing

12.5.1 Tests

CQA personnel will sample the GCL either during production at the manufacturing facility or after delivery to the construction site. The samples will be

forwarded to the Geosynthetics CQA Laboratory for testing to assess conformance with the *Technical Specifications*. The test methods and minimum testing frequencies are indicated in Table 10.

Samples will be taken across the width of the roll and will not include the first 3 ft (0.9 m) if the sample is cut on site. Unless otherwise specified, samples will be 3 ft (0.9 m) long by the roll width. The CQA Consultant will mark the machine direction with an arrow and the manufacturer's roll number on each sample.

The CQA Site Manager will examine results from laboratory conformance testing and will report non-conformance to the Construction Manager.

12.5.2 Conformance Sample Failure

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

- The Manufacturer will replace every roll of GCL that is in nonconformance with the *Technical Specifications* with a roll(s) that meets *Technical Specifications*.
- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample will be tested by the CQA Laboratory. These samples must conform to the *Technical Specifications*. If any of these samples fail, every roll of GCL on site from this lot and every subsequently delivered roll that is from the same lot must be tested by the CQA Laboratory for conformance to the *Technical Specifications*. This additional conformance testing will be at the expense of the Manufacturer.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

12.6 GCL Delivery and Storage

Upon delivery to the site, the CQA Consultant will check the GCL rolls for defects (e.g., tears, holes) and for damage. The CQA Consultant will report to the Construction Manager and the Geosynthetics Installer:

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

The GCL rolls delivered to the site will be checked by the CQA Consultant to document that the roll numbers correspond to those on the approved Manufacturer's quality control certificate of compliance.

12.7 GCL Installation

12.7.1 Surface Preparation

The CQA Site Manager will document that:

- a qualified land surveyor has verified lines and grades;
- that the supporting prepared subgrade or subgrade meets the *Technical Specifications* and has been approved; and
- placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying geosynthetic materials.

The Geosynthetic 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 Geosynthetic Installer to the Construction Manager prior to commencement of geomembrane installation in the area under consideration. The CQA Site Manager will be given a copy of this certificate by the Construction Manager.

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

12.7.2 Installation

At any time before and during the geomembrane installation, the CQA Site Manager will indicate to the Construction Manager locations that may not provide adequate support to the geomembrane.

The CQA Consultant will monitor and document that the GCL is installed in general accordance with the *Construction Drawings* and the *Technical Specifications*. The Geosynthetics Installer shall provide the CQA Consultant a certificate of subgrade acceptance prior to the installation of the GCL as outlined in the *Technical Specifications*. The GCL installation activities to be monitored and documented by the CQA Consultant include:

- monitoring that the GCL rolls are stored and handled in a manner which does not result in any damage to the GCL;
- monitoring that the GCL is not exposed to UV radiation for extended periods of time without prior approval;
- monitoring that the GCL are seamed in general accordance with the *Technical Specifications* and the Manufacturer's recommendations;
- monitoring and documenting that the GCL is installed on an approved subgrade, free of debris, protrusions, or uneven surfaces;
- monitoring that the GCL is not installed on a saturated subgrade or standing water and is not exposed such that it is hydrated prior to completion of the construction; and

- monitoring that any damage to the GCL is repaired as outlined in the *Technical Specifications*.

The CQA Site Manager will note non-compliance and report it to the Construction Manager.

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13. GEOCOMPOSITE

13.1 Introduction

This section of the CQA Plan outlines the CQA activities to be performed for the geocomposite installation. The CQA Consultant will review the *Construction Drawings*, and the *Technical Specifications*, and any approved addenda or changes.

13.2 Manufacturing

The Manufacturer will provide the CQA Consultant with a list of certified “minimum average roll value” properties for the type of geocomposite to be delivered. The Manufacturer will also provide the CQA Consultant with a written certification signed by a responsible representative of the Manufacturer that the geocomposite actually delivered have “minimum average roll values” properties which meet or exceed all certified property values for that type of geocomposite.

The CQA Consultant will examine the Manufacturers’ certifications to document that the property values listed on the certifications meet or exceed those specified for the particular type of geocomposite (geotextile and geonet). Deviations will be reported to the Construction Manager.

13.3 Labeling

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

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

The CQA Site Manager will examine rolls upon delivery and deviation from the above requirements will be reported to the Construction Manager.

13.4 Shipment and Storage

During shipment and storage, the geocomposite will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. Therefore, geocomposite rolls will be shipped and stored in relatively opaque and watertight wrappings. The CQA Site Manager will observe rolls upon delivery to the site and deviation from the above requirements will be reported to the Construction Manager. Damaged rolls will be rejected and replaced.

Wrapping protecting geocomposite rolls will be removed less than one hour prior to unrolling geocomposite before placement. After the wrapping has been removed, geocomposite should not be exposed to sunlight for more than 15 days, unless otherwise approved by the Manufacturer. Approval by the Manufacturer will be a guarantee that the properties of the exposed geotextile will not degrade upon prolonged exposure to such values that would cause the material to not meet the *Technical Specifications*. Any material that is exposed for more than 15 days, which has been approved for prolonged exposure by the Manufacturer, will be tested by the CQA Laboratory to document that the material properties are still in conformance with the *Technical Specifications*. Any material that fails to meet the *Technical Specifications* will be replaced by the Manufacturer.

The CQA Site Manager will observe that geocomposite is free of dirt and dust just before installation. The CQA Site Manager will report the outcome of this observation to the Construction Manager, and if the geocomposite is judged dirty or dusty, they will be cleaned by the Geosynthetic Installer prior to installation.

13.5 Conformance Testing

13.5.1 Tests

The geocomposite material will be tested for transmissivity (ASTM D 4716) and for peel strength (ASTM D 413) at the frequencies presented in Table 11.

13.5.2 Sampling Procedures

Upon delivery of the geocomposite rolls, the CQA Site Manager will document that samples are obtained from individual rolls at the frequency specified in this CQA Plan. The geocomposite samples will be forwarded to the CQA Laboratory for testing to evaluate conformance to both the *Technical Specifications* and the list of physical properties certified by the Manufacturer.

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

13.5.3 Test Results

The CQA Site Manager will examine results from laboratory conformance testing and compare results to the *Technical Specifications*. The criteria used to evaluate acceptability are presented in the *Technical Specifications*. The CQA Site Manager will report any nonconformance to the Construction Manager.

13.5.4 Conformance Test Failure

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

- The Manufacturer will replace every roll of geocomposite that is in nonconformance with the *Technical Specifications* with a roll that meets specifications.
- The Geosynthetic Installer will remove conformance samples for testing by the CQA Laboratory from the closest numerical rolls on both sides of the failed roll. These two samples must conform to the *Technical Specifications*. If either of these samples fail, the numerically closest rolls on the side of the failed sample that is not tested, will be tested by the CQA Laboratory. These samples must conform to the *Technical 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 CQA Laboratory for conformance to the *Technical Specifications*.

The CQA Site Manager will document actions taken in conjunction with conformance test failures.

13.6 Handling and Placement

The Geosynthetic Installer will handle all geocomposite in such a manner as to document they are not damaged in any way. The Geosynthetic Installer will comply with the following:

- In the presence of wind, the geocomposite will be weighted with sandbags or the equivalent. Sandbags will be used during installation only and will remain until replaced with the appropriate cover material.
- If in place, special care must be taken to protect other materials from damage, which could be caused by the cutting of the geocomposite.
- The Geosynthetic Installer will take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.
- **Prior to geocomposite installation, a visual examination of the geomembrane will be performed and documented.**
- During placement of geocomposite, care will be taken to prevent entrapment of 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, 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.

- A visual examination of the geocomposite will be carried out over the entire surface, after installation to document that no potentially harmful foreign objects are present.

The CQA Site Manager will note noncompliance and report it to the Construction Manager.

13.7 Drainage composite Seams and Overlaps

Adjacent geocomposite panels will be joined in general accordance with *Construction Drawings* and *Technical Specifications*. As a minimum, the following requirements will be met:

- ~~Adjacent rolls will be overlapped by at least 4 in. (100 mm).~~
- The geonet components shall be overlapped a minimum of 4 in. along the length and a minimum of 12 in. along the width.
- Each component of the geocomposite will be secured or seamed to the like component at overlaps.
- The geocomposite overlaps will be secured by tying, in general accordance with the *Technical Specifications*.
- The bottom layers of geotextile will be overlapped.
- The top layers of geotextile will be continuously sewn.

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

13.8 Repair

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 with 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 general accordance with Section 13.7.

The CQA Site Manager will observe repairs, note noncompliances with the above requirements and report them to the Construction Manager.

13.9 Placement of Soil Materials

The Contractor will place all soil materials located on top of a geocomposite in such a manner as to document:

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

Unless otherwise specified by the CQA Consultant, lifts of soil material will be in conformance with the *Technical Specifications*. If portions of the geocomposite are exposed, the 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.

The following ground pressures will be required for equipment operating at the site:

MAXIMUM ALLOWABLE EQUIPMENT GROUND PRESSURE (psi)	INITIAL LIFT THICKNESS OF OVERLYING MATERIALS (ft)
<10	1.0
≤20	2.0
21-50	3.0
51-80	4.0
81+	5.0

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

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14. CAST-IN-PLACE CONCRETE

14.1 Introduction

This section prescribes the CQA activities to be performed to monitor that cast-in-place concrete components are constructed in general accordance with *Construction Drawings* and *Technical Specifications*. The cast-in-place concrete construction procedures to be monitored by the CQA Consultant include:

- Subgrade preparation;
- Concrete lined storm water channels;
- Manholes; and
- Pipe Inlets and Outlets.

The Contractor will be responsible for submitting material qualification test results to the Construction Manager for review. The CQA Laboratory will perform the conformance testing and CQC testing. Cast-in-place concrete testing will be conducted in general accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) and American Concrete Institute (ACI) test procedures. The test methods and frequencies indicated in Table 12 are those that will be used for this testing unless the test methods are updated or revised prior to construction. Revisions to the test methods will be reviewed and approved by the Engineer and the CQA Site Manager prior to their usage.

14.2 Testing Activities

14.2.1 Compression Test

The Contractor shall facilitate the CQA Site Manager, or designee, in the collection of samples required for testing. Compression test specimens shall be prepared by the CQA Site Manager by the following method:

- compression test cylinders from fresh concrete in accordance with ASTM C 31.

Compression testing shall be completed on one cylinder at 7 days, one cylinder at 14 days, and two (2) cylinders at the 28 day strength. The CQA Site Manager will examine results from laboratory conformance testing and will report any non-conformance with the requirements outlined in the Technical Specifications to the Construction Manager.

14.2.2 Slump Test

The Contractor shall facilitate the CQA Site Manager, or designee, in the collection of samples required for testing. Slump test specimens shall be prepared by the CQA Site Manager by the following method:

- slump testing from fresh concrete in accordance with ASTM C 172.

The CQA Site Manager will examine results from conformance testing and will report any non-conformance with the requirements outlined in the Technical Specifications to the Construction Manager.

14.2.3 Flexural Strength

The Contractor shall facilitate the CQA Site Manager, or designee, in the collection of samples required for testing. Flexural strength test specimens shall be prepared by the CQA Site Manager by the following method:

- flexural strength testing from fresh concrete in accordance with ASTM C 293.

The CQA Site Manager will examine results from laboratory conformance testing and will report any non-conformance with the requirements outlined in the Technical Specifications to the Construction Manager.

14.2.4 Sample Frequency

The frequency of concrete sampling shall be in accordance with Table 12.

14.3 CQA Monitoring Activities

14.3.1 Subgrade Preparation

The CQA Site Manager, or designee, will monitor and document that the subgrade is prepared in accordance with the Technical Specifications and the Construction Drawings.

14.3.2 Concrete Installation

The CQA Site Manager, or designee, shall test, monitor, and document that the cast-in-place concrete is installed in accordance with the requirements of the Technical Specifications and the Construction Drawings. At a minimum, the CQA Site Manager, or designee, shall review the concrete tickets prior to installing the concrete to monitor that the concrete meets the requirements outlined in the Technical Specifications.

14.4 Deficiencies

If a defect is discovered in the cast-in-place concrete, the CQA Site Manager will immediately determine the extent and nature of the defect. The CQA Site Manager will determine the extent of the defective area by additional observations, a review of records, or other means that the CQA Site Manager deems appropriate.

14.4.1 Notification

After evaluating the extent and nature of a defect, the CQA Site Manager will notify the Construction Manager and Contractor and schedule appropriate re-evaluation when the work deficiency is to be corrected.

14.4.2 Repairs

The Contractor will correct deficiencies to the satisfaction of the CQA Site Manager. If a project specification criterion cannot be met, or unusual weather conditions hinder work, then the CQA Site Manager will develop and present to the Construction Manager suggested solutions for his approval.

Re-evaluations by the CQA Site Manager, or designee, shall continue until the defects have been corrected before any additional work is performed by the Contractor in the area of the deficiency.

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15. SURVEYING

15.1 Survey Control

Survey control will be performed by the Contractor. A permanent benchmark will be established for the site(s) in a location convenient for daily tie-in. The vertical and horizontal control for this benchmark will be established within normal land surveying standards.

15.2 Precision and Accuracy

A wide variety of survey equipment is available for the surveying requirements for these projects. The survey instruments used for this work should be sufficiently precise and accurate to meet the needs of the projects. Surveys shall be performed at 2nd order accuracy.

15.3 Lines and Grades

The following surfaces will be surveyed to verify the lines and grades achieved during soil placement and compaction.

- Excavation:
 - original grade surface;
 - completed excavation surface prior to fill placement.
- Engineered Fill:
 - subgrade surface; and
 - finished compacted engineered fill surface.
- Prepared Subgrade:
 - prepared subgrade surface.
- Cover Soil:
 - finished compacted cover soil surface.

The following structures will be surveyed to verify and document the lines and grades achieved during construction of the Project:

- all culverts, inlet, and drop structures;
- ditch bottoms and sideslopes;
- permanent erosion control features;
- geomembrane terminations and selected geomembrane seams, as indicated by the CQA Manager; and
- centerlines of pipes.

15.4 Frequency and Spacing

Surveying should be carried out immediately upon completion of a given installation to facilitate progress and avoid delaying commencement of the next installation. In addition, spot checks during placement and compaction will be necessary to assist the Contractor in compliance with required grades.

At the least the following minimum spacings and locations should be provided for survey points:

- all “flat” surfaces, such as the base of the landfill, with gradients less than 10 percent, should be surveyed on a square grid not wider spaced than 100 ft (30 m);
- on all slopes greater than 10 percent, a square grid not wider than 100 ft (30 m) should be used, but in any case, a line at the crest, midpoint, and toe of the slope should be taken;
- a line of survey points no further than 100 ft (30 m) apart must be taken along any slope break (this will include the inside edge and outside edge of any bench on a slope); and
- a line of survey points no further than 50 ft (15 m) apart must be taken at the invert of pipes or other appurtenances to the liner.

15.5 Documentation

Field survey notes should be retained by the Land Surveyor. The findings from the field surveys should be documented on a set of Survey Record Drawings, which shall be provided to the Engineer in AutoCADD 2004 format or other suitable format as directed by the Construction Manager.

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TABLE 1
TEST PROCEDURES FOR THE EVALUATION OF SOILS

TEST METHOD	DESCRIPTION	TEST STANDARD
<u>Laboratory Test Procedures:</u>		
Classification	Classification of Soils	ASTM D 2487
Moisture Content	Moisture Content	ASTM D 2216 ASTM D 4643
Modified Proctor	Moisture/Density Relationship of Soil (10 lb (4.54 kg) rammer and 18 in. (457 mm) drop)	ASTM D 1557
Hydrometer Analysis	Particle Size Distribution of Fine Fraction of Soils	ASTM D 422
Atterberg Limits	Plasticity of Soils	ASTM D 4318
Sieve Analysis	Particle Size Distribution of Coarse Fraction of Soils	ASTM D 422
Consolidated Undrained	Shear Strength of Cover Soil on Side Slopes	ASTM D 4767
One-Dimensional Consolidation	Consolidation and leachate generation potential of in-place Waste Material	ASTM D 2435
<u>Field Test Procedures:</u>		
Nuclear Densometer	In Situ Soil Unit Weight In Situ Moisture Content	ASTM D 2922 ASTM D 3017
Rubber Balloon Method	In Situ Soil Unit Weight In Situ Moisture Content	ASTM D 2167
Sand Cone	In Situ Soil Unit Weight Moisture Content	ASTM D 1556 ASTM D 2216
Drive Cylinder	In Situ Soil Unit Weight Moisture Content	ASTM D 2937 ASTM D 2216

TABLE 2

**MINIMUM SOILS TESTING FREQUENCIES
FOR MATERIAL QUALIFICATION TESTING**

TEST	ENGINEERED FILL AND COVER SOIL
Moisture Content	1 per source
Sieve Analysis	1 per source
Hydrometer Analysis	1 per source
Atterberg Limits	1 per source
Soil Classification	1 per source
Modified Proctor	1 per source
Consolidated Undrained	1 per source for cover side slope

TABLE 3**MINIMUM SOILS TESTING FREQUENCIES
FOR CONFORMANCE TESTING**

TEST	ENGINEERED FILL AND COVER SOIL	WASTE MATERIALS
Moisture Content	1 per 10,000 yd ³ (7,646 m ³)	1 per distinct type of material or contaminated soil to be placed in the CAMU
Sieve Analysis	1 per 10,000 yd ³ (7,646 m ³)	--
Hydrometer Analysis	1 per 10,000 yd ³ (7,646 m ³)	--
Atterberg Limits	1 per 10,000 yd ³ (7,646 m ³)	--
Soil Classification	1 per 10,000 yd ³ (7,646 m ³)	--
Modified Proctor	1 per 10,000 yd ³ (7,646 m ³)	1 per distinct type of material or contaminated soil to be placed in the CAMU

TABLE 4

**MINIMUM SOIL TESTING FREQUENCIES FOR
CONSTRUCTION QUALITY CONTROL**

TEST	ENGINEERED FILL AND COVER SOIL	WASTE MATERIAL
Nuclear densometer ⁽¹⁾	1 per 500 yd ³ (76 m ³)	1 per 2,500 yd ³ (765 m ³)
Sand cone or drive cylinder	1 per 20 nuclear densometer tests	--
Moisture Content	--	1 per 10,000 yd ³ (7,646 m ³)
Shelby Tube – One Dimensional Consolidation Test ⁽²⁾	--	1 per 50,000 yd ³ (38,230 m ³)

- Notes: (1) Nuclear densometer testing of the first lift of cover soil placed above the final cover system geosynthetics shall be performed at a depth no greater than 6 in. (i.e., 8-in. deep hole in 12-in. thick cover).
- (2) Consolidation test to be performed to demonstrate liquids are not squeezed out of waste soils. Normal stress for test shall be equivalent to final depth of sample (based on final cover system topography) multiplied by unit weight of overlying waste and cover system materials.

TABLE 5

TEST PROCEDURES FOR THE EVALUATION OF AGGREGATE

TEST METHOD	DESCRIPTION	TEST STANDARD
Sieve Analysis	Particle Size Distribution of Fine and Coarse Aggregates	ASTM C 136
Hydraulic Conductivity (Rigid Wall Permeameter)	Permeability of Aggregates	ASTM D 2434

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TABLE 6

**MINIMUM AGGREGATE TESTING FREQUENCIES FOR
MATERIAL QUALIFICATION TESTING**

TEST	DRAINAGE AGGREGATE
Sieve Analysis	1 per source
Hydraulic Conductivity	1 per source

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TABLE 7

**MINIMUM AGGREGATE TESTING FREQUENCIES FOR
CONFORMANCE TESTING**

TEST	TEST METHOD	DRAINAGE AGGREGATE
Sieve Analysis	ASTM C 136	1 per 5,000 yd ³ (3,823 m ³)
Hydraulic Conductivity	ASTM D 2434	1 per 10,000 yd ³ (7,646 m ³)

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TABLE 8**GEOMEMBRANE CONFORMANCE TESTING REQUIREMENTS**

TEST NAME	TEST METHOD	FREQUENCY
Specific Gravity	ASTM D 792 Method A or ASTM D 1505	100,000 ft ² (9,290 m ²)
Thickness	ASTM D 5994	100,000 ft ² (9,290 m ²)
Tensile Strength at Yield	ASTM D 638	100,000 ft ² (9,290 m ²)
Tensile Strength at Break	ASTM D 638	100,000 ft ² (9,290 m ²)
Elongation at Yield	ASTM D 638	100,000 ft ² (9,290 m ²)
Elongation at Break	ASTM D 638	100,000 ft ² (9,290 m ²)
Carbon Black Content	ASTM D 1603	100,000 ft ² (9,290 m ²)
Carbon Black Dispersion	ASTM D 5596	100,000 ft ² (9,290 m ²)

TABLE 9**GEOTEXTILE CONFORMANCE TESTING REQUIREMENTS**

TEST NAME	TEST METHOD	MINIMUM FREQUENCY FILTRATION	MINIMUM FREQUENCY UV PROTECTION
Grab Strength	ASTM D 4632	1 test per 200,000 ft ² (18,580 m ²)	---
Puncture Resistance	ASTM D 4833	1 test per 200,000 ft ² (18,580 m ²)	---
Permittivity	ASTM D 4491	1 test per 200,000 ft ² (18,580 m ²)	---
Apparent Opening Size	ASTM D 4751	1 test per 200,000 ft ² (18,580 m ²)	1 test per 200,000 ft ² (18,580 m ²)
Wide Width Tensile	ASTM D 4595	---	1 test per 200,000 ft ² (18,580 m ²)

TABLE 10

GCL CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Mass per Unit Area	ASTM D 3776	100,000 ft ² (9,290 m ²)
Index Flux	ASTM D 5887	400,000 ft ² (37,160 m ²)
Residual Shear Strength	ASTM D 5321	400,000 ft ² (37,160 m ²)

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TABLE 11

GEOCOMPOSITE CONFORMANCE TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM FREQUENCY
Peel Strength	ASTM D 413	1 test per 200,000 ft ² (18,580 m ²)
Hydraulic Transmissivity	ASTM D 4716	1 test per 200,000 ft ² (18,580 m ²)

Note: Testing will be carried out at a frequency of one per lot or at listed frequency, whichever yields the greater number of samples.

TABLE 12

CONCRETE TESTING REQUIREMENTS

Test Name	Test Method	Frequency
Compressive Strength	ASTM C 39	4 Cylinders per 75 or less cubic yards ¹
Slump Test	ASTM C 172	1 per 20 or less cubic yards
Test of Flexural Strength of Concrete	ASTM C 293	1 per 300 cubic yards

Note:

1 - One (1) additional test cylinder will be taken during cold weather (< 40 degrees F). Cylinders shall be cured on site under the same conditions as the concrete it represents.