CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

PLANT BOWEN ASH POND 1 (AP-1) CLOSURE

BARTOW COUNTY, GEORGIA

FOR

Georgia Power

REVISION 1 – JUNE 2025

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LIST OF ACRONYMS

ASTM	ASTM International
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CQA	Construction Quality Assurance
CQC	Construction Quality Control
GA EPD	Georgia Environmental Protection Division
GCL	Geosynthetic Clay Liner
GAI-LAP	Geosynthetic Accreditation Institute-Laboratory Accreditation Program
GPC	Georgia Power Company
GRI	Geosynthetic Research Institute
GSI	Geosynthetic Institute
HDPE	High Density Polyethylene
LCRS	Leachate Collection and Removal System
LGP	Low Ground Pressure
LL	Liquid Limit
LLDPE	Linear-Low Density Polyethylene
MQC	Manufacturer Quality Control
PCM	Project Construction Manager
PI	Plasticity Index
QA	Quality Assurance
QC	Quality Control

1. INTRODUCTION

1.1 OVERVIEW

This Construction Quality Assurance (CQA) Plan describes the quality assurance (QA) and quality control (QC) activities that will be undertaken during closure construction of Ash Pond 1 (AP-1) at Georgia Power Company's (GPC's) Plant Bowen in Bartow County, Georgia. The purpose of this document is to define the scope, procedures, and acceptance criteria necessary to perform QA tasks such that the construction elements of AP-1 closure (hereafter referred to as "the Project") comply with the design as shown or indicated in the approved permit documents including drawings, this CQA Plan, and any Georgia Environmental Protection Division (GA EPD)-approved design changes (collectively referred to as the "Permit Documents").

1.2 PROJECT DESCRIPTION

AP-1 will be closed using a consolidated lined closure approach for closure in place, whereby AP-1 coal combustion residuals (CCR) will be consolidated into an approximately 144-acre fully contained engineered structure (composite-lined and final covered area) that will be constructed in the south-central portion of the current AP-1. The Project will include the general activities described below:

- CCR removal, dewatering, consolidation, and placement;
- conducting foundation improvements in the to-be-lined consolidated area, including over-excavation of the residuum soil layer that underlies the impoundment, treatment of any cover-collapse features (i.e., depressions and/or drop outs), and placement of a compacted soil (structural fill) bridging layer;
- construction of earthen containment dikes for the final consolidated lined area;
- construction of a composite liner system, leachate collection and removal system (LCRS), final cover system, and associated stormwater management system features; and
- other general site work.

Note that many of the activities described above will be conducted in a phased and overlapping manner.

1.3 CQA PLAN SCOPE

CQA services will be provided by a consulting engineering firm, reporting to the Owner, specializing in the inspection and testing of soils and geosynthetics. The scope of this CQA Plan includes:

- defining the qualifications and responsibilities of the CQA Consultant;
- establishing testing protocols for the evaluation of the closure components;
- establishing procedures for construction documentation; and
- establishing procedures for providing final documentation verifying that the construction conforms to the Permit Documents.

This CQA Plan also presents the required acceptance criteria for materials that will be used during closure construction.

2. CQA PLAN DEFINITIONS

2.1 CONSTRUCTION QUALITY ASSURANCE AND CONSTRUCTION QUALITY CONTROL

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 actions taken by an organization that operates separately from the Contractor and the Owner (i.e., independent party) to verify that construction materials and/or services achieve compliance with technical (i.e., design), contractual, and regulatory requirements. This generally involves observation, review of submitted test results by others, and conducting independent testing to verify conformity of the various components of the Project with applicable requirements of the Permit Documents.

- Manufacturer Quality Control/Construction Quality Control (MQC/CQC) – A planned system of actions taken by the Contractor, Manufacturers, and Installers to monitor, check, and control the quality of their own work (verify that they are supplying materials and providing the workmanship required by the Permit Documents). In some cases, CQC services may be performed "in-house" by the Contractor, and other times CQC services are subcontracted to an outside consultant hired by the Contractor. **MQC** refers to QC functions performed by Manufacturers, and **CQC** refers to QC functions performed by construction contractors and installers.

2.2 CONFORMANCE TESTING AND PERFORMANCE TESTING

In the context of this document, conformance testing and performance testing are defined as follows:

- Conformance Testing – Testing performed to evaluate whether a construction material (e.g., soil, aggregate, geosynthetic, or other material) to be used on the Project possesses properties and characteristics that are in conformance with the specified parameters. By definition, conformance testing is conducted before a material is installed.

- Performance Testing – Testing performed on a completed work product to evaluate whether the construction material (e.g., soil, aggregate, or geosynthetic) as-constructed/installed possesses properties and characteristics that are in conformance with the specified performance parameters and work product acceptance criteria.

3. PERSONNEL

3.1 CQA CONSULTANT

3.1.1 Definition

The CQA Consultant is the party, retained by the Owner, but not affiliated with the Owner or the Contractor, responsible for observing and documenting CQC activities, reviewing CQC/MQC submittals prepared by the Contractor/Manufacturer related to the Project, and performing CQA activities as described in this CQA Plan. The qualifications and responsibilities of the CQA Consultant are described below. Resumes and qualifications, including experience with projects of similar type, size and complexity, will be provided to the Owner for their review and approval.

3.1.2 Qualifications

The CQA Consultant will:

- have specialized experience in the design of geo-environmental infrastructure involving earthwork, waste materials management, geosynthetics and piping installations, project-site water management, revegetation, containment (lining) systems, and final cover systems, and CQA of these components;

- possess the equipment, personnel, and licenses necessary to conduct the monitoring required by this CQA Plan and the Construction Documents;

- be experienced in the review of Contractor submittals for conformance with the Project requirements and in the resolution of non-conformances; and

- be experienced in the preparation and/or review of CQA documentation including CQA plans, field documentation, field testing procedures, laboratory testing procedures, technical specifications, technical drawings, and CQA certification reports.

The CQA Consultant organization will be led by the CQA Certifying Engineer, who will be a Professional Engineer registered to practice in the state of Georgia. The CQA Site Manager will be the on-site representative of the CQA Consultant and will have experience in construction activities required for the Project.

3.1.3 Responsibilities

The CQA Consultant will be responsible for:

- reviewing the Construction Documents prior to the start of the construction;
- monitoring the compliance of construction materials and manufactured products (e.g., geosynthetics) delivered to the site with the CQC/MQC submittals and conformance requirements and/or shop drawings previously reviewed and approved by the Design Engineer;
- monitoring that the Contractor's construction methods and workmanship are performed in accordance with the Construction Documents;
- performing on-site field and/or laboratory QA testing;
- maintaining calibration certificates of field-testing equipment in the CQA Consultant's on-site project file;
- reviewing field and laboratory CQC/MQC test results in a timely manner so as not to impede or delay construction activities; and
- promptly notifying the Owner of any nonconformances of the Contractor's work with any requirements of the Project, including those requirements related to the prompt delivery of CQC/MQC results to the CQA consultant.

The specific duties of the individual CQA personnel are discussed in the following subsections.

3.1.3.1 CQA Certifying Engineer

The CQA Certifying Engineer:

- reviews this CQA Plan and other relevant Permit Documents;
- attends scheduled meetings related to Project construction quality activities;
- administers the CQA program (i.e., assigns and manages all on-site CQA personnel, reviews all field reports, provides engineering review of all CQA-related activities);
- provides quality control of CQA documentation;
- reviews and documents changes to the design during construction; and
- prepares and seals the CQA Certification Reports.

3.1.3.2 CQA Site Manager

The CQA Site Manager:

- serves as the on-site representative of the CQA Consultant;
- familiarizes themself and all CQA field technicians with the site, this CQA Plan, and other relevant Permit Documents;
- manages the daily activities of the CQA field technicians;
- attends regularly scheduled CQA-related meetings on-site;
- reviews the ongoing preparation of the construction record drawings;
- reviews test results, certifications, and documentation provided by the Contractor, Geosynthetics Manufacturer, and Installer and makes appropriate recommendations;
- reviews the CQA field technicians' daily notes and logs;
- prepares a daily report for the Project;
- reviews the results of field and laboratory testing and makes appropriate recommendations;
- reports any unresolved deviations from the CQA Plan and Permit Documents to the Construction Manager and CQA Certifying Engineer;
- assists with the preparation of the CQA Certification Reports;
- reviews the Geosynthetics MQC documentation; and
- performs duties of CQA field technician, as needed.

3.1.3.3 CQA Field Technicians

CQA field technicians:

- monitor material stockpiles for any deterioration of materials;
- monitor surface-water drainage in the areas of soil and geosynthetic material stockpiles;

- monitor and test foundation improvement and earthwork placement and compaction operations;
- monitor the unloading, storage, and on-site handling of the geosynthetics;
- monitor geosynthetic material deployment and installation operations;
- monitor geosynthetic repair operations;
- assist with the collection and shipping of laboratory test samples;
- document any on-site activities that could result in damage to the soils or geosynthetic components of the construction and report them as soon as practical to the CQA Site Manager;
- prepare notes and logs; and
- report problems to the CQA Site Manager.

3.2 CQA EARTHWORK LABORATORY

3.2.1 Definition

The CQA Earthwork Testing Laboratory (CQA Earthwork Laboratory) is a party of the CQA Consultant and will be responsible for conducting CQA geotechnical laboratory testing in accordance with standards referenced in this CQA Plan. The testing results generated by the CQA Earthwork Laboratory will be used by the CQA Consultant to verify compliance of the earthwork with this CQA Plan.

3.2.2 Qualifications

The CQA Earthwork Laboratory will be experienced in testing soils and CCR using methods in accordance with ASTM International (ASTM) and other applicable soil test standards. The CQA Earthwork Laboratory will hold current, appropriate industry certification(s)/accreditation(s). The CQA Earthwork Laboratory will be capable of providing test results within a maximum of seven (7) working days of receipt of samples, except for those tests that require longer durations to perform, and will maintain that capability throughout the duration of the earthwork construction.

Prior to construction, the CQA Earthwork Laboratory will be required to submit their qualifications and QA/QC procedures to the CQA Consultant and the Owner for review and comment.

3.3 CQA GEOSYNTHETICS LABORATORY

3.3.1 Definition

The CQA Geosynthetics Testing Laboratory is a party of the CQA Consultant and will be responsible for conducting tests on samples of geosynthetic materials used in the construction in accordance with standards referenced in this CQA Plan. The testing results generated by the CQA Geosynthetics Laboratory will be used by the CQA Consultant to verify compliance of the geosynthetic materials with this CQA Plan.

3.3.2 Qualifications

The CQA Geosynthetics Laboratory will be currently accredited by the Geosynthetic Institute (GSI) under their Geosynthetic Accreditation Institute-Laboratory Accreditation Program (GAI-LAP), be approved by the CQA Certifying Engineer and the Owner, and have experience in testing the types of geosynthetics to be used for the Project. The CQA Geosynthetics Laboratory will be familiar with ASTM and other applicable geosynthetic test standards. The CQA Geosynthetics Laboratory will be capable of providing destructive test results for geomembrane field seams within 24 hours of receipt of samples and will maintain that capability throughout the duration of geosynthetic material installation.

Prior to construction, the CQA Geosynthetics Laboratory will be required to submit their qualifications and QA/QC procedures to the CQA Consultant and the Owner for review and comment.

3.4 CQC PERSONNEL

3.4.1 Definition

The Contractor is responsible for supplying materials and providing the workmanship as required by the Construction Documents. The Construction Documents may include required CQC activities for certain components of the Project, and/or may give the Contractor the option to develop a CQC program for control of their own work. Under this approach, if the Contractor implements a CQC program, they may perform CQC activities “in-house”, or may subcontract these activities to an outside party. Whether in-house or subcontracted, the individuals assigned to perform CQC on the Contractor’s behalf are referred to herein as “CQC Personnel”.

3.4.2 Qualifications

CQC Personnel should be experienced in the CQC of earthwork, geosynthetics, piping systems, and other activities required for the Project. CQC Personnel

should also possess the necessary equipment and materials to conduct CQC activities on behalf of the Contractor. CQC Personnel should be experienced in the preparation and/or review of CQC documentation including manufacturer and supplier documentation, field documentation, field testing procedures, and laboratory testing procedures and results.

3.5 DESIGN ENGINEER

The Design Engineer is the engineer-of-record responsible for the AP-1 Closure Design. The Design Engineer will be a Professional Engineer registered in the state of Georgia. The Design Engineer will be responsible for:

- approving all design and specification changes and making design clarifications that may be required during construction;
- assisting the Construction Manager in reviewing and approving the Contractor's shop drawings and submittals, as necessary;
- periodically visiting the site during construction and attending the project coordination meetings, as required, to verify conformance with the Permit Documents; and
- discussing and interpreting all elements of the design and having the authority to recommend changes or modifications to the Permit Documents for approval by the Owner and GA EPD, as required.

The CQA Consultant and Design Engineer may be from the same organization.

3.6 SURVEYOR

The Surveyor is the party acceptable to the Owner and retained by the Contractor or Owner, as applicable, who will be responsible for performing surveying activities and issuing survey products in accordance with the Construction Documents, and for signing and sealing the construction survey record drawings. The Surveyor will be a State of Georgia licensed Professional Land Surveyor, with personnel experienced in the provision of surveying services and their detailed documentation. The Owner may also retain a third-party surveyor, having similar qualifications, to perform verification surveys.

3.7 CONSTRUCTION MANAGER

The Project Construction Manager (PCM), hereafter referred to simply as the Construction Manager, is an individual, appointed by the Owner, who will serve as the Owner's representative and who will be responsible for overall management of the construction Project. The Construction Manager will give direction to the Contractor. The

CQA Consultant will provide the Construction Manager with notifications, reports, and monitoring logs as requested and as described further throughout this CQA Plan.

3.8 CONTRACTOR

The term "Contractor" refers to the General Contractor (i.e., the Prime Contractor) who is retained by the Owner to conduct the AP-1 closure construction. In general, the Contractor will be responsible for furnishing and installing materials in accordance with the Construction Documents (unless certain items may be procured and/or installed under separate contracts with or on behalf of the Owner). In this role, the Contractor will be responsible for earthwork activities, CCR excavation and placement activities, installation of lined cells and their leachate management systems, installation of the final cover system, and constructing associated surface water management features and other related site work. The Contractor may subcontract with various parties to conduct certain portions of the Project (e.g., geosynthetic Installer(s)). The Owner will select a Contractor qualified for this Project through experience constructing projects involving similar work elements, and with personnel and equipment availability as needed to execute a project of this magnitude.

As set forth in the Construction Documents, the Contractor will prepare various Work Plans for approval by the Owner. During construction, the Contractor will work with the Owner/Construction Manager to develop an approved schedule, execute the work according to that schedule, and communicate the timing of key milestones/activities with appropriate project parties (e.g., CQA Consultant). Note that the preceding description of the Contractor's roles and responsibilities is only a general summary and does not represent the comprehensive scope of work required by the Construction Documents.

3.9 GEOSYNTHETICS MANUFACTURERS AND INSTALLERS

Geosynthetics are manufactured materials. The Manufacturers who supply geosynthetic materials for this Project (either procured by the Contractor or procured by the Owner) are responsible for the manufacture/fabrication of such materials and for quality control during manufacture/fabrication. The Manufacturer(s) of the geomembrane components of the base liner and final cover systems should have experience manufacturing at least ten million square feet of such geomembranes.

The geosynthetic Manufacturers must implement an MQC program. MQC refers to actions taken at their manufacturing facility (i.e., prior to shipment to the jobsite) to control the quality of their products and to monitor/verify that the materials and workmanship of the geosynthetics meet the Project requirements as set forth herein and in the Construction Documents. The MQC program will be conducted by MQC personnel who are stationed at the manufacturing facility (i.e., employed or contracted by the Manufacturer), and overseen by an MQC manager.

Manufactured geosynthetics products are placed and installed in the field by an Installer, who will be subcontracted by the Contractor. The Installer responsible for the installation of the liner system and final cover system geomembrane components should have experience installing at least five million square feet of such geomembranes.

4. DOCUMENTATION

4.1 OVERVIEW

The CQA Consultant will prepare and retain necessary documentation related to the CQA monitoring activities performed, including review and evaluation of CQC daily reports, if any, and other submittals provided by the Contractor. The CQA Site Manager will provide these records to the Construction Manager as requested. The CQA Site Manager will also maintain a complete file of the Construction Documents, CQA Plan, Contractor's QC Plan(s), Work Plans, checklists, test procedures, daily field reports, QC data sheets and logs, and other pertinent design, construction, and CQA documentation at the site. All such documentation and related data files described in this CQA Plan will be maintained by the CQA Consultant in an organized, complete, and up-to-date manner.

4.2 DAILY RECORD KEEPING

The CQA Consultant's daily reporting procedures will include: (i) daily field report; (ii) monitoring logs; (iii) photographs; (iv) testing data sheets; and (v) when appropriate, non-conformance and corrective measures reports.

4.2.1 Daily Field Reports

The CQA Consultant's daily field reports will include the following information as applicable:

- date, project name, location, and other pertinent project identifiers;
- weather conditions;
- site equipment and personnel on-site (including the CQA personnel);
- summary of meetings held and their results;
- a list of off-site materials received, including a list of all QA/QC documentation received;
- process description(s) and location(s) of construction activities underway during the time frame of the report;
- descriptions and specific locations of areas, of work being tested and/or observed and documented;
- descriptions, maps, or sketches of locations where tests and samples were taken;

- a narrative summary of field test results;
- decisions made regarding acceptance of work, and/or corrective actions to be taken in instances of substandard testing results; and
- reference to data sheets and non-conformance reports used to substantiate the non-conformances described above.

4.2.2 Monitoring Logs, Test Data Sheets, and Photographs

The CQA Consultant will record CQA monitoring observations and test results on appropriate monitoring logs and test data sheets, respectively. The CQA Consultant will use the monitoring logs and test data sheets to track completeness of the required CQA activities.

The CQA Consultant's monitoring logs will include the following information as applicable:

- project specific information such as project name, location, and other pertinent project identifiers;
- the date the CQA activity was performed;
- a unique identifying sheet number for cross-referencing and document control;
- description or title of the CQA activity, along with the location and type of activity;
- recorded observation or test data;
- results of the CQA activity and comparison with specification requirements (pass/fail); and
- the initials or signature of personnel involved in CQA inspection activity.

The CQA Consultant will maintain separate monitoring logs to track and catalog any QC information received from the Contractor and to document conformance or nonconformance of the information with the requirements of the Permit Documents. The CQA Consultant will also maintain a log of periodic photographic documentation obtained as a pictorial record of construction.

4.2.3 Non-conformance and Corrective Measures Reporting

A non-conformance is defined herein as material or workmanship that does not meet the specified requirement(s) contained in this CQA Plan and the Permit Documents. The CQA Consultant will prepare non-conformance and corrective measures reports as needed and will cross-reference the reports to specific daily field reports or monitoring logs where the non-conformance was identified. The reports will include the following information, as applicable:

- a unique identifying sheet number for cross-referencing and document control;
- detailed description of the problem;
- location of the problem;
- probable cause;
- how and when the problem was located;
- estimation of how long problem has existed;
- suggested corrective measures;
- documentation of corrections (referenced to test data sheets);
- suggested methods to prevent similar problems; and
- signature of the appropriate CQA field technicians and the CQA Site Manager.

The CQA Consultant will inform the Construction Manager in writing of any significant recurring non-conformance with this CQA Plan and the Permit Documents. It will be the responsibility of the Construction Manager to direct the Contractor to make appropriate changes in materials or procedures to correct the non-conformance. The CQA Consultant will document the corrective actions taken to mitigate non-conformances.

4.3 CQA CERTIFICATION REPORT

At the completion of each major construction phase of the Project (e.g., completion of CCR removal for a section of AP-1, completion of lined cells, or completion of an increment of final cover system installation), the CQA Consultant will provide the Owner with a CQA Certification Report pertaining to that construction phase, for submittal to GA EPD. This report will acknowledge that: (i) the work has been performed in compliance with the Permit requirements; (ii) physical sampling and testing has been conducted with

appropriate standards and at required minimum frequencies as set forth in this CQA Plan; (iii) the Contractor's CQC and Manufacturer's MQC documentation is in conformance with the submittal requirements; and (iv) the test results met the minimum requirements defined in this CQA Plan; and (v) the phase covered by that CQA Certification Report was constructed in accordance with the GA EPD permit.

At a minimum, the CQA Certification Report will include:

- summary of CQA activities;
- daily field reports;
- monitoring logs;
- QA and QC test data sheets (summary sheets/tabulations) including sample locations;
- QA and QC certifications and laboratory test results;
- non-conformance and corrective measures reports;
- documentation of design clarifications or revisions; and
- a summary statement indicating compliance with the Permit requirements, CQA Plan, and any approved changes; and signed and sealed by the CQA Certifying Engineer.

The record drawings produced by the Surveyor will also be included as part of the CQA Certification Reports. In general, record drawings will include scaled drawings depicting the locations and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.) and geomembrane panel drawings. Required record drawings are listed below.

- For Work associated with CCR removal:
    - Bottom of Removed CCR
    - Bottom of Removed CCR Plus 6-Inches (minimum)
- For work associated with construction of the lined cells:
    - Bottom of Foundation Excavation
    - Liner Subgrade

- Top of Clay Liner (including thickness of clay liner)
- Geomembrane Liner Panel Layout Drawing
- Top of Granular Drainage Layer
- Leachate Management System

- For Work associated with each increment of the final cover system:
  - Top of CCR
  - Cover Geomembrane Panel Layout Drawing
  - Top of Final Cover (including thicknesses of protective soil and topsoil layers, if used)

5. EARTHWORK

5.1 INTRODUCTION

CQA monitoring will be performed during earthwork construction. This earthwork will include: (i) general earthwork for preparation of subgrade and installation of soil for the foundation improvement area, dikes, channels, roads, ponds, and ditches; (ii) installation of granular materials such as sand, gravel, base aggregate, and riprap; (iii) installation of soil components of the liner system for the consolidated lined area and stormwater ponds; and (iv) installation of soil components of the final cover system. Minimum acceptance criteria to be used for evaluation of acceptability of the various earthwork components are identified in Appendix A of this CQA Plan.

5.2 RECORD DRAWINGS AND AS-BUILT SURVEYS

During construction of the earthwork components, the CQA Consultant will routinely review record drawings submitted by the Contractor. Prior to the placement of successive soil or geosynthetic layers, the CQA Consultant will review as-built surveys that indicate compliance of the preceding layer thickness, limits, and grades with the Permit Documents.

5.3 FOUNDATION IMPROVEMENTS

During construction, the CQA Consultant will visually observe and document the Contractor's foundation improvement activities. The CQA Consultant will monitor and document that the foundation improvements are implemented to conform with the Permit Documents, including:

- proof-rolling over the entire bottom of excavation area;
- identification and characterization of cover-collapse features and soft spots;
- remediation of cover-collapse features as appropriate for the size and extent of the feature;
- excavation and backfilling around rock pinnacles or removal of the pinnacles; and
- ground improvement of soft areas.

It will be the responsibility of the CQA Consultant to delineate any areas of non-conformance and observe their mitigation to verify that acceptable conditions are achieved. Upon completion and approval/acceptance of the above activities, placement and compaction of soil fill for the bridging layer will commence, and the construction will be monitored, tested, and documented as set forth in the remainder of this section.

5.4 SUBGRADE

During construction, the CQA Consultant will monitor and document subgrade preparation to confirm that a firm and smooth surface free of vegetation and other deleterious materials is achieved Material placed to achieve design grades will be monitored and performance-tested by the CQA Consultant to verify that subgrade material properties, placement, grading, and compaction comply with the CQA Plan and the Permit Documents. The CQA Consultant will verify that subgrade acceptance certificates are prepared and signed by the Contractor and their Installer (and such forms also require signatures by the CQA Consultant and Purchaser) prior to the start of clay liner construction to indicate the parties' concurrence that the subgrade surface on which the clay liner will be constructed is acceptable.

It will be the responsibility of the CQA Consultant to delineate any areas of non-conformance and observe their mitigation to verify that acceptable results are achieved.

5.5 CONFORMANCE OBSERVATIONS AND TESTING

5.5.1 Conformance Observations

The CQA Consultant will observe the earthwork components to verify they are uniform and conform to the requirements of the CQA Plan and Permit Documents. For soil materials obtained from on-site sources, visual inspections will be performed by the CQA Consultant prior to the materials being used. If soil materials are obtained from off-site borrow sources, visual inspection may be performed by the CQA Consultant at the source location. Borrow area inspections may also be utilized by the CQA Consultant to verify that only suitable soil materials are transported to the site.

The CQA Consultant will confirm that granular materials (i.e., sand, gravel, base aggregate, and riprap) are certified by the Contractor's supplier to meet the requirements of the material type shown on the Permit Documents, specified in this CQA Plan, and are free of contamination. All materials failing to comply with conformance standards will be rejected for use at the site.

Initial on-site evaluation of various soil types by CQA personnel during construction will be largely by visual and manual methods; therefore, the CQA personnel will be experienced with visual and manual soil classification procedures.

5.5.2 Conformance Test Methods and Frequencies

Conformance testing to evaluate the suitability of soil and granular materials during construction will be performed by the CQA Consultant in accordance with current ASTM or other applicable test procedures. The specified methods and minimum

frequencies are presented for each soil and granular material in Appendix A of this CQA Plan. The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

5.6 CONSTRUCTION MONITORING

During installation of the earthwork components, the CQA Consultant will observe and document the earthwork components to verify they are installed in accordance with this CQA Plan and Permit Documents. The CQA Consultant will also evaluate the procedures, methods, and equipment used by the Contractor to install the earthwork components. This will include visual observation and documentation of the Contractor's earthwork activities for the following:

- changes in soil consistency;
- thickness of lifts as loosely placed and compacted;
- soil conditioning prior to placement including general observations regarding moisture distribution, clod size, etc.;
- condition of final surfaces;
- placement methods which may damage or cause displacement or wrinkling of geosynthetics;
- the action of the compaction and heavy hauling equipment on the construction surface (sheepsfoot penetration, pumping, cracking, rutting, etc.);
- the number of passes used to compact each lift; and
- desiccation cracks or the presence of ponded water.

5.7 PERFORMANCE TESTING

Performance tests that are used to evaluate the suitability of in-place constructed soil and granular components will be performed by the CQA Consultant in accordance with the current ASTM or other applicable test procedures. The specified methods and minimum frequencies are indicated in the tables for each material type, as presented in Appendix A.

The CQA Consultant may conduct additional performance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

5.8 DEFICIENCIES

If a deficiency (i.e., non-conformance of the materials or workmanship with the requirements of the CQA Plan and Permit Documents) is discovered in the earthwork construction, the CQA Consultant will assess the extent and nature of the deficiency by performing additional tests, observations, review of records, or other means that the CQA Consultant deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA Consultant will define the limits and nature of the defect.

If the deficiency cannot be resolved by the Contractor immediately or as soon as practical after identification, the CQA Site Manager will schedule appropriate re-tests for after the work deficiency is corrected.

The CQA Consultant will verify that:

- the Contractor has corrected all noted deficiencies before any additional work can be performed in the area of the deficiency; and
- if a specified criterion cannot be met because of site-specific reasons or unusual weather conditions hindering the work, the Contractor will submit suggested solutions or alternatives to the Design Engineer and Construction Manager for review.

5.9 DOCUMENTATION

CQA monitoring observations will be documented by the CQA Consultant on forms specifically designed for this purpose. Reports and forms will be submitted to the Construction Manager.

6. CCR REMOVAL AND PLACEMENT

6.1 INTRODUCTION

This section describes the construction oversight activities that will be performed by the CQA Consultant to verify the satisfactory removal of CCR from within AP-1, as detailed in Section 6.2, and subsequent placement into the consolidated lined area to the extent and grades shown on the Permit Documents.

In addition to the activities listed in the subsections below, the CQA Consultant will photograph the work being conducted and will document monitoring observations on forms specifically designed for this purpose.

6.2 CCR REMOVAL AND VERIFICATION PROTOCOL

6.2.1 Overview of Steps

CCR removal and verification in the CCR unit will be conducted in a three-step process:

1. Visible CCR will be excavated from the CCR unit footprint down to the interface between the CCR and the earthen perimeter dikes and the underlying residuum soil layer (anticipated to be the surface represented by the Bottom of AP-1 Grades shown on Closure Drawing 6 of 50). Visual observations and the Munsell Soil Color Chart will be used to confirm that all visible CCR has been excavated to the extent practicable from the former CCR unit footprint. The excavated CCR will be managed within the permit boundary by placing it within the AP-1 consolidated lined area for final closure; or the CCR may be managed by removal and reclamation for beneficial use, or removal for landfill disposal, per Section 9 of the Closure Plan.

2. A minimum of 6 inches of soil beneath the visible CCR will be excavated within the AP-1 footprint, provided its removal is feasible and is above rock. The excavated material will be managed in a similar way as described above.

3. If CCR is encountered in localized areas below excavation grades (e.g., karst features), it will be excavated to the extent practicable using conventional construction equipment. These areas will be mitigated as necessary to construct the foundation improvement measures in accordance with the Foundation Improvement Plan and as approved by the Design Engineer and CQA Certifying Engineer. The removed CCR will be managed in a similar way as described above.

6.2.2 Removal and Verification Field Procedures

Dewatered CCR from AP-1 will be mechanically excavated and transported to temporary stockpile areas or the consolidated lined area using haul trucks or other means. CCR removal activities will be observed and documented by the CQA Consultant. The CCR in AP-1 will be excavated to remove visible CCR plus a minimum 6-inch thickness of additional soil to the extent practicable (as described above in Section 6.2.1). Observations will be made with reference to a 100-foot by 100-foot alphanumeric grid system established for the Project so that each grid location is assigned a unique label for reference and documentation purposes. When the interface between the CCR and the underlying residuum soil layer is located during excavation, the following CCR removal verification protocol will be conducted:

- The excavated surface (bottom-of-CCR) will be jointly observed and documented to confirm removal of visible CCR by a representative of the Owner and CQA Consultant. Visual observations and the Munsell Soil Color Chart will be used as the basis to confirm that visible CCR has been excavated from the former CCR unit footprint to the extent practicable. At a minimum frequency of one per 100-foot grid, using the approximate centers of the 100-foot by 100-foot project grid system, the interface will be photographed by the CQA Consultant; and the area will be surveyed to develop a topographic map denoting the bottom-of-CCR across AP-1. A description of the residuum soil using the Unified Soil Classification System (ASTM D2488) together with a determination of the color of the residuum soil based on the Munsell Soil Color Chart will be documented by the CQA Consultant.

- Following the CQA Consultant's approval, concurrence by the Owner, and completion of the bottom-of-CCR survey, excavation will continue by removing at least six inches of additional soil (residuum) underlying the bottom of CCR to the extent practicable. Verification of removal thickness will be performed by the Surveyor by surveying the excavated area using the project grid system and comparing the final elevations to the surveyed bottom-of-CCR elevations. If excavation depths are found to be less than six inches by survey (provided that it is practicable to achieve the excavation, e.g., competent bedrock has not been encountered), the affected area(s) of the excavated surface will be jointly observed and documented consistent with the procedures in the first bullet point above. The CQA Consultant will confirm that the area has been re-excavated and re-surveyed and that the work conforms with the CQA Plan.

6.3 FOUNDATION IMPROVEMENTS

After completion and verification of CCR removal activities, foundation improvement activities will be monitored and documented by the CQA Consultant as described previously in Section 5.3 of this CQA Plan.

7. CONCRETE

7.1 INTRODUCTION

The CQA Consultant will monitor Contractor's construction and testing of concrete materials and finished products to verify compliance with the Permit Documents.

7.2 INSPECTIONS

The CQA Consultant will monitor concrete workmanship to verify that the Contractor does not place concrete until foundations, forms, reinforcing steel, pipes, conduits, sleeves, anchors, hangers, inserts, and other work required to be built into concrete has been inspected and approved by the CQA Consultant and Construction Manager.

7.3 FIELD QUALITY CONTROL TESTING

Testing to evaluate the conformance of fresh concrete and performance of as-placed concrete will be performed by the CQA Consultant in accordance with current ASTM or other applicable test procedures.

The CQA Consultant may conduct additional performance testing if deemed necessary by the Owner and/or CQA Certifying Engineer. Any nonconformances will be reported to the Contractor and Construction Manager.

8. GEOMEMBRANE

8.1 INTRODUCTION

The CQA Consultant will perform conformance and destructive seam testing, review the MQC documentation and test results, and monitor the installation of geomembranes to verify that the Manufacturer's specifications and the requirements of the Permit Documents and this CQA Plan are met. These procedures will be followed during installation of the geomembrane components of the base liner system and final cover system (including the geomembrane component of the ClosureTurf® system that may be used as an alternative final cover system).

8.2 MANUFACTURING PLANT VISIT

At the discretion of the Owner, the CQA Consultant may be requested by the Owner to visit the plant of the geomembrane Manufacturer to verify that MQC procedures are in conformance with the Construction Documents. If possible, such a visit will be performed prior to or during the manufacturing of the geomembrane rolls for the Project.

During the project-specific manufacturing plant visit, the CQA Consultant will:

- verify that the measurements of properties by the Manufacturer are properly documented, and test methods used are acceptable;
- spot-inspect the rolls and verify that they are free of holes, blisters, or any sign of contamination by foreign matter;
- review packaging and transportation procedures to verify that these procedures are not damaging the geomembrane;
- verify that all rolls are properly labeled; and
- verify that extrusion rods and/or beads manufactured for the field seaming of the geomembrane are derived from the same base resin type as the geomembrane.

Upon completion of the manufacturing plant visit, a report describing the findings and observations will be completed by the CQA Consultant and be included as an attachment to the final CQA Certification Report.

8.3 TRANSPORTATION, HANDLING, AND STORAGE

The CQA Consultant will monitor the transportation, handling, and storage of the geomembrane on the Project site. Upon delivery at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without unrolling the materials unless defects or damages

are found or suspected in the rolled material. The CQA Consultant will indicate to the Construction Manager:

- rolls, or portions thereof, that will be rejected and removed from the site because they have severe or non-repairable flaws that may compromise geomembrane quality; and
- rolls that include minor and repairable flaws that do not compromise geomembrane quality.

The CQA Consultant will also monitor that equipment used to handle the geomembrane on-site is adequate and does not pose any risk of damage to the geomembrane during handling.

8.4 MANUFACTURER QC (MQC) TESTING AND CQA CONSULTANT CONFORMANCE TESTING

8.4.1 Geomembrane Material MQC Testing Requirements

The geomembrane Manufacturer will perform QC testing on the geomembrane materials and panels that will be used on this Project in accordance with the current versions of the ASTM and other applicable test procedures, and at the minimum MQC frequencies presented in the Appendix B tables corresponding to each geomembrane material type that will be used.

The CQA Consultant will review the MQC certifications and test results to verify that the Manufacturer's specifications and the CQA Plan requirements are met. The conformance testing program that will be conducted by the CQA Consultant is described subsequently.

8.4.2 Geomembrane Conformance CQA Testing Requirements

The CQA Consultant will coordinate, and a qualified laboratory (i.e., the CQA Geosynthetics Laboratory) will perform, geomembrane CQA testing to evaluate the conformance of the geomembrane with the CQA Plan requirements. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies presented in the Appendix B tables corresponding to each geomembrane material type that will be used.

The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

8.4.3 Test Results

All MQC and conformance test results will be reviewed, accepted, and reported by the CQA Consultant before deployment of the geomembrane. Any non-conformance of the material properties with the CQA Plan requirements will be reported to the Contractor and Construction Manager.

8.4.4 Test Failure

In the case of failing test results, the Contractor may request that another sample from the failing roll be re-tested. If the re-test fails or if the option to re-test is not exercised, then two isolation conformance samples will be obtained by the CQA Consultant. These isolation samples will be taken from rolls, which have been determined by correlation with the Manufacturer's roll number, to have been manufactured prior to and after the failing roll. This method for choosing isolation rolls for testing will continue until passing tests are achieved. All rolls that fall numerically between the passing roll numbers will be rejected.

The CQA Consultant will verify that the Contractor has replaced all rejected rolls. The CQA Consultant will document all actions taken in conjunction with geomembrane conformance failures.

8.5 GEOMEMBRANE SUBGRADE SURFACES AND ANCHOR TRENCHES

8.5.1 Geomembrane Subgrade Surfaces

The CQA Consultant will monitor, verify, and document that the subgrade surface on which the geomembrane will be placed (e.g., top of clay liner surface) is constructed in accordance with the Permit Documents and that CQA activities are performed as described below.

The geomembrane will not be placed on surfaces which are softened due to high water content or cracked due to desiccation. The CQA Consultant and the Installer will jointly verify that the surface on which the geomembrane will be installed is acceptable. The Contractor will comply with subgrade preparation and acceptance requirements, and the CQA Consultant will verify that subgrade acceptance certificates are prepared and signed by the Contractor and their Installer (and such forms also require signatures by the CQA Consultant and Purchaser to indicate the parties' concurrence that the surface is ready for deployment of geomembrane). Additionally, when the geomembrane will be directly-placed on the top of a clay liner surface, or directly-placed on top of CCR (for the alternative final cover system option), the surface will be firm, smooth, and uniform, and will meet the related final surface acceptance criteria given in Table A.2A, including but not limited to allowable protrusion size. For situations

where the geomembrane will be placed on a GCL, the GCL subgrade preparation requirements set forth herein (per Section 9.4) will apply. The CQA Consultant will notify the Contractor of any observed change in the supporting soil condition that may require repair work and verify that compacted soil repair work is properly completed, consistent with Section 5 of this CQA Plan.

8.5.2 Anchor Trenches

The CQA Consultant will monitor, verify, and document that each anchor trench has been constructed as shown in the Permit Documents. To confirm conformance, the CQA Consultant will:

- monitor that the anchor trench is constructed with a slightly rounded corner where the geosynthetics enter the trench and is backfilled as soon as possible after all geosynthetics are installed;
- perform in-place moisture/density testing of the compacted anchor trench backfill as required;
- observe that geosynthetic materials in the anchor trench are temporarily anchored with sand bags or other suitable methods if the trench will remain open after the installation of geosynthetics;
- monitor that no loose soils are left to underlie the geosynthetics in the anchor trench and all temporary ballast (i.e., sandbags) and deleterious materials are removed from the anchor trench prior to backfilling; and
- monitor that backfilling of the anchor trench is performed using extreme care when the geomembrane is in its most contracted state to minimize wrinkling and stress concentrations.

8.6 GEOMEMBRANE PLACEMENT

8.6.1 CQA Consultant Responsibility During Placement

The CQA Consultant will monitor, verify, and document that geomembrane placement is conducted in accordance with the Permit Documents; including this CQA Plan and CQA activities will be performed as described in the subsections below.

8.6.2 Field Panel Identification

A field panel is a piece of geomembrane larger than approximately 10 square feet (ft^2) that is to be seamed in the field, i.e., a field panel is a roll or a portion of roll

to be seamed in the field. The CQA Consultant will verify that each field panel is given an "identification code" (number or letter-number) that will:

- be selected as simple and logical as possible;
- be substantially consistent with the as-built layout plan; and
- allow tracing of the Manufacturer's roll numbers to the field panel identification code.

The CQA Consultant will document the correspondence between roll numbers, factory panels, and field panel identification codes. The field panel identification code will be used for all CQA records.

8.6.3 Field Panel Placement

The CQA Consultant will monitor that field panels are installed substantially at the location indicated in the Installer's layout plan, as approved or modified. The CQA Consultant will record the field panel identification code, Manufacturer's roll number, location, date of installation, time of installation, and dimensions of each field panel.

The CQA Consultant will monitor that geomembrane placement does not proceed:

- at an ambient temperature below 40°F or above 104°F unless authorized by the Design Engineer; or
- 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.

The CQA Consultant will monitor that the above conditions are fulfilled and that the supporting soil has not been damaged by adverse weather conditions. The CQA Consultant will monitor geomembrane deployment for conformance with the Permit Documents, including that:

- the geomembrane is deployed under acceptable temperature and weather conditions;
- any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means;
- the prepared surface underlying the geomembrane has not deteriorated since previous acceptance and is still acceptable immediately prior to geomembrane placement;

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

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

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

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

- adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind; and

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

The CQA Consultant will observe the geomembrane panels, after placement and prior to seaming, for damage. The CQA Consultant will advise the Construction Manager of any panels, or portions of panels, that should be rejected, repaired, or accepted. 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 Consultant. CQA for geomembrane repairs will be in accordance with Section 8.8.

8.7 FIELD PANEL SEAMING

8.7.1 CQA Consultant Responsibility During Seaming

The CQA Consultant will monitor, verify, and document that geomembrane panel layout and field panel seaming is conducted in accordance with this CQA Plan as further described in the subsections below.

8.7.2 Panel Layout

The CQA Consultant will review the panel layout drawing previously submitted to the Construction Manager by the Installer and verify that:

- seams are generally oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope;

- the number of seams is minimized in corners and odd-shaped geometric locations;

- a seam numbering system is used that is compatible with the field panel identification numbering system and is agreed upon by the CQA Consultant and the Installer prior to any seaming; and

- the panel layout is consistent with accepted state of practice.

8.7.3 Seaming Equipment and Products

The CQA Consultant will verify that only extrusion welding and fusion welding are used for field seaming. The CQA Consultant will document that any alternate process proposed by the Installer is reviewed and approved by the Design Engineer and Construction Manager.

The CQA Consultant will verify that no geomembrane seaming is performed unless the CQA Consultant is on-site. The CQA Consultant will monitor the general seaming procedure used as follows:

- the Installer uses of seaming equipment specifically recommended by the Geosynthetics Manufacturer by make and model, and marked with an identification number;

- the Installer uses of a firm substrate such as a flat board, a conveyor belt, or similar hard surface directly under the seam overlap, if required, to achieve proper support;

- the Installer cuts fishmouths or wrinkles at the seam overlaps along the ridge of the wrinkle in order to achieve a flat overlap;

- the Installer cuts fishmouths or wrinkles, and patches any portion, where the overlap is inadequate, with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions;

- the Installer/Contractor provides adequate illumination if seaming operations are carried out at night and

- the Installer extends seaming to the outside edge of panels to be placed in the anchor trench.

8.7.3.1 Fusion Process

The CQA Consultant will monitor ambient temperatures, geomembrane surface temperatures, apparatus speed, and apparatus temperatures at appropriate intervals. The CQA Consultant will also monitor that:

- the fusion-welding apparatus is an automated, self-propelled device;
- the fusion-welding apparatus is equipped with gauges giving the applicable temperatures and welding speed;
- the number of spare operable seaming apparatus agreed by the Construction Manager are maintained on-site;
- equipment used for seaming will not damage the geomembrane;
- the seaming zone is dry and clean;
- there is sufficient overlap between panels;
- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;
- for cross seams, the edge of the cross seam is cut or ground to a smooth incline (top and bottom) prior to welding;
- an insulating material is placed beneath the hot welding apparatus after usage; and
- a movable protective layer is used, as necessary, directly below each overlap of geomembrane that is to be seamed to prevent build-up of moisture between the sheets.

8.7.3.2 Extrusion Process

The CQA Consultant will verify that the extrudate is comprised of the same resin as the geomembrane sheeting. The CQA Consultant will monitor extrudate temperatures, ambient temperatures, and geomembrane surface temperatures at appropriate intervals.

The CQA Consultant will also monitor that:

- the extrusion-welding apparatus is equipped with gauges giving the temperature in the apparatus and at the nozzle;

- the number of spare operable seaming apparatus agreed by the Construction Manager are maintained on-site;
- equipment used for seaming is not likely to damage the geomembrane;
- the seaming zone is dry and clean;
- 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; and
- an insulating material is placed beneath the hot welding apparatus after usage.

8.7.4 Seam Preparation

The CQA Consultant will monitor that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
- seams are overlapped by a sufficient amount to allow for testing to be performed on the seam;
- if seam overlap grinding is required, the process is completed according to the Geosynthetics Manufacturer's instructions prior to the seaming operation, and in a way that does not damage the geomembrane;
- the grind depth, if made, does not exceed ten percent of the geomembrane thickness;
- grinding marks do not appear beyond the extrudate after it is placed; and
- seams are aligned with the fewest possible number of wrinkles and fishmouths.

8.7.5 Weather Conditions for Seaming

The CQA Consultant will monitor that the weather conditions for seaming are within the acceptable range, as follows:

- the ambient temperature is not below 40°F or above 104°F, unless authorized by the Design Engineer;

- geomembrane is preheated by either sun or hot air device between ambient temperatures of 40°F and 50°F prior to performing seaming; and

- geomembrane seam areas are dry and protected from rain and wind.

The CQA Consultant will verify and document that methods used by the Installer for seaming at ambient temperatures below 40°F or above 104°F will produce seams that are entirely equivalent to seams produced at ambient temperatures between 40°F and 104°F and will protect the overall quality of the geomembrane. The CQA Consultant will monitor that seaming conducted during abnormal weather conditions is performed in accordance with the methods approved by the Design Engineer.

8.7.6 Overlapping and Temporary Bonding

The CQA Consultant will monitor that:

- the panels of geomembrane have a finished overlap of a minimum of 4 inches for both extrusion and fusion welding, but in any event sufficient overlap is provided to allow peel tests to be performed on the seam;

- no solvent or adhesive is used; and

- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane and specifically that the temperature of hot air at the nozzle of any spot-welding apparatus is controlled such that the geomembrane is not damaged.

8.7.7 Trial Seams

The CQA Consultant will verify that the Installer performs trial seam tests to verify that seaming conditions are adequate. The CQA Consultant will observe and document the Installer's trial seam testing procedures. The trial seam samples will be assigned an identification number and marked accordingly by the CQA Consultant. Each sample will be marked with the date, time, machine temperature(s) and setting(s), number of seaming unit, and name of seaming technician. Trial seam samples will be maintained until destructive seam testing of the applicable seams are tested and pass.

8.7.8 Nondestructive Seam Continuity Testing

The CQA Consultant will monitor that the Installer nondestructively tests all field seams over their full length using a vacuum test unit or air pressure test (for double fusion seams only). The CQA Consultant will monitor that the Installer performs spark testing if the seam cannot be tested using the vacuum or air pressure test methods. The purpose of nondestructive tests is to check the continuity of seams. The CQA Consultant will monitor that the Installer performs continuity testing as the seaming work progresses, not at the completion of all field seaming. The CQA Consultant will:

- monitor nondestructive testing;
- document the results of the nondestructive testing; and
- inform the Contractor and Construction Manager of any non-conformance.

The CQA Consultant will monitor that the Installer performs any required seam repairs. The CQA Consultant will:

- observe the repair procedures;
- observe the re-testing procedures; and
- document the results.

The seam number, date of observation, dimensions and/or descriptive location of the seam length tested, name of person performing the test, and outcome of the test will be recorded by the CQA Consultant.

8.7.9 Destructive Testing

The CQA Consultant will monitor the Installer performing destructive seam testing during the geomembrane installation. The purpose of this testing is to evaluate seam strength. The CQA Consultant will monitor that the Installer performs destructive seam testing as the seaming work progresses, not at the completion of all field seaming.

The CQA Consultant will also conduct laboratory destructive seam testing as required by this CQA Plan. The testing will be performed in accordance with the current versions of ASTM and other applicable test procedures and at the minimum frequencies indicated in Appendix B corresponding to each geomembrane material type that will be used.

The CQA Consultant will review the destructive seam test results to verify that the requirements of the CQA Plan are met. The CQA Consultant may conduct additional destructive seam testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

8.7.9.1 Location and Frequency

The CQA Consultant will select all destructive seam test sample locations. Sample locations will be established as follows.

- Destructive testing will be performed at a minimum frequency of one test location per 500 feet of seam length. This minimum frequency is to be determined as an average taken throughout the entire installation. This minimum frequency will be increased for seams made outside the normal ambient temperature range of 40°F to 104°F.

- Test locations will be determined during seaming at the CQA Consultant'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 Installer will not be informed in advance of the locations where the seam samples will be taken.

8.7.9.2 Sampling Procedures

Destructive seam testing will be performed by the CQA Geosynthetics Laboratory as seaming progresses in order to obtain test results prior to the geomembrane being covered by overlying materials. The CQA Consultant will:

- observe sample cutting;

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

- record sample location on geomembrane panel layout drawing.

The CQA Consultant will monitor that the Installer performs repairs to all holes in the geomembrane resulting from destructive seam test sampling in accordance with repair procedures described herein. In addition, the CQA Consultant will monitor that the Installer performs non-destructive testing as described in this Section to ensure the continuity of the new seams.

8.7.9.3 Size of Samples

The CQA Consultant will monitor that at a given sampling location, two types of samples (field test samples and laboratory test samples) are taken:

- First, a minimum of two field samples or test strips are taken for field testing. Each of these test strips are approximately 1 inch wide by 12 inches long, with the seam centered parallel to the width. The distance between these two specimens is approximately 42 inches. If both specimens pass the field test described in this Section, a second full laboratory destructive sample is taken for testing by the CQA Geosynthetics Laboratory.

- The full destructive sample is located between the two field test strips. The sample is approximately 12 inches wide by 42 inches long with the seam centered lengthwise. The sample is cut into three parts and distributed as follows:

  - one approximately 12 inches by 12 inches portion to the Installer;

  - one approximately 12 inches by 12 inches portion to the Construction Manager for archive storage; and

  - one approximately 12 inches by 18 inches portion for CQA Geosynthetics Laboratory testing.

8.7.9.4 Field Testing

The CQA Consultant will monitor that the test strips are tested in the field, for peel adhesion, using a gauged tensiometer by the Installer. In addition to meeting the strength requirements outlined in Appendix B, the CQA Consultant will monitor that all specimens exhibit a film tear bond and do not fail in the weld. If any field test sample fails to meet these requirements, the destructive sample has failed.

The CQA Consultant will witness all field tests and mark all samples and portions with their number. The CQA Consultant will also log the date, number of seaming unit, seaming technician identification, destructive sampling, and pass or fail description.

8.7.9.5 Geosynthetics Laboratory Testing

Destructive test samples will be tested by the CQA Geosynthetics Laboratory. Testing will include "Bonded Seam Strength" and "Peel

Adhesion". The minimum acceptable values to be obtained in these tests are presented in Appendix B. At least five specimens will be tested for each test method (i.e., five for peel and five for shear). Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear, etc.). Both the inside and outside tracks of the double track fusion seams will be tested for peel adhesion. A passing test will meet the minimum required values in Appendix B.

The CQA Geosynthetics Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Consultant will review laboratory test results as soon as they become available and report the results to the Construction Manager.

8.7.9.6 Procedures for Destructive Test Failure

The CQA Consultant will monitor that the following procedures apply whenever a sample fails a destructive test, whether that test was conducted in the field or by the CQA Geosynthetics Laboratory. The CQA Consultant will monitor that the Installer follows one of the two options below:

- The Installer can reconstruct the seam (e.g., remove the old seam and re-seam) between any two passed destructive test locations or between points judged by the CQA Consultant to represent conditions of the failed seam (e.g., a tie-in seam or a seam made by the apparatus and/or operator used in the failing seam); or

- The Installer can trace the welding path to an intermediate location a minimum of 10 feet from the point of the failed test in each direction and take a small sample for additional field testing in accordance with the destructive test procedure at each location. If these additional isolation samples pass the field test, then full laboratory samples are taken at both locations. If these laboratory samples meet the specified strength criteria, 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 or repaired.

The CQA Consultant will monitor that all failed seams are bound by two locations from which samples passing laboratory destructive tests have been taken or the entire seam is reconstructed and re-tested. In cases exceeding 150 feet of reconstructed seam, a sample will be taken from the reconstructed portion of the seam and must pass destructive testing. The CQA Consultant will observe that any repairs are made in accordance

with Section 8.8. The CQA Consultant will document all actions taken in conjunction with destructive test failures.

8.8 DEFECTS AND REPAIRS

8.8.1 CQA Consultant Responsibility for Monitoring Defects and Repairs

The CQA Consultant will monitor, verify, and document that geomembrane defects are addressed, and repairs are made as set forth herein and that CQA activities are performed as described in the subsections below.

8.8.2 Identification

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

8.8.3 Repair Procedures

The CQA Consultant will monitor that any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, is repaired by the Installer. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure, materials, and equipment will be agreed upon between the Installer and CQA Consultant.

In addition, the following conditions will be monitored by the CQA Consultant:

- surfaces of the geomembrane which are to be repaired are abraded no more than one hour prior to the repair;
- all surfaces are clean and dry at the time of the repair;
- patches or caps extend at least 6 inches beyond the edge of the defect, and all corners of patches are rounded with a radius of at least 3 inches; and
- the geomembrane below large caps is appropriately cut to avoid water or gas collection between the two sheets.

8.8.4 Verification of Repairs

Each repair will be numbered and logged by the CQA Consultant. The CQA Consultant will monitor that each repair is non-destructively tested by the Installer using approved methods. Repairs which pass the non-destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the CQA Consultant or as specified in Appendix B. The CQA Consultant will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

8.9 GEOMEMBRANE ACCEPTANCE

The Contractor retains all responsibility for the geosynthetics until acceptance by the Construction Manager. The terms and conditions for liner and cover system geomembrane acceptance are described in other project contractual documents.

8.10 MATERIALS IN CONTACT WITH THE GEOMEMBRANE

The procedures outlined in this section are intended to allow the CQA Consultant to verify that the installation of materials in contact with the geomembrane do not cause damage to it.

8.10.1 Soils

The CQA Consultant will monitor that the Contractor conforms with the applicable requirements of this CQA Plan and the Permit Documents and takes all necessary precautions to verify that the geomembrane is not damaged during its installation, during the installation of other components of the liner and the final cover systems, or by other construction activities. The CQA Consultant will monitor the following:

- placement of soil materials above the geomembrane and that soils are not placed at an ambient temperature below 40°F or above 104°F unless otherwise approved by the Design Engineer and Construction Manager;

- overlying soil and aggregate/riprap materials are not placed above the geomembrane until a cushion layer(s) is (are) in place;

- material placement operations above the geomembrane are performed by the Contractor in a manner that does not damage the geomembrane and that minimizes wrinkles in the geomembrane;

- equipment used for placing materials above the geomembrane are not driven directly on the geomembrane or other geosynthetic layers;

- a minimum material thickness of 1 foot is maintained between a low ground pressure (LGP - having a maximum ground pressure of 5 pounds per square inch [psi]) track-mounted dozer and the geomembrane;

- a minimum material thickness of 3 feet is maintained between rubber-tired or non-low ground pressure tracked vehicles and the geomembrane during construction activities; and

- material thickness above the geomembrane is greater than 3 feet in heavily trafficked areas such as access ramps.

8.10.2 Appurtenances

The CQA Consultant will monitor that:

- installation of the geomembrane in appurtenant areas and connection of geomembrane to appurtenances (e.g., concrete pads or concrete embedment strips at geomembrane termination) are made in accordance with Manufacturer recommendations or industry standards for such connections;

- extreme care is given by the Installer when seaming around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas; and

- the geomembrane is not visibly damaged when making connections to appurtenances.

9. GEOSYNTHETIC CLAY LINER

9.1 INTRODUCTION

The CQA Consultant will perform conformance testing, review the MQC documentation, and monitor the installation of the GCL to verify that the Manufacturer's specifications and the requirements of the Permit Documents and this CQA Plan are met.

9.2 TRANSPORTATION, HANDLING, AND STORAGE

The CQA Consultant will monitor the transportation, handling, and storage of the GCL on the Project site. Handling of the rolls will be performed in a competent manner such that damage does not occur to the GCL or its protective wrapping. Any protective wrapping that is damaged or stripped off the rolls will be repaired immediately to the satisfaction of the CQA Consultant. During transportation, handling, and storage the GCL rolls will be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

Upon delivery of the GCL at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without unrolling the materials unless defects or damages are found or suspected. The CQA Consultant 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 which include minor repairable flaws.

The CQA Consultant will also monitor that equipment used to handle the GCL on-site is adequate and does not pose any risk of damage to the GCL when used properly.

9.3 MANUFACTURER QC (MQC) TESTING AND CQA CONSULTANT CONFORMANCE TESTING

9.3.1 GCL Material MQC Testing Requirements

The GCL Manufacturer will perform QC testing on the GCL materials and rolls that will be used on this Project in accordance with the current versions of the ASTM and other applicable test procedures, and at the minimum MQC frequencies indicated in Appendix C.

The CQA Consultant will review the MQC certifications and test results to verify that the Manufacturer's specifications and the CQA Plan requirements are met. The conformance testing program that will be conducted by the CQA Consultant is described subsequently.

9.3.2 GCL Conformance CQA Testing Requirements

The CQA Consultant will coordinate, and a qualified laboratory (i.e., the CQA Geosynthetics Laboratory) will perform, GCL conformance testing to evaluate the conformance of the GCL with the CQA Plan requirements. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies indicated in Appendix C.

The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

9.3.3 Test Results

All MQC and conformance test results will be reviewed, accepted, and reported by the CQA Consultant before deployment of the GCL. Any non-conformance of the material properties with the CQA Plan requirements will be reported to the Contractor and Construction Manager.

9.3.4 Test Failure

In the case of failing test results, the Contractor may request that another sample from the failing roll be retested. If the retest fails or if the option to retest is not exercised, then two isolation conformance samples will be obtained by the CQA Consultant. These isolation samples will be taken from rolls, which have been determined by correlation with the Manufacturer's roll number, to have been manufactured prior to and after the failing roll. This method for choosing isolation rolls for testing should continue until passing tests are achieved. All rolls that fall numerically between the passing roll numbers will be rejected.

The CQA Consultant will verify that the Contractor has replaced all rejected rolls. The CQA Consultant will document all actions taken in conjunction with GCL conformance failures.

9.4 SURFACE PREPARATION

The CQA Consultant will monitor, verify, and document that GCL surface preparation (i.e., preparation of the surface on which the GCL will be placed) is constructed in accordance with the Permit Documents and CQA activities are performed as described below.

The GCL will not be placed on surfaces which are softened due to high water content or cracked due to desiccation. The CQA Consultant and the Installer will jointly verify that the surface on which the GCL will be installed is acceptable. The Contractor will comply with the surface preparation and acceptance requirements, and the CQA Consultant will verify that subgrade acceptance certificates are prepared and signed by the Contractor

and their Installer (and such forms also require signatures by the CQA Consultant and Purchaser to indicate the parties' concurrence that the subgrade surface on which the GCL will be deployed is ready and acceptable). Additionally, the surface will be firm, smooth, and uniform, and will meet the related final surface acceptance criteria given in Table A.2B, including but not limited to allowable protrusion size. The CQA Consultant will notify the Contractor of any observed change in the supporting soil condition that may require repair work and verify that compacted soil repair work is properly completed, consistent with Section 5 of this CQA Plan.

9.5 PLACEMENT

The CQA Consultant will monitor, verify, and document that GCL placement as described below.

The CQA Consultant will verify that the Installer has taken all necessary precautions to protect the underlying subgrade during GCL deployment operations. The CQA Consultant will verify that all GCL is handled in such a manner as to ensure they are not damaged in any way, and the following conditions are met:

- in the presence of wind, all GCL are weighted with sandbags or the equivalent;
- GCL is kept continually under tension to minimize the presence of wrinkles;
- GCL is cut using a utility blade in a manner recommended by the Manufacturer;
- during placement, care is taken not to entrap fugitive stones or other debris under the GCL;
- the exposed GCL is protected from damage in heavily trafficked areas;
- a visual examination of the GCL is carried out over the entire surface, after installation, to assure that damaged areas, if any, are identified and repaired; and
- if a white colored GCL is used, precautions are taken against "snow blindness" of personnel.

9.6 OVERLAPS

The CQA Consultant will monitor, verify, and document that GCL overlaps are made as described below.

GCL panels will be overlapped a minimum of 6 inches along panel sides and a minimum of 12 inches along panel ends. Dry bentonite powder will be applied, at a minimum rate of 1 pound per linear foot, around pipe penetrations or other perforations of GCL which may be required.

9.7 REPAIRS

The CQA Consultant will monitor, verify, and document that GCL repairs are conducted as described below.

The CQA Consultant will monitor the repair of any holes or tears in the GCL or the geotextile backing. Repairs will be made by placing a patch made from the same type GCL over the damaged area. On slopes greater than 5 percent, the patch will overlap the edges of the hole or tear by a minimum of 2 feet in all directions. On slopes, 5 percent or flatter, the patch will overlap the edges of the hole or tear by a minimum of 1 foot in all directions. The patch will be secured to the satisfaction of the CQA Consultant to avoid shifting during soil placement or covering with another geosynthetic layer.

10. GEOTEXTILES

10.1 INTRODUCTION

The CQA Consultant will perform conformance testing, review the MQC documentation, and monitor the installation of geotextile layers to verify that the Manufacturer's specifications and the requirements of the Permit Documents and this CQA Plan are met.

10.2 TRANSPORTATION, HANDLING, AND STORAGE

The CQA Consultant will monitor the transportation, handling, and storage of the geotextile on the Project site. The CQA Consultant will verify that the geotextile is protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

The CQA Consultant will monitor that transportation, handling, and storage of geotextile conforms with the following requirements:

- handling of the geotextile rolls is performed in a competent manner such that damage does not occur to the geotextile or to its protective wrapping;
- geotextile rolls are not stacked upon one another to the extent that deformation of the core occurs or to the point where accessibility can cause damage in handling;
- geotextile rolls are stacked in such a way that access for conformance sampling is possible;
- protective wrappings are removed less than one hour prior to unrolling the geotextile;
- after unrolling, a geotextile is not exposed to ultraviolet light for more than 30 calendar days;
- outdoor storage of geotextile rolls does not exceed the Manufacturer's recommendations or longer than six months, whichever is less;
- for storage periods longer than Manufacturer's recommendations or six months (whichever is less), a tarp or temporary enclosure is placed over the rolls, or they are moved to an enclosed facility; and
- the location of temporary field storage is not in areas where water can accumulate, and the rolls are elevated off the ground to prevent contact with ponded water.

Upon delivery at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without

unrolling the materials unless defects or damages are found or suspected. The CQA Consultant will indicate to the Construction Manager:

- rolls, or portions thereof, that will be rejected and removed from the site because they have severe flaws; and
- rolls that include minor repairable flaws that do not compromise geotextile functionality.

The CQA Consultant will also monitor that equipment used to handle the geotextiles on-site is adequate and does not pose any risk of damage to the geotextiles during handling.

10.3 MANUFACTURER QC (MQC) TESTING AND CQA CONSULTANT CONFORMANCE TESTING

10.3.1 Geotextile Material MQC Testing Requirements

The geotextile Manufacturer will perform QC testing on the geotextile rolls that will be used on this Project in accordance with the current versions of the ASTM and other applicable test procedures, and at the minimum MQC frequencies indicated in Appendix D.

The CQA Consultant will review the MQC certifications and test results to verify that the Manufacturer's specifications and the CQA Plan requirements are met. The conformance testing program that will be conducted by the CQA Consultant is described subsequently.

10.3.2 Geotextile Conformance CQA Testing Requirements

The CQA Consultant will coordinate, and a qualified laboratory (i.e., the CQA Geosynthetics Laboratory) will perform, geotextile CQA testing to evaluate the conformance of the geotextiles with the CQA Plan requirements. The testing will be performed in accordance with the current versions of ASTM and other applicable test procedures and at the minimum frequencies indicated in the Appendix D tables corresponding to each geotextile material type that will be used.

The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

10.3.3 Test Results

All MQC and conformance test results will be reviewed, accepted, and reported by the CQA Consultant before deployment of geotextiles. Any non-conformance of the material properties with the CQA Plan requirements will be reported to the Contractor and Construction Manager.

10.3.4 Test Failure

In the case of failing test results, the Contractor may request that another sample from the failing roll be re-tested. If the re-test fails or if the option to re-test is not exercised, then two isolation conformance samples will be obtained by the CQA Consultant. These isolation samples will be taken from rolls that have been determined by correlation with the Manufacturer's roll number to have been manufactured prior to and after the failing roll. This method for choosing isolation rolls for testing will continue until passing tests are achieved. All rolls that fall numerically between the passing roll numbers will be rejected. The CQA Consultant will verify that the Contractor has replaced all rejected rolls. The CQA Consultant will document all actions taken in conjunction with geotextile conformance failures.

10.4 PLACEMENT

The CQA Consultant will monitor, verify, and document the placement of all geotextiles to verify that they are not damaged in any way, and the following conditions are met:

- on slopes, the geotextiles are securely anchored in the anchor trench and then deployed down the slope in such a manner as to continually keep the geotextile in tension;
- in the presence of wind, all geotextiles are weighted with sandbags or equivalent; such sandbags are installed during placement and will remain until replaced with earth cover material;
- trimming of the geotextiles are performed using only an upward cutting hook blade and special care is given to protect other materials from damage which could be caused by the cutting of the geotextiles;
- the Installer is taking necessary precautions to prevent damage to underlying layers during placement of the geotextile;
- during placement of geotextiles, care is given not to entrap stones, excessive dust, or moisture that could generate clogging of drains or filters; and
- a visual examination of the geotextile is carried out over the entire surface, after installation, to verify that no potentially harmful foreign objects, (e.g., stones, sharp objects, small tools, sandbags, etc.) are present.

10.5 SEAMS AND OVERLAPS

The CQA Consultant will monitor, verify, and document that geotextile seams and overlaps are in accordance with the following requirements:

- all geotextiles are continuously sewn (i.e., no spot sewing);
- geotextiles are overlapped 6 inches prior to seaming;
- no horizontal seams are constructed on side slopes that are steeper than 10H:1V (horizontal:vertical) (i.e., seams to be aligned along, not across the slope), except as part of a patch;
- sewing uses polymeric thread with chemical and ultraviolet resistance properties equal to or exceeding those of the geotextile; and
- seams are sewn using a single row Stich Type 401 two-thread chain stitch.

10.6 REPAIRS

The CQA Consultant will monitor, verify, and document that geotextile repairs are made in accordance with the following requirements:

- For slopes steeper than 10H:1V, a patch made from the same geotextile is double seamed into place (with each seam 1/4 inches to 3/4 inches apart and no closer than 1 inch from any edge) with a minimum 12-inch overlap. Should any tear exceed 50 percent of the width of the roll, that roll is removed from the slope and replaced.
- For slopes flatter than 10H:1V, a patch made from the same geotextile is sewn in place with a minimum of 12-inch overlap in all directions away from the repair area.

The CQA Consultant will observe that care is given to remove any soil or other material which may have penetrated the torn geotextile, and all repairs and verify that any non-conformance with the above requirements is corrected.

10.7 PLACEMENT OF SOILS OR GRANULAR MATERIALS

The CQA Consultant will monitor, verify, and document that placement of soils or granular materials on top of geotextiles is conducted in accordance with the following requirements:

- no damage occurs to the geotextile;
- no shifting of the geotextile from its intended position occurs and underlying materials are not exposed or damaged;
- excess tensile stress does not occur in the geotextile;
- equipment does not drive directly on the geotextile; and

- Contractor uses only LGP equipment on layers less than 3-feet thick above the geomembrane and geotextile separator or cushion layer in accordance with Section 8.10.1 of this CQA Plan.

The CQA Consultant will monitor that covering of the geotextile with overlying layers is completed within 30 days of installation to prevent UV degradation; and on side slopes, that soil and granular layers are placed over the geotextile from the bottom of the slope upward.

11. GEOCOMPOSITE DRAINAGE LAYERS

11.1 INTRODUCTION

The CQA Consultant will perform conformance testing, review the QC documentation, and monitor the installation of geocomposite drainage layers to verify that the Manufacturer's specifications and the requirements of the Permit Documents and this CQA Plan are met.

11.2 TRANSPORTATION, HANDLING, AND STORAGE

The CQA Consultant will monitor the transportation, handling, and storage of the geocomposite on the Project site. The CQA Consultant will verify that during transportation, handling, and storage, the geocomposite is protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

The CQA Consultant will monitor that transportation, handling, and storage of geocomposite conforms with the following requirements:

- geocomposite rolls are handled in a competent manner such that damage does not occur to the geocomposite or to its protective wrapping;
- geocomposite rolls are not to be stacked upon one another to the extent that deformation of the roll occurs or to the point where accessibility can cause damage in handling;
- geocomposite rolls are stacked in such a way that access for conformance sampling is possible;
- protective wrappings are removed less than one hour prior to unrolling the geocomposite; and
- after unrolling, a geocomposite is not exposed to ultraviolet light for more than 30 calendar days.

The CQA Consultant will monitor that outdoor storage of geocomposite rolls does not exceed the Manufacturer's recommendations or longer than six months whichever is less. For storage periods longer than Manufacturer's recommendations or six months (whichever is less), the CQA Consultant will monitor that:

- a tarp or temporary enclosure is placed over the rolls, or they are moved to an enclosed facility;

- the location of temporary field storage is not in areas where water can accumulate; and

- rolls are elevated off the ground to prevent contact with ponded water.

Upon delivery at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without unrolling the materials unless defects or damages are found or suspected. The CQA Consultant will indicate to the Construction Manager:

- rolls, or portions thereof, that will be rejected and removed from the site because they have severe flaws; and

- rolls that include minor repairable flaws, that do not compromise geocomposite functionality.

The CQA Consultant will also monitor that equipment used to handle the geocomposite on-site is adequate and does not pose any risk of damage to the geocomposite when used properly.

11.3 MANUFACTURER QC (MQC) TESTING AND CQA CONSULTANT CONFORMANCE TESTING

11.3.1 Geocomposite Material MQC Testing Requirements

The geocomposite drainage layer Manufacturer will perform QC testing on the geocomposite rolls that will be used on this Project in accordance with the current versions of the ASTM and other applicable test procedures, and at the minimum MQC frequencies indicated in Appendix E.

The CQA Consultant will review the MQC certifications and test results to verify that the Manufacturer's specifications and the CQA Plan requirements are met. The conformance testing program that will be conducted by the CQA Consultant is described subsequently.

11.3.2 Geocomposite Conformance CQA Testing Requirements

The CQA Consultant will coordinate, and a qualified laboratory (i.e., the CQA Geosynthetics Laboratory) will perform, geocomposite CQA testing to evaluate the conformance of the geocomposite drainage layers with the CQA Plan requirements. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies indicated in Appendix E.

The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

11.3.3 Test Results

All MQC and conformance test results will be reviewed, accepted, and reported by the CQA Consultant before deployment of geocomposites. Any non-conformance of the material properties with the CQA Plan requirements will be reported to the Contractor and Construction Manager.

11.3.4 Test Failure

In the case of failing test results, the Contractor may request that another sample from the failing roll be re-tested. If the re-test fails or if the option to re-test is not exercised, then two isolation conformance samples will be obtained by the CQA Consultant. These isolation samples will be taken from rolls, that have been determined by correlation with the Manufacturer's roll number, to have been manufactured prior to and after the failing roll. This method for choosing isolation rolls for testing will continue until passing tests are achieved. All rolls that fall numerically between the passing roll numbers will be rejected. The CQA Consultant will verify that the Contractor has replaced all rejected rolls. The CQA Consultant will document all actions taken in conjunction with geocomposite conformance failures.

11.4 PLACEMENT

The CQA Consultant will monitor, verify, and document the placement of all geocomposites to verify that they are not damaged in any way, and the following conditions are met:

- on slopes, the geocomposites are secured atop the slope and then deployed down the slope in such a manner as to continually keep the geocomposites in tension;
- in the presence of wind, all geocomposites are weighted with sandbags or equivalent. Such sandbags are installed during placement and will remain until replaced with the cover material;
- trimming of the geocomposites is performed using only an upward cutting hook blade. Special care must be given to protect other materials from damage which could be caused by the cutting of the geocomposites;
- the Installer is taking necessary precautions to prevent damage to underlying layers during placement of the geocomposite;
- during placement of geocomposites, care is given not to entrap stones, soil, excessive dust, or moisture that could damage the geomembrane, generate clogging of drains or filters, or hamper subsequent drainage function; and

- a visual examination of the geocomposite is carried out over the entire surface, after installation, to verify that no potentially harmful foreign objects, (e.g., stones, sharp objects, small tools, sandbags, etc.) are present.

11.5 JOINING, SEAMS, AND OVERLAPS

The CQA Consultant will monitor, verify, and document that geocomposite joining, seaming, and/or overlaps are in accordance with the following requirements:

- the components of the geocomposite (e.g., geotextile and geonet) are seamed, joined, and overlapped to like components in adjacent geocomposites;

- lower geotextile components of the geocomposites are overlapped such that the overlap is a minimum of 4 inches. Adjacent edges of geonet component along the length of the geocomposite are overlapped a minimum 2 to 3 inches and joined by tying the geonet together with plastic fasteners or polymeric thread at a spacing recommended by the Manufacturer. Geonet for adjoining geocomposite panels (end to end) along the roll width are shingled down in direction of slope and overlapped a minimum of 12 inches;

- upper geotextile components of the geocomposites are continuously sewn (i.e., spot sewing is not allowed). Geotextiles are overlapped a minimum of 4 inches prior to sewing;

- no horizontal seams are constructed on side slopes that are steeper than 10H:1V (i.e., seams to be aligned along, not across the slope), except as part of a patch;

- sewing of geotextiles uses polymeric thread with chemical and ultraviolet resistance properties equal to or exceeding those of the geotextile; and

- seams are sewn using a single row type "401" two-thread chain stitch.

11.6 REPAIRS

The CQA Consultant will monitor, verify, and document that geocomposite repairs are made in accordance with the following requirements:

- a patch made from the same geocomposite is secured into place by tying fasteners through the bottom geotextile and the geonet of the patch, and through the top geotextile and geonet of the geocomposite needing repair;

- the patch extends 2 feet beyond the edges of the hole or tear;

- the patch is secured every 6 inches and heat-sealed to the top geotextile of the geocomposite needing repair; and

- if the hole or tear 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.

The CQA Consultant will monitor that care is given to remove any soil or other material which may have penetrated the torn geocomposite component. The CQA Consultant will observe any repair and verify that any non-conformance with the above requirements is corrected.

11.7 PLACEMENT OF SOILS OR GRANULAR MATERIALS

The CQA Consultant will monitor, verify, and document that placement of soils or granular materials on top of geocomposites is conducted in accordance with the following requirements:

- no damage occurs to the geocomposite;
- no shifting of the geocomposite from its intended position occurs and underlying materials are not exposed or damaged;
- excess tensile stress does not occur in the geocomposite; and
- equipment does not drive directly on the geocomposite and the Contractor only uses LGP equipment on layers less than 3-feet thick above the geocomposite layer in accordance with Section 8.10.1 of this CQA Plan.

The CQA Consultant will monitor that covering of the geocomposite with overlying layers is completed within 30 days to prevent UV degradation; and on side slopes, that soil layers are placed over the geocomposite from the bottom of the slope upward.

12. INTERFACE SHEAR STRENGTH CONFORMANCE TESTING

The CQA Consultant will conduct (through the CQA Geosynthetics Laboratory) an interface shear strength conformance testing program to measure the shear strengths of the base liner system and soil-geosynthetic final cover system interface configurations. The testing will be performed in accordance with the current versions of the applicable ASTM procedures and at the minimum frequencies indicated in Appendix F. The parameters and testing conditions for the interface shear strength testing program, along with the acceptance criteria for the measured liner system and final cover system interfaces, is also specified in Appendix F.

The CQA Consultant will review the procedures used and the results of the interface shear strength testing to verify that the requirements specified in Appendix F (including confirmation that the interface strengths meet or exceed the specified values) are met.

13. HDPE PIPES AND FITTINGS

13.1 INTRODUCTION

The CQA Consultant will review the MQC documentation and will monitor the installation of HDPE pipes and fittings to verify that the Manufacturer's specifications and the requirements of the Permit Documents and this CQA Plan are met.

13.2 BUTT-FUSION WELDING PROCESS

The CQA Consultant will monitor the assembling of lengths of HDPE pipe into suitable installation lengths by the butt-fusion welding process. Butt-fusion welding is the butt-joining of the pipe by softening the aligned faces of the pipe ends in a suitable apparatus and pressing them together under controlled pressure. The CQA Consultant will monitor that butt-fusion welding of the HDPE pipes and fittings is performed by the Contractor in accordance with Pipe Manufacturer's recommendations as to equipment and technique.

13.3 TRANSPORTATION, HANDLING, AND STORAGE

The CQA Consultant will monitor:

- the off-loading of the pipes to verify that handling is done in a competent manner and that the pipes are not placed in areas where water can accumulate;
- the pipes are not stacked more than three layers high or in such a manner that could cause damage to the pipe; and
- for outdoor storage periods longer than 12 months, a temporary covering is placed over the pipes, or they are moved to within an enclosed facility.

13.4 INSTALLATION

The CQA Consultant will monitor that pipes are installed in accordance with applicable requirements, including verification that the following conditions are met:

- care is given during installation of the pipes such that they are not be cut, kinked, or otherwise damaged;
- ropes, fabric, or rubber-protected slings and straps are used by the Contractor when installing pipes; chains, cables, or hooks inserted into the pipe are not used for this purpose;
- the Contractor installs the pipes and fittings in such a manner that the materials are not damaged;

- slings for handling the pipe are not positioned at butt-fused joints of HDPE pipes;
- sections of the pipes with deep cuts and/or gouges are removed and the ends of the pipeline re-joined; and
- care is exercised when lowering pipe into the trench to prevent damage or twisting of the pipe.

13.5 TESTING

The CQA Consultant will monitor the field testing, including hydrostatic testing of all pipes, as required, to confirm that it is performed by the Contractor and that no visible leaks or excessive pressure drops occur, and as necessary to verify that workmanship conforms to the state-of-practice.

APPENDIX A

Material Properties and Acceptance Criteria
for Earthwork

TABLE A.1

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA FOR SOIL MATERIALS USED AS FILL

SYSTEM COMPONENT	REQUIRED TEST	MINIMUM CQA FREQUENCY	ACCEPTANCE CRITERIA[3]
Structural Fill / Foundation Improvement Conformance Testing[1]	Visual Observation	As required (continuous during placement)	Substantially free of debris, large rocks, plant materials, or other deleterious material.
	Particle Size Analysis ASTM D6913 or D422	1 per source or visual change in material type & 1 per 5,000 yd^3	Max. 3 in. particle size
	Atterberg Limits ASTM D4318	1 per source or visual change in material type & 1 per 5,000 yd^3	Results used to make soil classification
	Soil Classification ASTM D2487	1 per source or visual change in material type & 1 per 5,000 yd^3	SC, CL, CH, MH, ML, or other Engineer approved classifications
	Moisture Content ASTM D2216	1 per source or visual change in material type & 1 per 5,000 yd^3	Results used to determine if adequate moisture is present prior to compaction
	Standard Proctor ASTM D698	1 per source or visual change in material type & 1 per 20,000 yd^3	Results used to determine compaction conditions
	Triaxial Testing (Remolded) ASTM D4767; ASTM D2850	1 per source or visual change in material type	Consolidated-Undrained (CU) shear strength envelope: $c' \geq 200$ psf; $\phi' \geq 29$ degrees; Unconsolidated-Undrained (UU) shear strength of not less than 1,850 psf
Structural Fill / Foundation Improvement Performance Testing[2]	Visual Observation	Continuous	Final surface firm, smooth, and uniform.
	Lift Depth Check	As required	6 to 8 in. compacted lift (8 to 10 in. loose lifts)
	In-place Density and Moisture Content; Nuclear Densometer or Drive Tube Sample ASTM D6938 or ASTM D2937	1 per 10,000 sf per lift or 1 test per 200 lf per lift for linear features	≥ 95% Standard Proctor maximum dry density and within moisture range (1% dry to 3% wet of optimum moisture)
	Moisture Content Verification of Nuclear Densometer ASTM D2216	1 per 10 nuclear densometer tests	Check nuclear densometer measurements to verify moisture correction.
	Density Verification of Nuclear Densometer; Sand Cone Density or Drive Tube Sample	1 per 25 nuclear densometer tests	Check nuclear densometer measurements to verify moisture correction and density.

SYSTEM COMPONENT	REQUIRED TEST	MINIMUM CQA FREQUENCY	ACCEPTANCE CRITERIA[3]
	ASTM D1556 or ASTM D2937		
	Triaxial Testing (Undisturbed) ASTM D4767	4 per lined cell and 4 per 1,000 lf of containment dike (i.e., new north and south perimeter earthen dikes)	Consolidated-Undrained (CU) shear strength envelope: c' ≥ 200 psf; ϕ' ≥ 29 degrees

Notes:

in – inch lb – pound lf – linear feet psf – pounds per square feet sf – square feet yd^3 – cubic yards

1. Conformance testing is performed on borrow sources prior to placement of material to verify the minimum required values are met and the material remains consistent.
2. Performance testing is performed on materials after placement is complete to verify that the lift or layer meets design requirements.
3. Deviations from the specified shear strengths may be allowed upon review by and approval from the Design Engineer.

TABLE A.2A

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
FOR SOIL MATERIALS USED AS COMPACTED CLAY LINER (for LINER OPTION L1)

SYSTEM COMPONENT	REQUIRED TEST	MINIMUM CQA FREQUENCY	ACCEPTANCE CRITERIA[3]
Compacted Clay Liner Conformance Testing[1]	Visual Observation	As required (continuous during placement)	Substantially free of debris, large rocks, plant materials, or other deleterious material.
	Particle Size Analysis ASTM D6913 or D422	1 per source or visual change in material type & 1 per 5,000 yd^3	Fine Screened Compacted Clay Liner: ≤ 0.25 in. and at least 50% passing #200 sieve; Coarse Screened Compacted Clay Liner: ≤ 2 in. and at least 50% passing #200 sieve
	Atterberg Limits ASTM D4318	1 per source or visual change in material type & 1 per 5,000 yd^3	Plasticity Index (PI) ≥ 15; Liquid Limit (LL) > 30
	Soil Classification ASTM D2487	1 per source or visual change in material type & 1 per 5,000 yd^3	CL, CH, or other Engineer approved classifications
	Moisture Content ASTM D2216	1 per source or visual change in material type & 1 per 5,000 yd^3	Results used to determine if adequate moisture is present prior to compaction
	Standard Proctor ASTM D698	1 per source or visual change in material type & 1 per 5,000 yd^3	Results used to determine compaction conditions
	Remolded Permeability ASTM D5084	1 per source or visual change in material type & 1 per 10,000 yd^3	$k \leq 1x10^{-7}$ cm/sec
sCompacted Clay Liner Performance Testing[2]	Visual Observation of Final Surface	Continuous	Final surface compact, firm, smooth and uniform, and free of debris, rock, plant materials, and other foreign material. No particles greater than 0.25-in in upper 6in lift (final surfaces) that will receive geomembrane.
	Lift Depth Check	As required	6 to 8 in. compacted lift (8 to 10 in. loose lifts)
	In-place Density and Moisture Content; Nuclear Densometer or Drive Tube Sample ASTM D6938 or ASTM D2937	1 per 10,000 sf per lift or 1 test per 200 lf per lift for linear features	≥ 95% Standard Proctor maximum dry density and within specified moisture range (acceptable permeability zone[4])
	Moisture Content Verification of Nuclear Densometer ASTM D2216	1 per 40,000 sf per lift or 1 test per 800 lf per lift for linear features	Check nuclear densometer measurements to verify moisture correction.
	Density Verification of Nuclear Densometer; Sand Cone Density or	1 per 40,000 sf per lift or	Check nuclear densometer measurements to verify moisture correction and density.

SYSTEM COMPONENT	REQUIRED TEST	MINIMUM CQA FREQUENCY	ACCEPTANCE CRITERIA[3]
	Drive Tube Sample ASTM D1556 or ASTM D2937	1 test per 800 lf per lift for linear features	
	Undisturbed Permeability ASTM D5084	1 per 40,000 sf per lift or 1 test per 800 lf per lift for linear features	$k \leq 1x10^{-7}$ cm/sec

Notes:

cm/sec – centimeters per second
in - inch
sf - square feet
psf - pounds per square feet
lb - pound
lf - linear feet
yd^3 – cubic yards

1. Conformance testing is performed on borrow sources prior to placement of material to verify the minimum required values are met and the material remains consistent.
2. Performance testing is performed on materials after placement is complete to verify that the lift or layer meets design requirements.
3. Deviations from the specified particle sizes and Atterberg limits may be allowed upon review and approval from the Design Engineer.
4. The acceptable permeability zone (APZ) moisture content is defined as either:

   a) Moisture content on or to the right of (in the direction of increasing moisture content) the line of percent saturation that is determined through the pre-construction testing program (and supplemented by ongoing conformance test results) to produce recompacted specimens tested to achieve acceptable remolded hydraulic conductivity, and not greater than 4% wet of the standard Proctor optimum moisture content; or

   b) In lieu of using the line of percent saturation approach described above, the line of optimums may be used to develop the APZ if it is a more representative defining-line to form the boundary of acceptable results (i.e., able to produce the required hydraulic conductivity). The line of optimums is determined by connecting the optimum moisture contents from standard and modified Proctor compaction tests on the moisture-density plot.
5. The fine screened compacted clay liner (i.e., the upper 6” lift) for Cells 1A and 1B was constructed with maximum particle size specification of 0.5-inches.

TABLE A.2B

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
FOR SOIL MATERIALS USED AS COMPACTED CLAY LINER WITH GCL (LINER OPTION L2)

SYSTEM COMPONENT	REQUIRED TEST	MINIMUM CQA FREQUENCY	ACCEPTANCE CRITERIA[3]
Compacted Clay Liner Conformance Testing[1]	Visual Observation	As required (continuous during placement)	Substantially free of debris, large rocks, plant materials, or other deleterious material.
	Particle Size Analysis ASTM D6913 or D422	1 per source or visual change in material type & 1 per 5,000 yd^3	Upper 6-inch Lift: ≤ 0.25 in. and at least 30% passing #200 sieve; Lower Lift(s): ≤ 2 in. and at least 30% passing #200 sieve;
	Atterberg Limits ASTM D4318	1 per source or visual change in material type & 1 per 5,000 yd^3	PI ≥ 10; LL > 30
	Soil Classification ASTM D2487	1 per source or visual change in material type & 1 per 5,000 yd^3	SC, CL, CH, MH, ML, or other Engineer approved classifications
	Moisture Content ASTM D2216	1 per source or visual change in material type & 1 per 5,000 yd^3	Results used to determine if adequate moisture is present prior to compaction
	Standard Proctor ASTM D698	1 per source or visual change in material type & 1 per 5,000 yd^3	Results used to determine compaction conditions
	Remolded Permeability ASTM D5084	1 per source or visual change in material type & 1 per 10,000 yd^3	$k \leq 1x10^{-5}$ cm/sec
Compacted Clay Liner Performance Testing[2]	Visual Observation of Final Surface	Continuous	Final surface compact, firm, smooth and uniform, and free of debris, rock, plant materials, and other foreign material. No particles greater than 0.25-in in upper 6" lift (final surfaces) that will receive GCL.
	Lift Depth Check	As required	6 to 8 in. compacted lift (8 to 10 in. loose lifts)
	In-place Density and Moisture Content; Nuclear Densometer or Drive Tube Sample ASTM D6938 or ASTM D2937	1 per 10,000 sf per lift or 1 test per 200 lf per lift for linear features	≥ 95% Standard Proctor maximum dry density and within specified moisture range (acceptable permeability zone[4])
	Moisture Content Verification of Nuclear Densometer ASTM D2216	1 per 40,000 sf per lift or 1 test per 800 lf per lift for linear features	Check nuclear densometer measurements to verify moisture correction.
	Density Verification of Nuclear Densometer; Sand Cone Density or	1 per 40,000 sf per lift or	Check nuclear densometer measurements to verify moisture correction and density.

SYSTEM COMPONENT	REQUIRED TEST	MINIMUM CQA FREQUENCY	ACCEPTANCE CRITERIA[3]
	Drive Tube Sample ASTM D1556 or ASTM D2937	1 test per 800 lf per lift for linear features	
	Undisturbed Permeability ASTM D5084	1 per 40,000 sf per lift or 1 test per 800 lf per lift for linear features	$k \leq 1x10^{-5}$ cm/sec

Notes:

cm/sec – centimeters per second
in - inch
sf - square feet
psf - pounds per square feet
lb - pound
lf - linear feet
yd^3 – cubic yards

1. Conformance testing is performed on borrow sources prior to placement of material to verify the minimum required values are met and the material remains consistent.
2. Performance testing is performed on materials after placement is complete to verify that the lift or layer meets design requirements.
3. Deviations from the specified particle sizes and Atterberg limits may be allowed upon review by and approval from the Design Engineer.
4. The acceptable permeability zone (APZ) moisture content is defined as either:

   a) Moisture content on or to the right of (in the direction of increasing moisture content) the line of percent saturation that is determined through the pre-construction testing program (and supplemented by ongoing conformance test results) to produce recompacted specimens tested to achieve acceptable remolded hydraulic conductivity, and not greater than 4% wet of the standard Proctor optimum moisture content; or

   b) In lieu of using the line of percent saturation approach described above, the line of optimums may be used to develop the APZ if it is a more representative defining-line to form the boundary of acceptable results (i.e., able to produce the required hydraulic conductivity). The line of optimums is determined by connecting the optimum moisture contents from standard and modified Proctor compaction tests on the moisture-density plot.

5. Cells 1A and 1B were not constructed with Liner Option L2. .

TABLE A.3

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
FOR SOIL COMPONENTS OF THE FINAL COVER SYSTEM

SYSTEM COMPONENT	REQUIRED TEST	MINIMUM CQA FREQUENCY	ACCEPTANCE CRITERIA
Protective Soil Layer (Final Cover System and Stormwater Ponds) Conformance Testing[1]	Visual Observation	As required (continuous during placement)	Substantially free of debris, large rocks, plant materials, or other deleterious material
	Sieve Analysis ASTM D6913 or D422	1 per source or visual change in material type & 1 per 10,000 yd^3	2 in. max. particle size
	Atterberg Limits ASTM D4318	1 per source or visual change in material type & 1 per 10,000 yd^3	Results used to make soil classification
	Soil Classification ASTM D2487	1 per source or visual change in material type & 1 per 10,000 yd^3	SC, CL, CH, ML, MH, or other Engineer approved classifications
Protective Soil Layer (Final Cover System and Stormwater Ponds) Performance Testing[2]	Visual Observation	Continuous	Material compacted by tracking in with dozer; final surface firm, smooth, and uniform.
	Lift Depth Check	As required	First lift 12 in. compacted lift then, 6 to 8 in. compacted lift (8 to 10 in. loose lift)
Vegetative Cover Layer (Final Cover System) Conformance Testing[1]	Visual Observation	As required	Substantially free of debris, large rocks, plant materials, or other deleterious material.
	Sieve Analysis ASTM D6913 or D422	1 per source or visual change in material type & 1 per 10,000 yd^3	100% passing 1 in. sieve
	Atterberg Limits ASTM D4318	1 per source or visual change in material type & 1 per 10,000 yd^3	Results used to make soil classification
	Soil Classification ASTM D2487	1 per source or visual change in material type & 1 per 10,000 yd^3	ML, SM, or SC, or other Design Engineer approved classification
Vegetative Cover Layer (Final Cover System) Performance Testing[2]	Visual Observation	As required	Substantially free of debris, large rocks, plant materials, or other deleterious material. Must not pump or rut excessively.

SYSTEM COMPONENT	REQUIRED TEST	MINIMUM CQA FREQUENCY	ACCEPTANCE CRITERIA
	Lift Depth Check	As required	6 in. (min) lift

Notes:

in – inch yd^3 – cubic yards

lb – pound

1. Conformance testing is performed on borrow sources prior to placement of material to verify the minimum required values are met and the material remains consistent.
2. Performance testing is performed on materials after placement is complete to verify that the lift or layer meets design requirements.

TABLE A.4

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
FOR SOIL MATERIALS USED AS LINER SYSTEM GRANULAR SOIL COMPONENTS

SYSTEM COMPONENT	REQUIRED TEST	MINIMUM CQA FREQUENCY	ACCEPTANCE CRITERIA[3]
Liner System Granular Soils Conformance Testing[1]	Visual Observation	As required (continuous during placement)	Visually consistent with specified particle size gradation (varies by granular soil layer), and substantially free of detrimental material
	Particle Size Analysis ASTM C136	1 per source or visual change in material type & 1 per 5,000 yd^3	Sand: GDOT Section 801.2.02, Size No. 10NS or 10SM Fine Gravel: Class A or B GDOT Section 800.2.01 material, Size No. 89 Medium Gravel: Class A or B GDOT Section 800.2.01 material, Size No. 67 Coarse Gravel: Class A or B GDOT Section 800.2.01 material, Size No. 57
	Granular Soils/Aggregate Permeability ASTM D2434	1 per source or visual change in material type & 1 per 10,000 yd^3	Sand: $k \geq 1x10^{-3}$ cm/sec Fine Gravel: $k \geq 1$ cm/sec Medium Gravel: $k \geq 3.5$ cm/sec Coarse Gravel: $k \geq 10$ cm/sec
	Calcium Carbonate Content ASTM D3042	1 per source or visual change in material type & 1 per 10,000 yd^3	Sand: <5% Fine Gravel: <5% Medium Gravel: <5% Coarse Gravel: <5%
Liner System Granular Soils Performance Testing[2]	Visual Observation	Continuous	Visually consistent with specified particle size gradation (varies by granular soil layer), and substantially free of detrimental material
	Lift Depth/Layer Thickness Check	As required	Thickness varies per component/layer (see Permit Drawings)
	Particle Size Analysis ASTM C136	1 per 1,500 yd^3	Same as conformance testing table entries above
	Granular Soils/Aggregate Permeability ASTM D2434	1 per 3,000 $yd^3$3	Same as conformance testing table entries above

Notes:
in - inch sf - square feet psf - pounds per square feet lb - pound lf - linear feet yd^3 – cubic yards
N/A – Not Applicable

1. Conformance testing of granular soils is performed on proposed sources of material from samples obtained at the supplier and/or from on-site stockpiles of delivered materials to verify the minimum required values are met and the material remains consistent.
2. Performance testing is performed on materials after placement is complete to verify that the lift or layer meets design requirements.
3. Deviations from the specified granular soil components acceptance criteria may be allowed upon review by and approval from the Design Engineer.

APPENDIX B

Material Properties and Acceptance Criteria for Geomembranes and Seams

TABLE B.1
MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
TEXTURED 60-MIL HDPE GEOMEMBRANE

Properties	Minimum MQC Test Frequency	Minimum CQA Test Frequency	Units[1]	Specified Values	Test Method
Physical Properties					
Thickness	Every Roll	1 per 100,000 ft^2	mils	57 (min. avg.) 54 (lowest individual reading for 8 out of 10) 51 (lowest individual reading for any of 10)	ASTM D5994
Asperity Height	Every 2nd Roll	1 per 100,000 ft^2	mils	16 (min. average) (top and bottom)	ASTM D7466
Sheet Density and Resin Specific Gravity	1 per 200,000 lb	1 per 100,000 ft^2	g/cm^3	0.940 (minimum for sheet density) 0.932 (minimum for resin density)	ASTM D1505 / ASTM D792
Carbon Black Content	1 per 20,000 lb	1 per 100,000 ft^2	%	2.0-3.0 (range)	ASTM D1603 / ASTM D4218
Carbon Black Dispersion	1 per 45,000 lb	1 per 100,000 ft^2	None	9 of 10 views in Category 1 or 2[2]	ASTM D5596
Resin - Melt Flow Index	1 per 200,000 lb	--	g/10 min.	≤1.0	ASTM D1238
Tensile Properties (each direction)					
1. Tensile Strength at Yield	1 per 20,000 lb	1 per 100,000 ft^2	lb/in	126 (min. average)	ASTM D6693 - Type IV
2. Tensile Strength at Break	1 per 20,000 lb	1 per 100,000 ft^2	lb/in	90 (min. average)	ASTM D6693 - Type IV
3. Elongation at Yield	1 per 20,000 lb	1 per 100,000 ft^2	%	12 (min. average)	ASTM D6693 - Type IV
4. Elongation at Break	1 per 20,000 lb	1 per 100,000 ft^2	%	100 (min. average)	ASTM D6693 - Type IV
Tear Resistance	1 per 45,000 lb	1 per 100,000 ft^2	lb	42 (min. average)	ASTM D1004 Die C Puncture
Puncture Resistance	1 per 45,000 lb	1 per 100,000 ft^2	lb	90 (min. average)	ASTM D4833
Oxidative Induction Time (OIT) Standard OIT or High Pressure OIT	1 per 200,000 lb	--	Minutes	100 (min. average) 400 (min. average)	ASTM D3895 or ASTM D5885
Notched Constant Tensile Load Stress Cracking (NCTLSC) [3]	1 per 200,000 lb	--	hours	≥300	ASTM D5397
Oven Aging at 85°C [3] Std. OIT - retained after 90 days High Pressure OIT - retained after 90 days	1 per Formulation	--	 % %	 55 80	 ASTM D5721 ASTM D3895 ASTM D5885
UV Resistance [3] High Pressure OIT	1 per Formulation	--	 %	 50	GRI GM11 ASTM D5885

Notes:

1. % = percent; g = grams; g/cm^3 = grams per cubic centimeter; lb = pound; lb/in = pounds per inch; mils = milli-inches
2. Carbon dispersion for 10 different views. One view allowed in Category 3.
3. For NCTLSC, oven aging, and UV resistance, Manufacturer's certification may be accepted in lieu of actual test results.

TABLE B.2

SEAM PROPERTY AND
INSTALLATION ACCEPTANCE CRITERIA
TEXTURED 60-MIL HDPE GEOMEMBRANE

Material Property	Minimum CQA Test Frequency	Value	Units	Test Method
Shear Strength Fusion and Extrusion [(1)]	1 per 500 ft	120 (min)	lb/in	ASTM D6392 Strain rate: 2 in./min. 1 in. strips.
Peel Adhesion Fusion[(2)] Extrusion [(3)]	1 per 500 ft	91 (min) 78 (min)	lb/in. lb/in.	ASTM D6392 Strain Rate: 2 in./min 1 in. strips.
Vacuum Testing Welded Seams	Observe / document 100% of extrusion welds	-	-	-
Air Pressure Testing Welded Seams	Observe / document 100% of fusion welds	-	-	-

Notes:

in - inch
lb - pound
min. - minute

1. For shear testing of both fusion and extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the given value. The 5th specimen must meet at least 80 percent of the specified value. Shear elongation at break must be at least 50 percent.
2. For peel testing of fusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value. The 5th specimen must achieve at least 80% of the specified value. All specimens shall fail due to film tear bond or with less than 25% incursion of the weld (peel).
3. For peel testing of extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value with less than 25% incursion at the weld. The 5th specimen must achieve at least 80% of the specified value. One specimen may exhibit greater than 25% incursion at the weld if the specified strength value is achieved.
4. For double fusion welded seams, both tracks will be tested for compliance with the specified minimum seam peel strengths.

TABLE B.3
MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
TEXTURED 40-MIL HDPE GEOMEMBRANE

Properties	Minimum MQC Test Frequency	Minimum CQA Test Frequency	Units[1]	Specified Values	Test Method
Physical Properties					
Thickness	Every Roll	1 per 100,000 ft^2	mils	38 (min. avg.) 36 (lowest individual reading for 8 out of 10) 34 (lowest individual reading for any of 10)	ASTM D5994
Asperity Height	Every 2nd Roll	1 per 100,000 ft^2	mils	16 (min. average) (top and bottom)	ASTM D7466
Sheet Density and Resin Specific Gravity	1 per 200,000 lb	1 per 100,000 ft^2	g/cm^3	0.940 (minimum for sheet density) 0.932 (minimum for resin density)	ASTM D1505 / ASTM D792
Carbon Black Content	1 per 20,000 lb	1 per 100,000 ft^2	%	2.0-3.0 (range)	ASTM D1603 / ASTM D4218
Carbon Black Dispersion	1 per 45,000 lb	1 per 100,000 ft^2	None	9 of 10 views in Category 1 or 2[2]	ASTM D5596
Resin - Melt Flow Index	1 per 200,000 lb	--	g/10 min.	≤1.0	ASTM D1238
Tensile Properties (each direction)					
1. Tensile Strength at Yield	1 per 20,000 lb	1per 100,000 ft^2	lb/in	84 (min. average)	ASTM D6693 - Type IV
2. Tensile Strength at Break	1 per 20,000 lb	1 per 100,000 ft^2	lb/in	60 (min. average)	ASTM D6693 - Type IV
3. Elongation at Yield	1 per 20,000 lb	1 per 100,000 ft^2	%	12 (min. average)	ASTM D6693 - Type IV
4. Elongation at Break	1 per 20,000 lb	1 per 100,000 ft^2	%	100 (min. average)	ASTM D6693 - Type IV
Tear Resistance	1 per 45,000 lb	1 per 100,000 ft^2	lb	28 (min. average)	ASTM D1004 Die C Puncture
Puncture Resistance	1 per 45,000 lb	1 per 100,000 ft^2	lb	60 (min. average)	ASTM D4833
Oxidative Induction Time (OIT) Standard OIT or High Pressure OIT	1 per 200,000 lb	--	Minutes	100 (min. average) 400 (min. average)	ASTM D3895 or ASTM D5885
Notched Constant Tensile Load Stress Cracking (NCTLSC) [3]	1 per 200,000 lb	--	hours	≥300	ASTM D5397
Oven Aging at 85°C [3] Std. OIT - retained after 90 days High Pressure OIT - retained after 90 days	1 per Formulation	--	 % %	 55 80	ASTM D5721 ASTM D3895 ASTM D5885
UV Resistance [3] High Pressure OIT	1 per Formulation	--	 %	 50	GRI GM11 ASTM D5885

Notes:

1. % = percent; g = grams; g/cm^3 = grams per cubic centimeter; lb = pound; lb/in = pounds per inch; mils = milli-inches
2. Carbon dispersion for 10 different views. One view allowed in Category 3.
3. For NCTLSC, oven aging, and UV resistance, Manufacturer's certification may be accepted in lieu of actual test results.

TABLE B.4

SEAM PROPERTY AND INSTALLATION ACCEPTANCE CRITERIA
TEXTURED 40-MIL HDPE GEOMEMBRANE

Material Property	Minimum CQA Test Frequency	Value	Units	Test Method
Shear Strength Fusion and Extrusion [(1)]	1 per 500 ft	80 (min)	lb/in	ASTM D6392 Strain rate: 2 in./min. 1 in. strips.
Peel Adhesion Fusion[(2)] Extrusion [(3)]	1 per 500 ft	60 (min) 52 (min)	lb/in. lb/in.	ASTM D6392 Strain Rate: 2 in./min 1 in. strips.
Vacuum Testing Welded Seams	Observe / document 100% of extrusion welds	-	-	-
Air Pressure Testing Welded Seams	Observe / document 100% of fusion welds	-	-	-

Notes:

in - inch
lb - pound
min. - minute

1. For shear testing of both fusion and extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the given value. The 5th specimen must meet at least 80 percent of the specified value. Shear elongation at break must be at least 50 percent.
2. For peel testing of fusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value. The 5th specimen must achieve at least 80% of the specified value. All specimens shall fail due to film tear bond or with less than 25% incursion of the weld (peel).
3. For peel testing of extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value with less than 25% incursion at the weld. The 5th specimen must achieve at least 80% of the specified value. One specimen may exhibit greater than 25% incursion at the weld if the specified strength value is achieved.
4. For double fusion welded seams, both tracks will be tested for compliance with the specified minimum seam peel strengths.

TABLE B.5

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
TEXTURED 40-MIL LLDPE GEOMEMBRANE

Properties	Minimum MQC Test Frequency	Minimum CQA Test Frequency	Units[1]	Specified Values	Test Method
Physical Properties					
Thickness	Every Roll	1 per 100,000 ft^2	mils	38 (min. avg.) 36 (lowest individual reading for 8 out of 10) 34 (lowest individual reading for any of 10)	ASTM D5994
Asperity Height	Every 2nd Roll	1 per 100,000 ft^2	mils	16 (min. average) (top and bottom)	ASTM D7466
Sheet Density and Resin Specific Gravity	one per 200,000 lb	1 per 100,000 ft^2	g/cm^3	0.939 (max.)	ASTM D1505/ ASTM D792
Carbon Black Content	one per 20,000 lb	1 per 100,000 ft^2	%	2.0-3.0 (range)	ASTM D4218/ ASTM D1603
Carbon Black Dispersion	one per 45,000 lb	1 per 100,000 ft^2	None	9 out of 10 in Category 1 or 2[2]	ASTM D5596
Resin - Melt Flow Index	one per 200,000 lb	--	g/10 min.	≤1.0	ASTM D1238
Tensile Properties (each direction)					
1. Tensile Strength at Break	one per 20,000 lb	1per 100,000 ft^2	lb/in	60 (min. average)	ASTM D6693 – Type IV
2. Elongation at Break	one per 20,000 lb	1 per 100,000 ft^2	%	250 (min. average)	ASTM D6693 – Type IV
Tear Resistance	one per 45,000 lb	1 per 100,000 ft^2	lb	22 (min. average)	ASTM D1004
Puncture Resistance	one per 45,000 lb	1 per 100,000 ft^2	lb	44 (min. average)	ASTM D4833
Oxidative Induction Time (OIT) Standard OIT or High Pressure OIT	one per 200,000 lb	--	Minutes	100 (min. average) 400 (min. average)	ASTM D3895 or ASTM D5885
2% Modulus	Per Formulation	--	lb/in	2400 (max.)	ASTM D5323
Axisymmetric Break Resistance Strain [3]	Per Formulation	--	%	30 (min.)	ASTM D5617
Oven Aging at 85°C [3] Std. OIT - retained after 90 days High Pressure OIT - retained after 90 days	Per Formulation	--	% %	35 (min. average) 60 (min. average)	ASTM D5721 ASTM D3895 ASTM D5885
UV Resistance [3][4] High Pressure OIT	Per Formulation	--	%	35 (min. average)	ASTM D7238 ASTM D5885

Notes:

1. % = percent; g = grams; g/cm^3 = grams per cubic centimeter; lb = pound; lb/in = pounds per inch; mils = milli-inches
2. Carbon dispersion for 10 different views. One view allowed in Category 3.
3. For 2% modulus, axisymmetric break resistance, oven aging, and UV resistance, Manufacturer's certification may be accepted in lieu of actual test results.
4. The condition of the test will be 20-hour UV cycle at 75°C followed by 4-hour condensation at 60°C.

TABLE B.6

SEAM PROPERTY AND INSTALLATION ACCEPTANCE CRITERIA
TEXTURED 40-MIL LLDPE GEOMEMBRANE

Material Property	Minimum CQA Test Frequency	Value	Units	Test Method
Shear Strength Fusion and Extrusion [(1)]	1 per 500 ft	60 (min)	lb/in.	ASTM D6392 Strain rate: 12 in./min. 1 in. strips.
Peel Adhesion Fusion[(2)] Extrusion [(3)]	1 per 500 ft	50 (min) 44 (min)	lb/in. lb/in.	ASTM D6392 Strain Rate: 12 in./min 1 in. strips.
Vacuum Testing Welded Seams	Observe / document 100% of extrusion welds	-	-	-
Air Pressure Testing Welded Seams	Observe / document 100% of fusion welds	-	-	-

Notes:

in - inch
lb - pound
min. - minute

1. For Shear Testing of both fusion and extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the given value. The 5th specimen must meet at least 80 percent of the specified value. Shear elongation at break must be at least 50 percent.

2. For Peel Testing of fusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value. The 5th specimen must achieve at least 80% of the specified value. All specimens shall fail due to film tear bond or with less than 25% incursion of the weld (peel).

3. For Peel Testing of extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value with less than 25% incursion at the weld. The 5th specimen must achieve at least 80% of the specified value. One specimen may exhibit greater than 25% incursion at the weld if the specified strength value is achieved.

4. For double fusion welded seams, both tracks will be tested for compliance with the specified minimum seam peel strengths.

5. LLDPE field samples will be allowed to cool to a minimum of 75 degrees Fahrenheit prior to testing. Testing will be performed in a climate-controlled environment at the site such as an office or trailer.

TABLE B.7

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
SUPER GRIPNET® 50-MIL HDPE GEOMEMBRANE
(FOR CLOSURETURF® ALTERNATIVE)

Properties	Minimum MQC Test Frequency	Minimum CQA Test Frequency	Units[1]	Specified Values	Test Method
Physical Properties					
Thickness	Every Roll	1 per 100,000 ft^2	mils	48 (min. avg.) 45 (lowest individual reading for 8 out of 10) 43 (lowest individual reading for any of 10)	ASTM D5994
Drainage Stud Height	Every 2nd Roll	1 per 100,000 ft^2	mils	130 (min. average)	ASTM D7466
Friction Spike Height	Every 2nd Roll		mils	175 (min. average)	ASTM D7466
Sheet Density and Resin Specific Gravity	one per 200,000 lb	1 per 100,000 ft^2	g/cm^3	0.940 (minimum for sheet density) 0.932 (minimum for resin density)	ASTM D1505 / ASTM D792
Carbon Black Content	one per 20,000 lb	1 per 100,000 ft^2	%	2.0-3.0 (range)	ASTM D4218/ ASTM D1603
Carbon Black Dispersion	one per 45,000 lb	1 per 100,000 ft^2	None	9 out of 10 in Category 1 or 2 [2]	ASTM D5596
Resin - Melt Flow Index	one per 200,000 lb	--	g/10 min.	≤1.0	ASTM D1238
Tensile Properties (each direction)					
1. Tensile Strength at Yield	one per 20,000 lb	1per 100,000 ft^2	lb/in	110 (min. average)	ASTM D6693 - Type IV
2. Tensile Strength at Break	one per 20,000 lb	1 per 100,000 ft^2	lb/in	110 (min. average)	ASTM D6693 - Type IV
3. Elongation at Yield	one per 20,000 lb	1 per 100,000 ft^2	%	12 (min. average)	ASTM D6693 - Type IV
4. Elongation at Break	one per 20,000 lb	1 per 100,000 ft^2	%	200 (min. average)	ASTM D6693 - Type IV
Tear Resistance	one per 45,000 lb	1 per 100,000 ft^2	lb	38 (min. average)	ASTM D1004 Die C Puncture
Puncture Resistance	one per 45,000 lb	1 per 100,000 ft^2	lb	80 (min. average)	ASTM D4833
Oxidative Induction Time (OIT) Standard OIT or High Pressure OIT	one per 200,000 lb	--	minutes	100 (min. average) 400 (min. average)	ASTM D3895 or ASTM D5885
Notched Constant Tensile Load Stress Cracking (NCTLSC) [3]	one per 200,000 lb	--	hours	≥300	ASTM D5397
Oven Aging at 85°C [3] Std. OIT - retained after 90 days High Pressure OIT - retained after 90 days	Per Formulation	--	% %	55 80	ASTM D5721 ASTM D3895 ASTM D5885
UV Resistance [3] High Pressure OIT	Per Formulation	--	%	50	ASTM D7238 ASTM D5885

Notes:

1. % = percent; g = grams; g/cm^3 = grams per cubic centimeter; lb = pound; lb/in = pounds per inch; mils = milli-inches
2. Carbon dispersion for 10 different views. One view allowed in Category 3.
3. For NCTLSC, oven aging, and UV resistance, Manufacturer's certification may be accepted in lieu of actual test results.
4. The properties in this table are based on GRI-GM13 Standard Specification for textured HDPE geomembranes of this thickness along with the manufacturer's (Agru's) latest available product data

sheet for 50-mil HDPE SuperGripnet® Geomembrane. If the manufacturer revises their published data sheet properties, such revised properties should be used as the acceptance criteria – provided that the material properties should maintain consistency with the industry standards of the GRI-GM13 Standard Specification for textured HDPE geomembranes of this thickness.

TABLE B.8

SEAM PROPERTY AND INSTALLATION ACCEPTANCE CRITERIA
SUPER GRIPNET® 50-MIL HDPE GEOMEMBRANE
(FOR CLOSURETURF® ALTERNATIVE)

Material Property	Minimum CQA Test Frequency	Value	Units	Test Method
Shear Strength Fusion and Extrusion (1)	1 per 500 ft	100 (min)	lb/in	ASTM D6392 Strain rate: 2 in./min. 1 in. strips.
Peel Adhesion Fusion(2) Extrusion(3)	1 per 500 ft	76 (min) 65 (min)	lb/in. lb/in.	ASTM D6392 Strain Rate: 2 in./min 1 in. strips.
Vacuum Testing Welded Seams	Observe / document 100% of extrusion welds	-	-	-
Air Pressure Testing Welded Seams	Observe / document 100% of fusion welds	-	-	-

Notes:

in - inch
lb – pound
min. - minute

1. For shear testing of both fusion and extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the given value. The 5th specimen must meet at least 80 percent of the specified value. Shear elongation at break must be at least 50 percent.

2. For peel testing of fusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value. The 5th specimen must achieve at least 80% of the specified value. All specimens shall fail due to film tear bond or with less than 25% incursion of the weld (peel).

3. For peel testing of extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value with less than 25% incursion at the weld. The 5th specimen must achieve at least 80% of the specified value. One specimen may exhibit greater than 25% incursion at the weld if the specified strength value is achieved.

4. For double fusion welded seams, both tracks will be tested for compliance with the specified minimum seam peel strengths.

TABLE B.9

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
SUPER GRIPNET® 50-MIL LLDPE GEOMEMBRANE
(FOR CLOSURETURF® ALTERNATIVE)

Properties	Minimum MQC Test Frequency	Minimum CQA Test Frequency	Units[1]	Specified Values	Test Method
Physical Properties					
Thickness	Every Roll	1 per 100,000 ft^2	mils	48 (min. avg.) 45 (lowest individual reading for 8 out of 10) 43 (lowest individual reading for any of 10)	ASTM D5994
Drainage Stud Height Friction Spike Height	Every 2nd Roll	1 per 100,000 ft^2	mils	130 (min. average) 175 (min. average)	ASTM D7466
Sheet Density and Resin Specific Gravity	one per 200,000 lb	1 per 100,000 ft^2	g/cm^3	0.939 (max.)	ASTM D1505/ ASTM D792
Carbon Black Content	one per 20,000 lb	1 per 100,000 ft^2	%	2.0-3.0 (range)	ASTM D4218/ ASTM D1603
Carbon Black Dispersion	one per 45,000 lb	1 per 100,000 ft^2	None	9 in Category 1 or 2 [2]	ASTM D5596
Resin - Melt Flow Index	one per 200,000 lb	--	g/10 min.	≤1.0	ASTM D1238
Tensile Properties (each direction)					
1. Tensile Strength at Break	one per 20,000 lb	1per 100,000 ft^2	lb/in	105 (min. average)	ASTM D6693 – Type IV
2. Elongation at Break	one per 20,000 lb	1 per 100,000 ft^2	%	300 (min. average)	ASTM D6693 – Type IV
Tear Resistance	one per 45,000 lb	1 per 100,000 ft^2	lb	30 (min. average)	ASTM D1004
Puncture Resistance	one per 45,000 lb	1 per 100,000 ft^2	lb	55 (min. average)	ASTM D4833
Oxidative Induction Time (OIT) Standard OIT or High Pressure OIT	one per 200,000 lb	--	Minutes	100 (min. average) 400 (min. average)	ASTM D3895 or ASTM D5885
2% Modulus	Per Formulation	--	lb/in	3000 (max.)	ASTM D5323
Axisymmetric Break Resistance Strain [3]	Per Formulation	--	%	30 (min.)	ASTM D5617
Oven Aging at 85°C [3] Std. OIT - retained after 90 days High Pressure OIT - retained after 90 days	Per Formulation	--	%	35 60	ASTM D5721 ASTM D3895 ASTM D5885
UV Resistance [3], [4] High Pressure OIT	Per Formulation	--	%	35 (min. average)	ASTM D7238 ASTM D5885

Notes:

1. % = percent; g = grams; g/cm^3 = grams per cubic centimeter; lb = pound; lb/in = pounds per inch; mils = milli-inches
2. Carbon dispersion for 10 different views. One view allowed in Category 3.
3. For 2% modulus, axisymmetric break resistance, oven aging, and UV resistance, Manufacturer's certification may be accepted in lieu of actual test results.
4. The condition of the test will be 20-hour UV cycle at 75°C followed by 4-hour condensation at 60°C.
5. The properties in this table are based on GRI-GM17 Standard Specification for textured LLDPE geomembranes of this thickness along with the manufacturer's (Agru's) latest available product data sheet for 50-mil LLDPE SuperGripnet® Geomembrane. If the manufacturer revises their published data sheet properties, such revised properties should be used as the acceptance criteria – provided

that the material properties should maintain consistency with the industry standards of the GRI-GM17 Standard Specification for textured LLDPE geomembranes of this thickness.

TABLE B.10

SEAM PROPERTY AND INSTALLATION ACCEPTANCE CRITERIA
SUPER GRIPNET® 50-MIL LLDPE GEOMEMBRANE
(FOR CLOSURETURF ® ALTERNATIVE)

Material Property	Minimum CQA Test Frequency	Value	Units	Test Method
Shear Strength Fusion and Extrusion (1)	1 per 500 ft	75 (min)	lb/in	ASTM D6392 Strain rate: 12 in./min. 1 in. strips.
Peel Adhesion Fusion(2) Extrusion (3)	1 per 500 ft	63 (min) 57 (min)	lb/in. lb/in.	ASTM D6392 Strain Rate: 12 in./min 1 in. strips.
Vacuum Testing Welded Seams	Observe / document 100% of extrusion welds	-	-	-
Air Pressure Testing Welded Seams	Observe / document 100% of fusion welds	-	-	-

Notes:

in - inch
lb - pound
min. - minute

1. For shear testing of both fusion and extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the given value. The 5th specimen must meet at least 80 percent of the specified value. Shear elongation at break must be at least 50 percent.

2. For peel testing of fusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value. The 5th specimen must achieve at least 80% of the specified value. All specimens shall fail due to film tear bond or with less than 25% incursion of the weld (peel).

3. For peel testing of extrusion welds, the strength of 4 out of 5 specimens must meet or exceed the specified value with less than 25% incursion at the weld. The 5th specimen must achieve at least 80% of the specified value. One specimen may exhibit greater than 25% incursion at the weld if the specified strength value is achieved.

4. For double fusion welded seams, both tracks will be tested for compliance with the specified minimum seam peel strengths.

5. LLDPE field samples will be allowed to cool to a minimum of 75 degrees Fahrenheit prior to testing. Testing will be performed in a climate-controlled environment at the site such as an office or trailer.

APPENDIX C

Material Properties and Acceptance Criteria for Geosynthetic Clay Liners

TABLE C.1

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
GEOSYNTHETIC CLAY LINERS (IF USED AS PART OF A LINER SYSTEM)

Properties	Units [1]	Specified Values [2]	Test Method	Minimum MQC Test Frequency	Minimum CQA Test Frequency
GCL (as manufactured) Properties					
Bentonite Content [3]	lb/ft2	0.75	ASTM D5993	1 per 5,000 yd^2	1 per 100,000 ft^2
Bentonite Moisture Content	%	35	ASTM D5993	1 per 5,000 yd^2	--
Hydraulic Conductivity [5,6]	cm/s	5×10^{-9}	ASTM D5887	1 per 30,000 yd^2	1 per 100,000 ft^2
Hydraulic Flux [5,6]	$cm^3/s\text{-}cm^2$	1×10^{-6}	ASTM D5887	1 per 30,000 yd^2	--
Tensile / Grab Strength [4]	ppi	23	ASTM D6768	1 per 25,000 yd^2	--
Peel Strength [4]	ppi	2.1	ASTM D6496	1 per 5,000 yd^2	--
Internal Shear Strength		Note 7	ASTM D6243	1 per lined cell or change in GCL product	1 per lined cell or change in GCL product
GCL Compatibility including permeability, swell index and fluid loss testing		Note 8	ASTM D6766 D5890(M) D5891(M)	--	1 per Project or change in GCL product
Clay Component Properties					
Bentonite Free Swell	ml/2g	24	ASTM D5890	1 per 50 tonnes	1 per 100,000 ft^2
Fluid Loss	ml	18	ASTM D5891	1 per 50 tonnes	--
Sodium Montmorillonite Content of Bentonite	%	90	Certification	--	--
Geotextile Component Properties					
Polymer Composition	%	95 polyester or polypropylene	Certification	--	--

Notes:

1. cm/s = centimeter per second % = percent lb = pound ppi = pounds per inch ft = feet
   ml/2g = milliliters per two grams lb/ft^2 = pounds per square foot
2. All values represent minimum average roll values, with the exception of hydraulic conductivity (permeability) and flux properties, which are specified as maximum values.
3. Measured on an oven dried sample.
4. For geotextile backed GCLs.
5. The GCL test specimen shall be hydrated with tap water for a minimum of 48 hours using sufficient backpressure to achieve a minimum B coefficient of 0.9 and using a confined effective consolidation stress not exceeding 10 psi. Then, the hydraulic conductivity test on the GCL specimen shall be conducted, using the appropriate permeant fluid, at a confined effective consolidation stress not exceeding 10 psi. The hydraulic conductivity test shall continue until steady state conditions are reached or a minimum of two pore volumes of permeant fluid have passed through the test specimen. The permeant fluid shall be either leachate from another lined cell at this facility (or similar/representative CCR pore fluid) if the GCL is used in a liner system of a lined cell.
6. Hydraulic conductivity may be performed using water once the relationship between hydraulic conductivities measured using the appropriate permeant fluid and water is established for the GCL product being supplied for the project.

7. Internal shear strength requirement applies to GCL used for cell liner system. Interface testing not required if GCL only used in leachate collection system sumps. Strength value will be developed during detailed design and specified in the Construction Documents.
8. Compatibility testing requirement applies to GCL used for cell liner system. For such cases, unless polymer-modified GCL is used for which there is adequate test data showing compatibility with a range of CCR leachates, compatibility testing shall be performed using site-specific leachate, or a synthetic leachate representative of the anticipated leachate characteristics. Both Scenario 1 and Scenario 2 of ASTM D6766 are acceptable, provided that the test termination criteria are satisfied for both scenarios. Notation (M) following ASTM D5890 and 5891 indicates that the standard test procedures will be modified using site-specific leachate, or a synthetic leachate representative of the anticipated leachate characteristics.

APPENDIX D

Material Properties and Acceptance Criteria for Geotextiles

TABLE D.1

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
NON-WOVEN GEOTEXTILE CUSHION LAYER

Material Property	Qualifier	Minimum MQC Test Frequency	Minimum CQA Test Frequency	Units	Specified Value	Test Method
Polymer Composition	Minimum	--	--	%	95 polypropylene or polyester by weight	Certification
Mass per Unit Area	Minimum Average	1 per 90,000 ft^2	1 per 100,000 ft^2	oz/yd^2	20	ASTM D5261
Grab Tensile Strength	Minimum Average	1 per 90,000 ft^2	1 per 100,000 ft^2	lbs	450	ASTM D4632
Grab Elongation	Minimum	1 per 90,000 ft^2	1 per 100,000 ft^2	%	50	ASTM D4632
CBR (Static) Puncture Strength	Minimum Average	1 per 540,000 ft^2	1 per 540,000 ft^2	lbs	1,000	ASTM D6241
Trapezoidal Tear Strength	Minimum Average	1 per 90,000 ft^2	1 per 100,000 ft^2	lbs	175	ASTM D4533
Ultraviolet Resistance	Minimum	1 per Formulation	--	%/hrs	70/500	ASTM D4355

Notes:

in - inch
lbs - pounds
oz - ounce
yd^2 - square yard

TABLE D.2

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
NON-WOVEN GEOTEXTILE SEPARATOR FOR
OUTLET PROTECTION AND GRAVEL/SOIL SEPARATION

Material Property	Qualifier	Minimum MQC Test Frequency	Minimum CQA Test Frequency(2)	Units	Specified Value	Test Method
Polymer Composition	Minimum	--	--	%	95 polypropylene or polyester by weight	Certification
Mass per Unit Area	Minimum Average	1 per 90,000 ft^2	1 per 100,000 ft^2	oz/yd^2	8	ASTM D5261
Grab Tensile Strength	Minimum Average	1 per 90,000 ft^2	1 per 100,000 ft^2	lbs	220	ASTM D4632
Grab Tensile Elongation	Minimum	1 per 90,000 ft^2	1 per 100,000 ft^2	%	50	ASTM D4632
CBR (Static) Puncture Strength	Minimum Average	1 per 540,000 ft^2	1 per 540,000 ft^2	lbs	575	ASTM D6241
Trapezoidal Tear Strength	Minimum Average	1 per 90,000 ft^2	1 per 100,000 ft^2	lbs	90	ASTM D4533
Ultraviolet Resistance	Minimum	Per formulation	--	%/hrs	70/500	ASTM D4355
Apparent Opening Size	Maximum Average	1 per 540,000 ft^2	1 per 540,000 ft^2	sieve	70	ASTM D4751

Notes:

1. in - inch
   lbs - pounds
   oz - ounce
   yd^2 - square yard
2. CQA testing is only required for geotextile separators used for gravel/soil separation as part of a liner system, leachate collection system, or final cover system. For geotextiles used as outlet protection (e.g., for riprap aprons at culvert outlets and pond outlets), CQA testing is not required.

APPENDIX E

Material Properties and Acceptance Criteria for Geocomposites

TABLE E.1

MATERIAL PROPERTIES AND ACCEPTANCE CRITERIA
DOUBLE-SIDED GEOCOMPOSITE DRAINAGE LAYER

Properties	Qualifier	Minimum MQC Test Frequency	Minimum CQA Test Frequency	Units	Specified Values[1]	Test Method
Geonet Component: (HDPE, bi-planar/bi-axial)						
Polymer composition	Minimum	--	--	%	95 polyethylene by weight	Certification
Polymer density	Minimum	1 per 50,000 ft^2	1 per 100,000 ft^2	g/cm^3	0.94	ASTM D792 (Method B) or ASTM D1505
Carbon black content	Range	1 per 50,000 ft^2	--	%	2 - 3	ASTM D1603 or D4218
Nominal thickness	Minimum	1 per 50,000 ft^2	1 per 100,000 ft^2	mil	300[3]	ASTM D5199
Tensile Strength	Minimum	1 per 50,000 ft^2	--	lb/in.	75	ASTM D7179
Geotextile Component: (non-woven needle punched)						
Polymer composition	Minimum	--	--	%	95 polyester or polypropylene	Certification
Mass per unit area	Minimum	1 per 90,000 ft^2	1 per 100,000 ft^2	oz/yd^2	8	ASTM D5261
Apparent opening size	Maximum	1 per 540,000 ft^2	1 per 100,000 ft^2	mm	$O_{95} \leq 0.21$ mm	ASTM D4751
Permittivity	Minimum	1 per 540,000 ft^2	1 per 100,000 ft^2	sec^{-1}	1.3	ASTM D4491
Grab strength	Minimum	1 per 90,000 ft^2	1 per 100,000 ft^2	lb	200	ASTM D4632 [2]
Tear strength	Minimum	1 per 90,000 ft^2	1 per 100,000 ft^2	lb	75	ASTM D4533 [2]
CBR (static) puncture strength	Minimum	1 per 540,000 ft^2	1 per 100,000 ft^2	psi	500	ASTM D6241
UV Resistance	Minimum	1 per Formulation	--	%/hrs	70/500	ASTM D4355
Geocomposite: (double sided with geotextile heat laminated on both sides of the geonet)						
Transmissivity[4]	Minimum	1 per 540,000 ft^2	1 per 100,000 ft^2	m^2/s	9×10^{-4}	ASTM D4716
Ply Adhesion	Minimum	1 per 50,000 ft^2	1 per 100,000 ft^2	lb/in.	1.0	ASTM D7005

Notes:

in – inch yd^2 – square yard mm – millimeter oz – ounce cm – centimeter
lb – pounds psi – pounds per square inch m – meter N/A – Not Applicable

1. All values represent minimum average roll values.
2. Minimum value measured in machine and cross-machine direction.
3. Nominal thickness may be reduced to 250 mil, provided the transmissivity requirements are met.
4. Specified value must be met at the following conditions:
   a. For the liner system geocomposite: a gradient of 0.33, normal load of 10,000 psf, and water temperature at 70° F, between steel plates for 15 minutes.
   b. For the final cover system geocomposite: a gradient of 0.04, normal load of 250 psf, and water temperature at 70° F, between steel plates for 15 minutes.

APPENDIX F

Interface Shear Strength CQA Requirements

TABLE F.1

INTERFACE SHEAR STRENGTH CQA TESTING REQUIREMENTS

System Components	Required Test	Minimum CQA Frequency	Acceptance Criteria[3]
Liner System Interfaces[1]	Interface Shear Strength ASTM D5321 or D6243	1 per lined cell or change in product or material type/source	See Note 1
Final Cover System Interfaces[2]	Interface Shear Strength ASTM D5321	1 per 25 acres or change in product or material type/source	See Note 2

Notes:

1. Required minimum liner system interface shear strength values are tabulated below. Tests (for both peak and large displacement strengths) will be conducted for the following interfaces (depending on the liner system option selected as noted):
   a. Geomembrane – fine-screened compacted clay liner (if the liner system incorporates fine-screened compacted clay liner material at an interface);
   b. Geomembrane – GCL (if the liner system alternative using a GCL is selected);
   c. GCL – compacted clay liner (if the liner system alternative using a GCL is selected);
   d. Geomembrane – geocomposite drainage layer or non-woven geotextile cushion layer; and
   e. Geocomposite drainage layer or non-woven geotextile cushion layer – sand or gravel layer.

Peak		**Large Displacement**	
Normal Stress (psi)	**Shear Strength (psi)**	**Normal Stress (psi)**	**Shear Strength (psi)**
2	0.81	2	0.43
10	2.49	10	1.92
50	12.47	50	6.13
100	24.93	100	11.38

2. If the soil-geosynthetic final cover system option is selected for use, the required minimum final cover system interface shear strength is a peak secant friction angle of 24.6 degrees and a large displacement secant friction angle of 20.2 degrees when tested at a normal stress of 240 psf. Tests (for both peak and large displacement strengths) will be conducted for the following interfaces of that final cover system:
   a. Geomembrane – CCR;
   b. Geomembrane – geocomposite drainage layer; and
   c. Geocomposite – protective soil layer.
3. Deviations from the specified interface shear strengths may be allowed upon review by and approval from the Design Engineer.