

CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

PLANT BOWEN
COAL COMBUSTION RESIDUALS
(CCR) LANDFILL
BARTOW COUNTY, GEORGIA
FOR



Georgia
Power

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1. GENERAL

This Construction Quality Assurance Plan (CQA Plan) has been prepared as part of the site's CCR permit application per Rule 391-3-4-.10(9)(c)1(v), and it provides the Construction Quality Assurance (CQA) and Construction Quality Control (CQC) standards, procedures, and minimum acceptance criteria for construction of the liners, leachate collection, and final cover systems at the Plant Bowen CCR Landfill.

This CQA Plan addresses those areas of construction pertaining to environmental protection including the necessary earthwork required for construction of the bottom liner and the leachate management and final cover systems. As each cell of the disposal facility is constructed or closed, Georgia Power Company (GPC) will submit a Construction Certification Report to the Georgia Environmental Protection Division (EPD) Solid Waste Program that includes a registered engineer's certification that the cell under consideration was constructed or closed within the limitations of and according to the approved permit.

Georgia Power will notify EPD of each major cell construction or closure event prior to initiating construction. CQA and CQC services will be provided by consulting engineering firms specializing in the inspection and testing of soils and geosynthetics. The services of the CQA/CQC firms required during construction and installation of all landfill components are described in this document.

The project team will consist of the following:

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:
 - a. 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 the requirements of the Construction Documents.
 - b. 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 as required by the Construction 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. CQA Consultant: The CQA Engineer 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 Engineer 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.

The CQA Engineer 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 organization will be led by the CQA Certifying Engineer (CQA 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 Engineer and will have experience in construction activities required for the Project.

The CQA Engineer 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 Engineer'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.

The specific duties of the CQA (Certifying) Engineer are:

- a. Reviews the Construction Documents;
- b. Attends scheduled meetings related to Project construction quality activities;
- c. 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);
- d. Provides quality control of CQA documentation; reviews and documents changes to the design during construction; and
- e. Prepares and seals the final CQA Certification Report.

The specific duties of the CQA Site Manager are:

- a. Serves as the on-site representative of the CQA Engineer and Certifying Engineer;
- b. Familiarizes all CQA field technicians with the site, Construction Documents, and the CQA requirements;
- c. Manages the daily activities of the CQA field technicians;
- d. Attends regularly scheduled CQA-related meetings on-site;
- e. Reviews the ongoing preparation of the construction record drawings;
- f. Reviews test results, certifications, and documentation provided by the Contractor, Geosynthetics Manufacturer, and Installer and makes appropriate recommendations;
- g. Reviews the CQA field technicians' daily notes and logs; prepares a daily report for the Project;
- h. Reviews the results of field and laboratory testing and makes appropriate recommendations;
- i. Reports any unresolved deviations from the CQA Plan and Construction Documents to the Construction Manager and CQA Certifying Engineer;
- j. Assists with the preparation of the final CQA Certification Report; reviews the Geosynthetics MQC documentation; and performs duties of CQA field technician, as needed.

The specific duties of the CQA Engineering Technicians (Technicians) include:

- a. Monitor material stockpiles for any deterioration of materials;
- b. Monitor surface-water drainage in the areas of soil and geosynthetic material stockpiles;
- c. Monitor and test foundation improvement and earthwork placement and compaction operations;
- d. Monitor the unloading, storage, and on-site handling of the geosynthetics;
- e. Monitor geosynthetic material deployment and installation operations;
- f. Monitor geosynthetic repair operations;
- g. Assist with the collection and shipping of laboratory test samples;

- h. 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;
 - i. Prepare notes and logs; and report problems to the CQA site manager.
- 3. Design Engineer: Responsible for providing interpretations and clarifications of the technical specifications, reviewing and approving shop drawings, authorizing minor variations in the work from the requirements of the technical specifications, and rejecting defective work. The Design Engineer will be a registered professional engineer licensed in Georgia.
- 4. CQC Engineer: Responsible for CQC monitoring, testing and documentation for all field work performed during the construction of the facility. The Contractor will have the responsibility for providing for all field CQC testing by the CQC Engineer, or his representative, for all work performed. Reference to the CQC Engineer, for the purpose of this document, will include the CQC Engineer and his/her designated representatives.
- 5. Contractor: The term “Contractor” refers to the General Contractor (i.e., the Prime Contractor) who is retained by the Owner to perform the construction of the landfill cells. 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, 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. 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 Engineer). 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. In the event of any discrepancies, the Construction Documents will govern.
- 6. Geosynthetics Manufacturers and Installers: Geosynthetics are manufactured materials. The Manufacturers who will supply geosynthetic materials for this Project (either procured by the Contractor or procured by the Owner, as established for the scope of work set forth in the Construction Documents) 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 liner system and final cover system should have experience manufacturing at least ten million square feet of such geomembranes. Further details of the required minimum Manufacturer qualifications for the various other geosynthetic materials of the Project will be provided in the Construction Documents. 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. Further details of the required minimum geosynthetics Installer qualifications for the various other geosynthetic materials of the Project will be set forth in the Construction Documents.

7. As-Built Surveyor: As required by specific sections of this CQA Plan, a registered professional land surveyor licensed in Georgia will perform the required as-built certification surveys on the components of the liner, leachate collection and/or final cover systems being constructed.

A separate set of technical specifications will be developed and included in the contract documents for cell construction and closure of the disposal facility. The technical specifications will provide the detailed processes, inspections and controls to ensure the structural fill, liner, leachate collection and final cover systems are constructed in accordance with this CQA Plan and the approved permit.

2. CQC/CQA INSPECTION ACTIVITIES DURING CONSTRUCTION

In accordance with the design and the Engineering Measures/Preparation Protocol of Section 6 of the Operations Plan, this CQA Plan includes specific construction inspection procedures that will be implemented during cell construction.

1. Initial Site Preparation:

The initial site preparation activities include the construction of the perimeter storm water diversion structures, installation of appropriate erosion and control (E&S) devices, and initial site clearing.

In addition to confirming that these activities are conducted in accordance with acceptable industry practice, the CQA Engineer will observe the ground conditions during clearing, grubbing, and initial excavation activities.

Should any anomalous subsurface conditions be identified (e.g., surface dropouts, soil voids, excessive seepage from the bottom or sidewalls of the excavation, etc.), appropriate notification and documentation procedures are specified (See the following Section 2.3, Inspections and Reporting).

2. Foundation Preparation and Base Grade Construction:

Foundation preparation activities focus on excavation of at least 5 ft. of soils in all areas, including those that will receive 15 ft. or more of new fill, proof-rolling, and inspection to provide an acceptable foundation for the cell base grade construction. The excavation activities will be monitored primarily to assess the consistency and composition of the excavated materials, as well as the occurrence of cracks and voids in the overburden.

Documentation of the subsurface conditions exposed during excavation will be maintained.

Procedures have been developed regarding the occurrence of any anomalous subsurface conditions identified during excavation as well as the appropriate notification and documentation procedures. (See the following Section 2.3, Inspections and Reporting.) Specific procedures are provided for repair of void collapses that might occur during proof-rolling of the excavation grades. (See Section 3.D.3).

The constructed foundation will consist of a structural earth fill interval comprised of a minimum of 13 feet of compacted overburden material and a minimum 2-foot compacted clay liner overlying a 5-foot thick zone of proof-rolled subgrade.

Appropriate material characterization and compaction criteria will be identified and monitored.

3. Inspections and Reporting

These guidelines will focus on storm water management and controls to assure that storm water will not be allowed to pond in the cells and conveyance ditches. Procedures are provided for periodic pre – construction and construction inspections. Post construction inspections are provided in Section 6.B.6 of the Operations Plan.

A notification protocol, which describes the notification procedures to be followed if anomalous conditions are identified during the inspection process are provided below.

a. Pre-Construction Inspections

The emphasis of this program will be the inspection of the site prior to and during initial clearing, grubbing, and excavation activities. The purpose of this program is to provide early recognition of locally unstable ground conditions.

Prior to any land disturbing activity, the cell construction area shall be thoroughly inspected by a qualified geologist and/or a geotechnical engineer to delineate, as a minimum, the following:

- i. lineaments in the area,
- ii. indications of surface depressions,
- iii. evidence of surface cracks and fractures,
- iv. indications of areas where water has (or had) the ability to either pond or infiltrate,
- v. areas of unusually soft surficial soils,
- vi. occurrence of recently fallen or leaning trees.

The surveyed location of any of the above conditions shall be determined and the location depicted on the cell development drawing as a permanent record. The resulting location map shall be maintained in the Operating Record for Cell construction.

Any identified locations shall be monitored during site development, particularly the grading activity, since some of the aforementioned near-surface features may become more evident at this time.

The results of the initial and subsequent inspections shall be documented and maintained in the Operating Record.

b. Cell Construction Foundation Inspections

The cell construction area shall be inspected and monitored during the course of construction. Inspections shall be performed on a daily basis by the CQA Engineer on site during the course of construction. The inspection intervals may increase as construction progresses. Post construction inspections will be performed in accordance with the Operations Plan.

The cell construction area shall be inspected by the CQA Engineer to delineate, as a minimum, the following:

- i. Areas of ponding of surface storm water in the cell or in the CCR fill area,
- ii. Formation of concentric cracking that could be an early indication of a foundation Instability and potential collapse, and,
- iii. Newly developed depressions and/or collapse features.

The ponding of any surface storm water within the cell area identified during construction shall be immediately corrected by grading to facilitate run-off.

Any area exhibiting potential foundation instability, potential collapse, newly developed depressions and/or collapse features shall be located by survey. The conditions of the area shall be documented. The location and documentation shall be maintained in the operating records of the facility.

If the condition is identified during the excavation process, the excavation may proceed to the excavation limit. If the condition has not been eliminated, the area shall be repaired in accordance with the **Cover-Collapse** Repair Procedures (Section 3.D.3). prior to beginning the placement of compacted fill. The area shall be continuously monitored during the placement of fill.

If any occurrence and/or reoccurrence of instability is identified during fill placement, the area shall be repaired in accordance the **Cover-Collapse** Repair Procedures (Section 3.D.3) prior to resuming placement of compacted fill.

The surveyed location of any of the above conditions shall be determined and the location depicted on the cell development drawing as a permanent record. The resulting location map shall be maintained in the operating record for the facility.

Upon identification of potential foundation instability, potential collapse, newly developed depressions and/or collapse features, the Notification Procedure outlined in the following Section 6 shall be followed.

4. Surface water body inspections

These inspections will include the existing surface waters of the site, most notably the Etowah River and the existing spring identified as being located in the northern favorable area.

5. Storm water management system inspections

Storm water monitoring will be in accordance with the NPDES General Permit for Stand-Alone Construction Activities (Permit No. GAR 100001) During Construction (Construction

Storm Water Permit) as well as in accordance with NPDES General Permit for Industrial Activities during operations (Industrial Storm Water Permit, Permit No. GAR 100000).

6. Notification Protocol

The identification of any area exhibiting potential foundation instability, potential collapse, newly developed depressions and/or collapse features shall be communicated immediately in accordance with the following procedures:

a) Pre-Construction Period:

The location, and condition, of any area exhibiting potential foundation instability, potential collapse, newly developed depressions and/or collapse features shall be documented and forwarded to the Construction Manager, Plant Manager, Owner's Engineer, and the Environmental Manager, Land and Remediation of Georgia Power Company's Environmental Affairs Department. Documentation of the detection and results of the initial inspection shall be subsequently forwarded to the Georgia EPD.

b) Construction Period:

The location and condition of any area exhibiting potential foundation instability, potential collapse, and/or newly developed depressions and/or collapse features detected during the construction period shall be immediately communicated to the Plant Manager, Environmental Manager, Land and Remediation, and Owner's Engineer. Upon receipt of this notification, the Environmental Manager, Land and Remediation, shall immediately notify the Georgia EPD.

3. GRADING

A. GENERAL

The CQA Engineer will observe and document all earthwork grading (excavation/fill placement) activities and test the compaction of in-situ materials and structural fill. The CQA Engineer is responsible for certifying that the materials and construction of the earthworks are in accordance with the plans, technical specifications, and this CQA Plan.

B. EARTHWORKS MATERIALS

The technical specifications will list all requirements for the physical properties and construction procedures of all earthworks in accordance with this CQA Plan.

C. MINIMUM REQUIREMENTS

1. A minimum of five (5) feet of residual soils below the existing ground surface within the footprint of the cells, sedimentation ponds, clear ponds, leachate ponds, and perimeter ditches, will be excavated and replaced with thirteen (13) feet of structural fill.
2. The structural fill will consist of on-site cohesive soils, synthetically improved soils, or imported cohesive soils with a remolded permeability of $k \leq 1 \times 10^{-6}$ cm/sec.
3. Prior to placing any structural fill, the entire subgrade will be proof-rolled utilizing loaded, off-road trucks with a 40-tons gross machine weight that includes a payload of soil.
4. Any areas failing the proof-rolling evaluation, will be undercut and replaced with structural fill and re-rolled. No structural fill will be placed on any part of the subgrade until such areas have been proof-rolled, inspected, and approved in writing by the CQA Engineer.

D. FOUNDATION IMPROVEMENTS

1. During construction, the CQA Engineer will visually observe and document the Contractor's foundation improvement activities. The CQA Engineer will monitor and document that the foundation improvements are implemented to conform with the requirements of the Construction Documents, including:
 - a. Excavation of a minimum of five (5) feet of residual soils below existing ground surface as described above;
 - b. Proof-rolling over the entire bottom of excavation area;
 - c. Identification and characterization of cover-collapse features and soft spots;

- d. Remediation of cover-collapse features as appropriate for the size and extent of the feature;
 - e. Excavation and backfilling around rock pinnacles or removal of the pinnacles; and
 - f. Ground improvement of soft areas.
2. It will be the responsibility of the CQA Engineer 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.
3. **Cover-Collapse Feature Repair Procedures**

As required in Section 6.B.2, Engineering Measures/Preparation Protocol, of the Operations Plan, any depressions encountered during execution of this Protocol will be photo-documented and reported to EPD. Should these features be encountered below the excavation grade, they will be photo-documented, repaired, and reported to EPD.

The following procedures shall be followed for remediation of Cover Collapse Features (CCFs) found within the Permit Boundary. These procedures, methods, or materials may be modified to address actual conditions of the CCF.

- a. If a CCF has been identified, all work shall cease in the immediate area of the CCF until the extent of the CCF has been delineated.
- b. Cordon off the delineated area to prevent personnel and equipment access.
- c. Excavate the collapse feature to a minimum depth of 10 ft. below subgrade or to a firm bottom, whichever is deeper. The depth may be increased as directed by the CQA Engineer.
- d. Extend the excavation of the collapse a minimum of 2 ft. horizontally outside the limits of the surface expression to provide a bench for the geotextile.
- e. The soil conditions of the excavation shall be determined by probing the bottom and side walls of the excavation. If the void diameter exceeds 10 ft., engineering analysis will be performed to develop a specific repair procedure. Any engineered measures to repair voids or throats greater than 10 ft. in diameter must be approved in writing by EPD prior to implementation.
- f. If the void diameter is 10 ft. or less, an inverted filter, will be placed within the bottom of the excavation. The inverted filter will consist of the following layers, from the bottom of the excavation up. Layer thicknesses and materials may be modified to meet actual conditions.

- i. If an open throat, or zone where the soil has raveled downward, is visible, concrete, or flowable fill may be placed or pumped into the throat to potentially block any further migration of soils.
 - ii. If used, the concrete or flowable fill plug shall extend approximately 2 ft. above the top of the throat of the CCF.
 - iii. If the void does not readily plug, cease pumping for 24 hours and allow the fill to set. This process should be followed until the throat is adequately plugged.
 - iv. If the throat was not identified, a layer of shot rock (surge stone) or Type III riprap shall be placed on the bottom of the excavation to block the path of potential soil migration. If concrete or flowable fill was used to plug the throat, place the shot rock on top of the plug.
 - v. Place a 1 ft. thick layer of smaller-sized graded stone, such as No. 57 stone, to fill the voids within the shot rock, fully covering the extent of the shot rock or riprap.
 - vi. Place a 1 ft. thick layer of smaller-sized graded rock, such as No. 89 stone, up to the level of the bench.
 - vii. Place a geotextile over the layer extending onto the bench. The Design Engineer may also specify that a layer of geogrid reinforcement (or other reinforcing material) be placed above the geotextile.
 - viii. Place and compact suitable structural fill, or clay liner, to the original ground surface or as directed by the CQA Engineer. The layer shall be a minimum 2-foot thick.
 - ix. Grade the final surface to promote positive run-off or to prevent run-on to the CCF location.
- g. CCF documentation shall include, as a minimum, photographs, location, initial condition, dimensions, inspections, and repair procedures. A final CCF Remediation Report shall be prepared, including all documentation, and submitted to Georgia Power Environmental Affairs.

E. ROCK REMOVAL BY BLASTING

1. In the event rock is encountered during subsurface preparation of the landfill which is too hard and cannot be ripped and excavated by conventional methods, the rock may be broken apart using blasting methods. The Contractor shall develop and submit for review a written blasting plan to the Owner no less than seven (7) days prior to blasting operations. Criteria for the program shall be the prevention of damage to existing structures, adjacent CCR cells and foundation soils, and the prevention of any

interruption of their services. The blasting methods will follow the outlined procedures listed below:

- a. Prepare a pre-blast report, which shall include the following:
 - Blasting company, company license number, date, and location.
 - Scalable map or figure showing the distance and direction from shot to the nearest structure or cell, including description of structure.
 - Type of shot with minimum planned scaled distance or regression data.
 - Maximum and minimum borehole depth, borehole diameter, and maximum charge weight at closest distance.
 - Blasting products, type of rock, locations, pattern with burden and spacing, inclination of blast holes, and powder factor per hole and per blast.
 - Stemming feet, stemming type, and stemming length ratio relative to burden.
 - The sequence and pattern of delays, if any.
 - Cover/existing overburden with amount and type, and direction to open face.
 - Date of bulk explosive truck calibration (if used).
 - Description of blast conditions, noting high fly rock potential, including but not limited to over confined shots, lift shots, outfall/wet conditions, spacing and burden exceeding the depth of any borehole in shot, and/or hole deviation. Document measures taken to compensate for high fly rock potential.
- b. Monitor the peak particle velocity at the location of the nearest existing landfill cell, groundwater monitoring well, earthen containment structures, CCR stockpiles or stacks, and in the direction of the nearest residence at the permit boundary. The peak particle velocity shall not exceed 1.0 inch per second at 40 Hz or greater. At lower frequencies use the established limits in the vibration criteria as presented in the U.S. Bureau of Mines RI 8507.
- c. Immediately prior to the blast, all landfill and construction traffic shall be stopped and all construction and landfiling activities shall cease until the blast is complete and it is safe to enter the area.
- d. A post-blast report which shall include the drilling log, record of vibration monitoring, approximate volume, and location(s) shall be included in the CQA report for the cell construction for each blasting occurrence.
- e. Conduct all blasting activities and handling of explosives in accordance with the Georgia Blasting Standards Act, and the Georgia Rules and Regulations for Explosives and Blasting Agents.
- f. Rock will be removed to provide for the minimum 13' of compacted earth fill between the top of rock and bottom of the compacted clay liner, as defined in the permit drawings.
- g. Any observed voids will be repaired in accordance with Section 3.D.3 of the CQA Plan. Compacted earth fill shall be placed above the rock in thin lifts and

compacted in accordance with the criteria in the permit drawings and facility CQA plan.

F. SUBGRADES

1. During construction, the CQA Engineer will test the subgrade soil materials. The CQA Engineer will monitor and document proof-rolling of areas that are excavated to achieve grade. Soil placed to achieve the grades indicated on the plans will be tested by the CQA Engineer in accordance with the test methods and frequencies listed herein to verify that the structural fill materials used by the Contractor comply with this CQA Plan. Areas of proofrolling or compacted fill that do not meet the requirements of this CQA Plan will be delineated and reported to the Contractor.
2. The CQA Engineer will document that these areas are reworked by the Contractor and retested until passing results are achieved.
3. The CQA Engineer will monitor and document any subgrade that is damaged by excess moisture (causing softening), insufficient moisture (causing desiccation and shrinkage), or by freezing. When such conditions exist, the CQA Engineer will evaluate the suitability of the subgrade by one or more of the following methods:
 - a. Moisture / density testing;
 - b. Continuous visual inspection during proofrolling; and
 - c. Other test methods identified herein.
4. The CQA Engineer will inform the Contractor and will document when the Contractor repairs areas damaged as indicated above. The CQA Engineer will retest the repaired areas until passing results are achieved.

G. CONFORMANCE AND PERFORMANCE TESTING

1. The CQA Engineer will observe and test the structural fill soils to confirm that they are uniform and meet or exceed the requirements of this CQA Plan. For soil materials obtained from on-site or off-site borrow areas, the CQA Engineer will perform visual inspections and conformance tests prior to the materials being used to confirm that only soil materials meeting the requirements of this CQA Plan are transported to the site. For both on-site and off-site borrow areas containing non-uniform materials, the Contractor and the CQA Engineer will coordinate excavation, monitoring, and proper segregation of soil materials. The CQA Engineer will advise the Contractor and will document when the Contractor removes materials that fail to meet the requirements of this CQA Plan from the project site.
2. The CQA Engineer will observe soils for deleterious materials, (e.g., roots, stumps, rocks, and large objects). When necessary, the visual-manual procedure for the description and identification of soils will be conducted by the CQA Engineer in accordance with test method ASTM D2488.

3. In order to confirm the shear strength assumptions used in the Demonstration of Engineering Measures analyses, appropriate triaxial shear tests shall be performed on representative undisturbed samples of the 13-foot thick structural fill layer. Prior to cell development, conformance testing shall be performed on potentially excavated soils and potential borrow area soils to assess the likely range of shear strength parameters. During construction of the compacted materials, field verification testing will be conducted to confirm the compacted unit weight, moisture content, shear strength, and compacted hydraulic conductivity. Results of the site-specific testing program will be included in the CQA Certification Report that is to be completed for each constructed cell and submitted to EPD

H. TEST METHODS AND FREQUENCY

1. All soil testing performed to confirm compliance with the requirements of this CQA Plan will be conducted in accordance with this CQA Plan. The field-testing methods used to evaluate the suitability of soils during their placement will be performed by the CQA Engineer in accordance with current ASTM test procedures indicated in the table below.
2. Documentation and reporting of the test results will be the responsibility of the CQA Engineer.
3. The Standard Proctor Test (ASTM D698) will be used for the determination of moisture/density relationships unless otherwise indicated. In-place moisture/density testing will be by nuclear test method ASTM D6938, the sand cone test method ASTM D1556 or drive cylinder test method ASTM D2937. The sand cone test method ASTM D1556 or drive cylinder test method ASTM D2937 will be used to establish correlations of moisture and density in cases of uncertainty, and as a check of the nuclear surface moisture/density gauge calibration.
4. The minimum conformance and performance testing frequencies for structural fill are presented in the table below. The frequency may be increased at the discretion of the CQA Engineer if variability of the materials is observed by the CQA Engineer. Sampling locations will be selected by the CQA Engineer. If necessary, the location of routine in-place density tests will be determined using a non-biased sampling approach.

Minimum Testing Requirements for Structural Fill/Foundation Improvements		
Type	Test	Frequency
Conformance Testing (Borrow Material)	Laboratory Moisture-Density/ASTM D698	1 test for each type of soil encountered and 1 test per 20,000 c.y.
	Liquid Limit, Plastic Limit, Plasticity Index/ASTM D4318	1 test for each type of soil encountered and 1 test per 5,000 c.y.
	Sieve Analysis/ASTM D422	1 test for each type of soil encountered and 1 test per 5,000 c.y.
	Remolded permeability (ASTM D5084)	1 test every 10,000 cy
Performance Testing	Field Density and Moisture Content Nuclear, ASTM D6938 or D8167	4 test per 1,000 c.y. of structural fill or 4 per acre per lift (minimum 4 per lift/day when fill is placed)
	Moisture /ASTM D2216	1 test per 10 Nuclear Gauge
	Field Density and Moisture Content/Sand Cone, ASTM D1556; Drive Cylinder, ASTM D2937	1 test per 25 Nuclear Gauge Tests
	Undisturbed Permeability (ASTM D5084)	1 test every 8,000 cy or 1 drive-tube per five vertical feet per acre.

5. A special testing frequency will be used at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem.

ACCEPTANCE CRITERIA

The CQA Engineer will confirm that structural fill conforms to compaction requirements as follows:

Description	ACCEPTANCE CRITERIA	
Landfill foundations, structural fill, perimeter berms and ditches; Sediment pond foundations and embankments	General Compaction	95% Standard Proctor at 0 to +2% of OMC ¹
	Top 12"	95% Standard Proctor at 0 to +2% of OMC ¹
	Permeability	1x10 ⁻⁶ cm/sec
Road shoulders and embankments Utilities under structures and other areas	General Compaction	95%
	Top 12"	95%
Roadways	General Compaction	95%
	Top 12"	98%

¹Or as needed to meet the required permeability.

I. PROTECTION OF SUBGRADES AND COMPACTED FILL SURFACES

The CQA Engineer will monitor newly graded areas to verify the Contractor is protecting these areas from traffic and erosion until construction is complete.

4. CLAY LINER

A. GENERAL

The CQA Engineer will certify the materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. MINIMUM REQUIREMENTS

The clay liner will consist of on-site cohesive soils, synthetically improved soils, or imported cohesive soils meeting the remolded permeability criteria of $k \leq 1 \times 10^{-7}$ cm/sec.

C. PRE-CONSTRUCTION MATERIAL EVALUATION

1. All material to be used to construct the clay liner will be sampled and tested by the CQA Engineer in advance of being placed. Such testing can be performed during excavation of the borrow area or from existing stockpiles.
2. The procedure for pre-construction testing during excavation and stockpiling of material to be used for clay liner soils is outlined below:
 - a. The CQA Engineer will examine each load of soil either at the borrow source or the stockpile area. Soil that does not meet the technical specification for clay liner material will be rejected or routed to separate stockpiles.
 - b. The following tests will be performed at the frequencies listed in the CCR Landfill Clay Liner Construction Quality Assurance Requirements Table in Section 4.G., prior to placement of any clay liner material:
 - i. Method for Particle - Size Analysis of Soils, ASTM D422 (Mechanical Sieve Method Only),
 - ii. Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures, ASTM D2216,
 - iii. Test Method for Liquid Limit, and Plasticity Index of Soils, ASTM D4318,
 - iv. Moisture-Density Curve (ASTM D698), and
 - v. Remolded permeability testing (ASTM D5084 - Measurement of Permeability of Saturated Porous Materials using a Flexible Wall Permeameter).
3. Reports for clay liner will be prepared by the CQA Engineer and will include:
 - a. Summary of laboratory test data, and

- b. A summary of construction, sampling and testing method, and recommendations for compaction moisture content to achieve the required permeability.

D. SUBGRADE

1. The CQA Engineer will verify that the clay liner subgrade is constructed in accordance with the technical specifications.
2. The CQA Engineer will document that the subgrade is scarified to a depth of 6 inches and compacted to a density of 95% or more as determined by the Standard Proctor Test, ASTM D-698.
3. The CQA Engineer will document that the subgrade is reasonably free of large rocks, large roots, stumps, and other debris.

E. TEST PAD CONSTRUCTION

1. The CQA Engineer will document the construction of a test pad prior to, or coinciding with, the beginning of construction of the clay liner.
2. The CQA Engineer will sample and test soil samples obtained from the constructed test pad to confirm that the material and the Contractors' placement and compaction methods used can consistently produce a clay liner layer that meets the requirements of this CQA Plan.
3. The CQA Engineer will confirm that the Contractor uses the same placement and compaction methods, equipment, and material to construct the remaining clay liner.

F. CONSTRUCTION

1. Only soil from a source previously sampled, tested and confirmed to meet the requirements of this CQA Plan will be used to construct the clay liner. The CQA Engineer will notify the Contractor when material does not meet the requirements of this CQA Plan and will document that this material will not be used for clay liner construction.
2. The CQA Engineer will complete all required field density and moisture content tests before the overlying lift of clay liner is placed.
3. The CQA Engineer will observe and document that the Contractor completes all surface preparation (e.g., wetting, drying, scarification, etc.) before placement of subsequent lifts.
4. The CQA Engineer will observe and document that loose lift thicknesses do not exceed 10 inches (unless otherwise required in this CQA Plan) for a final 6-inch compacted lift thickness.
5. The CQA Engineer will check each lift visually for the presence of rocks, debris, plant materials, and other foreign material as well as for particle sizes or clods that exceed the

requirements in this CQA Plan. The CQA Engineer will inform the Contractor if such materials are found and will document their removal.

6. The CQA Engineer will observe and document that the exposed surface of the clay liner is rolled with a smooth drum roller or equivalent at the end of each workday or when required to protect the compacted soil liner from adverse weather conditions.
7. The CQA Engineer will observe and document that the exposed surface of the clay liner is reasonably free of all rock, rock fragments, or loose materials. The CQA Engineer will observe and document that rock or other materials protruding more than ¼ -inch and other loose materials are removed, all cracks or voids filled, and the surface made uniform.
8. The CQA Engineer will observe and document that the surface on which the geosynthetics are to be placed is maintained in a firm, clean, dry, and smooth condition before and during the geosynthetics installation. Additionally, the CQA Engineer will inform the Contractor when desiccation cracking is excessive and will document that all desiccation cracks are repaired as required by this CQA Plan.
9. The CQA Engineer will inspect the clay liner and certify that it is in accordance with this CQA Plan and approved permit drawings. Placement of geosynthetics on any portion of the clay liner surface by the geosynthetics installer will constitute his/her acceptance of the surface.
10. The CQA Engineer will document that the required as-built certification surveys are performed on the clay liner prior to installing the overlying geosynthetics materials.

G. SAMPLING AND TESTING

1. Construction Quality Control field and laboratory testing will meet the minimum requirements indicated in the Table below.

CCR Landfill			
Clay Liner Construction Quality Assurance Requirements			
Item	Testing	Minimum Frequency	Minimum Criteria
Clay Liner Material Borrow Source (Conformance Testing)	Grain Size (ASTM D422, Sieves Only)	1,000 yd ³	< 1.0 inch (99%) < ¼ inch (Top 6") (99% of all Tests) 30% min passing the No. 200 sieve
	Moisture Content (ASTM D2216)	1,000 yd ³	

CCR Landfill			
Clay Liner Construction Quality Assurance Requirements			
Item	Testing	Minimum Frequency	Minimum Criteria
	Atterberg Limits (ASTM D4318)	5,000 yd ³	
	Moisture-Density Curve (ASTM D698)	5,000 yd ³ and All Changes in Material	
	Permeability of Remolded Samples (ASTM D5084)	10,000 yd ³	$k \leq 1 \times 10^{-7}$ cm/sec
Clay Liner During Construction (Performance Testing)	Density and Moisture-Nuclear, Sand Cone or Drive Tube (ASTM D-6938, D-1556 or D-2937)	1 Test/10,000 sf/lift and 1 Test/Lift/200 lf of Sidewall	≥ 95% Standard Proctor At moisture content per test fill (but no less than 0% below OMC)
Laboratory Testing on Undisturbed Samples of the Constructed Clay liner	Permeability (ASTM D5084)	1 test/40,000 sf/lift and 1 test/lift/800 lf of sidewall	$k \leq 1 \times 10^{-7}$ cm/sec
	Dry Density (ASTM D-5084)		≥ 95% Standard Proctor
	Moisture Content (ASTM D-2216)		

2. The CQA Engineer will randomly determine the location of each test. All test holes will be patched with a mixture of clay liner soils and sodium bentonite pellets hydrated and compacted in the holes.
3. The CQA Engineer will follow this procedure in the event of a density or permeability test failure. If the density does not meet minimum requirements of this CQA Plan, recompaction of the failed area (minimum 100 feet x 100 feet) will be performed and retested until the area meets or exceeds requirements outlined in this CQA Plan. If a permeability sample fails to meet the minimum permeability requirements outlined in this CQA Plan, the area of failing permeability (minimum 40,000 sf) will be reconstructed. Optionally, at least four (4) replicate samples will be obtained in the immediate vicinity of the failed test. Should the replicate samples confirm the failure of the soil to meet the requirements listed in this CQA Plan, the area of failure will be localized according to the results of the replicate samples and reconstructed. All areas of reconstruction will be retested as outlined in this CQA Plan.
4. The CQA Engineer will screen material obtained from a one square foot section of low-permeability soil liner for every 20,000 square feet of liner constructed and confirm that the following particle size criteria is met:

Lower 18 inches Clay Liner	
Percentage of Material Passing (By Weight)	Screen Size
99% (All Test)	1"
99.5% (Avg. of All Test)	1 ½"
99.8% (Avg. of All Test)	2"

Upper 6 inches Clay Liner	
Percentage of Material Passing (By Weight)	Screen Size
99% (All Test)	¼"
99.5% (Avg. of All Test)	½"
100% (Avg. of All Test)	1"

Should any sample fail the passing (99% passing 1/4 inches for the upper six (6") inches and 99% passing 1 inch for the lower 18"), then four (4) additional test areas within the 20,000 square foot test area will be selected by the CQA Engineer and tested in like manner. If the four (4) areas pass, then all test areas will be repaired, and the 20,000 square foot area accepted. If any one of the four (4) areas fails, then the 20,000 square foot area will be reworked and retested. Rocks or roots remaining on or protruding through the surface will be removed and the surface repaired.

5. REINFORCED GEOSYNTHETIC CLAY LINER (GCL) – LEACHATE PONDS ONLY

A. GENERAL

The CQA Engineer will certify that the material and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. GCL MATERIAL PRE-DEPLOYMENT REVIEW

1. GCL PRODUCT DATA

The CQA Engineer will review the Contractor's submittals for conformance with this CQA Plan and/or the latest version of GRI-GCL3 – Standard Technical specification for “*Test Methods, Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)*”, whichever is more stringent, unless otherwise directed by the Design Engineer.

The CQA Engineer will verify that the GCL to be used is a reinforced Coal-Ash Resistant (CAR) product. Additionally, the CQA Engineer will verify that the GCL consists of a bentonite mat manufactured with a non-woven geotextile on each side, unless otherwise approved by the Design Engineer.

2. SHIPMENT AND STORAGE

The CQA Engineer will verify that all GCL delivered to the project site is stored in a dry area protected from precipitation and direct sunlight. The GCL will be individually wrapped in protective plastic and placed on pallets to assure drainage beneath the rolls. The GCL rolls will be completely covered with polyethylene, maintained in good condition, until the GCL is deployed. GCL which has become wet (water content > 40%) prior to deployment will be rejected.

3. QUALITY CONTROL CERTIFICATES

The CQA Engineer will:

- a. Verify that the manufacturer's quality control (QC) certificates have been provided at the specified frequency and that each certificate identified the rolls related to it, and
- b. Review the manufacturer's QC certificates and verify that the certified properties meet the requirements in this CQA Plan or GRI-GCL3, whichever is more stringent.

4. GCL CONFORMANCE TESTS

The CQA Engineer will perform the Conformance Tests in accordance with and at the frequencies listed below. The sampling will be performed at the GCL manufacturing plant and the test results reviewed and accepted prior to delivery of the GCL to the project site.

Required GCL Properties ¹				
Property	Test Method	Units	Value	Test Frequency
Permeability (or by Index Flux)	ASTM D5084 ² (ASTM 5887 APPX 2)	cm/sec	$k \leq 5.0 \times 10^{-9}$	Per GRI-GCL3

Notes:

- ¹. In addition to the requirements used on this/her table, the manufactured GCL will be tested and meet the requirements set forth in the latest version of the Geosynthetic Research Institute's technical specification GCL-3 (GRI-GCL3) for reinforced GCLs.

Samples will be taken across the entire width of the roll and will not include the first lineal 3 feet. Unless otherwise specified, samples will be 3 feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow. All test results must be available at the site prior to the deployment of all GCL. The CQA Engineer will examine all results from laboratory testing.

5. MATERIAL CONFORMANCE TEST FAILURE:

The following procedure will apply whenever a sample fails a material conformance test:

- a. The GCL manufacturer will replace the roll of GCL that is in non-conformance with this CQA Plan with a roll that meets the requirements of this CQA Plan.
- b. The GCL manufacturer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to the requirements of this CQA Plan. If either of these samples fails, then the next numerical roll will be tested until a passing roll is found. If either of the two closest rolls fails, the CQA Engineer will dictate the frequency of additional testing. The CQA Engineer will document actions taken in conjunction with material control test failures.

C. GCL INSTALLATION

1. HANDLING AND PLACEMENT

The CQA Engineer will monitor and document the installation of the GCL according to this CQA Plan and the manufacturer's installation recommendations. The CQA Engineer will

monitor, verify, and document that GCL overlaps are made in accordance with the Construction Documents and that CQA activities are performed as described below. If the GCL has a woven geotextile side and a non-woven geotextile side, the CQA Engineer will document which geotextile side of the GCL is placed against the soil liner and which side is placed against the textured HDPE geomembrane.

2. SEAMS AND OVERLAPS

The CQA Engineer will monitor and document that the GCL is seamed or overlapped in accordance with this CQA Plan and will monitor and verify the GCL overlapping procedures conform to the requirements of Construction Documents. GCL panels will be overlapped at 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.

3. REPAIRS

The CQA Engineer will observe and document the repair of any holes or tears in the GCL, according to this CQA Plan.

The CQA Engineer 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 Engineer to avoid shifting during soil placement or covering with another geosynthetic layer.

4. PLACEMENT OF OVERLYING MATERIAL

The CQA Engineer will monitor and document placement of materials located on top of the GCL in accordance with this CQA Plan.

D. DEFICIENCIES

The CQA Engineer will determine the extent and nature of all defects and deficiencies and report them to Georgia Power and to the Contractor. All defects and deficiencies will be properly documented by the CQA Engineer. The CQA Engineer will observe all retests on repaired defects after the Contractor corrects the defects and deficiencies according to the CQA Plan and/or the technical specifications.

6. BOTTOM LINER GEOMEMBRANE

A. GENERAL

The CQA Engineer will certify that the bottom liner geomembrane materials and installation are in accordance with the approved permit, technical specifications, and this CQA Plan.

B. MATERIAL

1. The geomembrane will be a minimum 60 mil Textured High Density Polyethylene (HDPE) supplied and installed by firms approved by Georgia Power.
2. Seams for providing watertight joints will be extrusion or double hot wedge fusion seams.
3. The textured material will have an interface shear resistance with contiguous liner components of 23 degrees or as directed by the Design Engineer. This interface shear resistance is the minimum shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combination that provide satisfactory factors of safety may be approved by the Design Engineer. The interface shear strength will be determined by direct shear testing conducted at normal loads directed by the Design Engineer.
4. Manufacturer Quality Control (QC) will confirm that the material meets the minimum physical properties a 60-mil thick HDPE geomembrane as listed in the latest version of GRI-GM13- *Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes*.

C. GEOMEMBRANE MANUFACTURER AND INSTALLER

1. The Geomembrane Installer will submit the following information obtained from the Geomembrane Manufacturer to the CQA Engineer:
 - a. Production Certification including project references
 - b. Testing Program of Compound Ingredients
 - c. Material Certification
 - d. Test Data for Material and Resin
2. All of the above submittals will be reviewed and retained by the CQA Engineer. The Geomembrane Installer will submit the following information to the CQA Engineer 14 days prior to the installation:
 - a. Qualifications of Geomembrane Installer Superintendent and Foreman
 - b. Resumes of Geomembrane Contractor field crew

- c. Six (6) sets of proposed geomembrane panel layout drawings

D. TRANSPORTATION, HANDLING, AND STORAGE

1. The CQA Engineer will monitor the transportation, handling, and storage of the geomembrane on the Project site. Upon delivery at the site, the Contractor, Installer, and CQA Engineer 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 Engineer will indicate to the Construction Manager:
 - a. 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
 - b. rolls that include minor and repairable flaws that do not compromise geomembrane quality.
2. The CQA Engineer 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.

E. GEOMEMBRANE SUBGRADE SURFACES AND ANCHOR TRENCHES

1. Geomembrane Subgrade Surfaces

The CQA Engineer 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 Construction 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 Engineer and the Installer will jointly verify that the surface on which the geomembrane will be installed is acceptable. The Contractor will comply with the subgrade preparation and acceptance requirements identified in the Construction Documents. The CQA Engineer 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 Engineer and Purchaser to indicate the parties' concurrence that the surface is ready for deployment of geomembrane). Additionally, the surface will contain no ruts or loose stones larger than the maximum rut depth and loose stone size specified in the Construction Documents for geomembrane subgrade surfaces. The CQA Engineer 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 completed in accordance with the requirements of the Construction Documents.

2. Anchor Trenches

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

- a. 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;
- b. Perform in-place moisture/density testing of the compacted anchor trench backfill as required by the construction documents;
- c. Observe that geosynthetic materials in the anchor trench are temporarily anchored with sandbags or other suitable methods if the trench will remain open after the installation of geosynthetics;
- d. 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
- e. 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.

F. GEOMEMBRANE INSTALLATION

1. A pre-deployment CQA meeting will be held prior to installation of the geomembrane. The Contractor, the Geomembrane Installer, the CQA Engineer, the CQC Engineer, and representatives of Georgia Power will attend. The following issues will be discussed and agreed upon by all parties and will be included in a report in the CQA documentation.
 - a. Testing of welds.
 - b. Characteristics of “good” weld, and
 - c. Repair procedures
2. The CQA Engineer will obtain samples of the geomembrane rolls from the manufacturing plant prior to shipment to the site.
3. Random samples must be representative of the material supplied and exclude the outer wrap of geomembrane. Samples should be full roll width and at least two (2) feet long.
4. The laboratory testing of the samples selected will be coordinated by the CQA Engineer and will confirm conformance with the properties listed in the table below:

Geomembrane Conformance Testing Requirements

TEST NAME	TEST METHOD	MINIMUM CQA TESTING FREQUENCY and ACCEPTANCE CRITERIA ⁽¹⁾
Thickness	ASTM D 5994	1 per roll
Density	ASTM D 1505 or ASTM D 792	1/100,000 ft ²
Asperity Height	ASTM D7466	
Tensile Strength at Yield	ASTM D 6693, Type IV	
Tensile Strength at Break		
Elongation at Yield		
Elongation at Break		
Carbon Black Content	ASTM D 1603 or ASTM D 4218	
Carbon Black Dispersion	ASTM D5596	
Tear Resistance	ASTM D1004 (Die C Puncture)	
Puncture Resistance	ASTM D4833	
Interface Shear Strength ⁽²⁾ (with GDM and clay liner or GCL)	ASTM D5321	1 per 10 acres (min. 2 per project) per interface

Notes:

⁽¹⁾ Acceptance Criteria will be per the latest version of GRI-GM13- *Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes* found at: <https://geosynthetic-institute.org/grispecs/gm13.pdf>

⁽²⁾ Testing parameters for interface shear strengths are provided in Section 6.B.3.

- The CQA Engineer will review the geomembrane thickness of each roll made for the project prior to shipment. Material that does not fall within acceptable thickness criteria will be rejected.
- The CQA Engineer will mark all areas where grinding is considered to be excessive. The location and repair method for the excessive grinding will be recorded in the daily field reports.

7. Overheating of the geomembrane during welding will be monitored by the CQA Engineer. At the discretion of the CQA Engineer, coupons will be cut from the end of the extrusion seams and the bottom side of the seam will be observed for visible warping or deformation. The location and repair method of overheated areas will be recorded in the daily field reports. The method of repair will be determined in the field by the CQA Engineer.
8. During seaming, the CQA Engineer will observe the seams for the following:
 - a. proper preparation,
 - b. grinding technique, where applicable, and
 - c. overheating
9. The CQA Engineer will observe the geomembrane during the coolest part of the day to check for slack. Any areas where excessive "trampolining" occurs will be marked by the CQA Engineer for repair by the Geomembrane Installer.
10. The CQA Engineer will mark all areas where the geomembrane indicates a protrusion from the clay liner or GCL. The method of repair will be determined in the field by the CQA Engineer.

G. FIELD PANEL IDENTIFICATION

1. A field panel is a piece of geomembrane 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 Engineer will verify that each field panel is given an "identification code" (number or letter-number) that will:
 - a. Be physically marked on each respective panel;
 - b. be as simple and logical as possible;
 - c. be substantially consistent with the as-built layout plan; and
 - d. allow tracing of the Manufacturer's roll numbers to the field panel identification code.
2. The CQA Engineer 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.

H. FIELD PANEL PLACEMENT

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

2. The CQA Engineer will monitor that geomembrane placement does not proceed:
 - a. at an ambient temperature below 40°F or above 104°F unless authorized by the Design Engineer; or
 - b. 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.
3. The CQA Engineer will monitor that the above conditions are fulfilled and that the supporting soil has not been damaged by adverse weather conditions. The CQA Engineer will monitor geomembrane deployment for conformance with the Construction Documents, including that:
 - a. the geomembrane is deployed under acceptable temperature and weather conditions;
 - b. any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means;
 - c. the prepared surface underlying the geomembrane has not deteriorated since previous acceptance and is still acceptable immediately prior to geomembrane placement;
 - d. any geosynthetic elements immediately underlying the geomembrane are clean and free of foreign objects or debris;
 - e. all personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane;
 - f. the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting subbase;
 - g. the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);
 - h. adequate temporary loading and/or anchoring (e.g., sandbags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind; and
 - i. 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.
4. The CQA Engineer will observe the geomembrane panels, after placement and prior to seaming, for damage. The CQA Engineer 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 Engineer. CQA for geomembrane repairs will be in accordance with Section P of this Section.

I. PANEL LAYOUT

1. The CQA Engineer will review the panel layout drawing previously submitted to the Construction Manager by the Installer and verify that:
 - a. seams are generally oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope;
 - b. the number of seams is minimized in corners and odd-shaped geometric locations;
 - c. a seam numbering system is used that is compatible with the field panel identification numbering system and is agreed upon by the CQA Engineer and the Installer prior to any seaming; and
 - d. the panel layout is consistent with accepted state of practice.

J. SEAM PREPARATION

1. To confirm conformance with the Construction Documents, the CQA Engineer will monitor that:
 - a. prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
 - b. seams are overlapped in accordance with the requirements of the Construction Documents;
 - c. if seam overlap grinding is required, the process is completed according to the Geosynthetics Manufacturer's instructions or the Construction Documents, whichever is the more stringent, prior to the seaming operation, and in a way that does not damage the geomembrane;
 - d. the grind depth is constructed in accordance with the requirements of the Construction Documents;
 - e. grinding marks do not appear excessively beyond the extrudate after it is placed; and
 - f. seams are aligned with the fewest possible number of wrinkles and fishmouths.

K. OVERLAPPING AND TEMPORARY BONDING

1. The CQA Engineer will monitor that:
 - a. 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;

- b. no solvent or adhesive is used; and
- c. 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.

L. TEST SEAMS

1. The CQA Engineer will document and verify that the Geomembrane Installer performs a test seam for each welding machine in use every 4-5 hours, or at a minimum prior to start of construction work, and at midday. At least one test seam will be made for each machine in use for each seam. Should any postproduction test seam fail, the immediate prior production seam will be sampled for destructive testing in accordance with Section F below. The test seam should be approximately 5 feet long. The CQA Engineer will sample the test seam from the center 3 feet of the test sample.
 - a. The date, time, and equipment, as well as welding temperature, and seaming parameters will be recorded for each test seam.
 - b. A minimum of five (5) specimens for peel and for shear from each sample will be tested for the properties listed in the latest version of GRI-GM19, "*Standard Technical specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*" in accordance with test method ASTM D6392. Testing will be performed in the field by the Geomembrane Installer under full-time observation by the CQA Engineer.
 - c. Untested portions of the test seam will be retained by the CQA Engineer for the project record and future testing as required.
2. All test seams must pass the field testing before production seaming is performed by the Geomembrane Installer.

M. FIELD DESTRUCTIVE TESTING

1. The Geomembrane Installer will obtain approximately 12" x 48" samples of field seams, suitable for testing, as indicated in the table below. The date, time, equipment, and seam number will be marked on each sample and recorded by the CQA Engineer.

Field Seam Testing Requirements

TEST NAME	TEST METHOD	AVERAGE TESTING FREQUENCY AND ACCEPTANCE CRITERIA ⁽³⁾
Seam Peel Strength	ASTM D 6392 ⁽¹⁾	1 test per 500 feet of seam
Seam Shear Strength	ASTM D 6392 ⁽²⁾	1 test per 500 feet of seam

Notes:

- ⁽¹⁾ For double wedge fusion seams, both tracks will be tested in peel.
- ⁽²⁾ For shear tests, the sheet will yield before failure of the seams.
- ⁽³⁾ Acceptance Criteria per latest version of GRI-GM19, "Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane", see <https://geosynthetic-institute.org/grispecs/gm19a.pdf>

2. Samples retained will be tested in the field by the Geomembrane Installer. A minimum of five (5) specimens from each sample for peel and for shear will be tested for the properties listed above and in the latest version of GRI-GM19, "Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane" in accordance with test method ASTM D6392.
3. The CQA Engineer or Georgia Power may require additional random samples to be taken for testing in areas that visually appear defective and not in accordance with this CQA Plan or the technical specifications.

N. NON-DESTRUCTIVE TESTING

1. The Geomembrane Installer is responsible for the completion of non-destructive testing of the entire length of all field seams, verifying that said seam is airtight. Said testing can be a vacuum test, pressure test, or approved equal and will be described by the Geomembrane Installer and verified by the CQA Engineer in advance.
2. The CQA Engineer 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 Engineer 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 Engineer will monitor that the Installer performs continuity testing as the seaming work progresses, not at the completion of all field seaming. The CQA Engineer will:
 - a. monitor nondestructive testing;
 - b. document the results of the nondestructive testing; and
 - c. inform the Contractor and Construction Manager of any non-conformance.
3. The CQA Engineer will monitor that the Installer performs any required seam repairs in accordance with the Construction Documents. The CQA Engineer will:

- a. observe the repair procedures;
 - b. observe the re-testing procedures; and
 - c. document the results.
4. 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 Engineer.

O. DESTRUCTIVE FIELD AND LABORATORY TESTING

1. Destructive seam samples will be laboratory tested by the CQA Engineer. The field destructive test will be done by the Geomembrane Installer.
2. Testing frequency will be a minimum average frequency of one (1) sample per 500 linear feet of field seam.
 - a. Test samples will be at least 12 x 36 inches. A minimum of five (5) specimens will be tested for the properties listed in the latest version of GRI-GM19, "*Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*" in accordance with test method ASTM D6392. These test samples will be taken at the same locations as the contractor's destructive testing samples.
 - b. Acceptance Criteria for the destructive test will be according to the latest version of GRI-GM19, "*Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*"; found at <https://geosynthetic-institute.org/grispecs/gm19a.pdf>.
 - c. All laboratory specimens will be conditioned for a minimum of one (1) hour prior to testing at the standard atmosphere for testing geosynthetics, that is, air maintained at a relative humidity of 65 ±5% and a temperature of 21 ±2°C (70±3.5°F).
 - d. Peel tests will be performed on both sides of a double-wedge fusion seam.
3. The load and elongation at failure will be measured for each specimen. The CQA Engineer will describe the type of failure for each specimen and record the presence of any disbonding, delamination, foreign material in the bond area, etc.
4. The average values of each set of five specimens for peel and for shear must meet this CQA Plan, and four of the five specimen tests must meet this CQA Plan for the seam to be considered a passing seam. If the average of the five specimens is adequate, but one of the specimens is failing, values for the failing specimen must be at least 80 percent of the values required for the seam for the sample to pass. A maximum of one non-film tear

bond failure out of five tests is acceptable provided the destructive sample meets strength requirements discussed above. If unresolved discrepancies exist between the CQA Engineer and Contractor's test results, the archived sample may be tested by the CQA Engineer. Samples that do not pass the shear and peel tests will be resampled from locations at least 10 feet on each side of the original location. These two re-test samples must pass both shear and peel testing. If these two samples do not pass, then additional samples will continue to be obtained until the questionable seam area is defined.

5. Seams represented by a failing destructive field or laboratory test sample will be cut out and replaced or covered with a cap strip and the seam bounded by supplemental passing field and laboratory destructive test samples at both ends.
6. The CQA Engineer will verify and document that the strength and other properties of the 60-mil thick HDPE geomembrane seams meet or exceed the requirements set forth in the latest version of GRI-GM19, *"Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane"*.

P. DEFECTS AND REPAIRS

1. The CQA Engineer will monitor, verify, and document that geomembrane defects are addressed, and repairs are made, in accordance with the Construction Documents and that CQA activities are performed as described in the subsections below.
2. All seams and non-seam areas of the geomembrane will be examined by the CQA Engineer 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 Engineer will request that the Contractor broom or wash the geomembrane surface if the amount of dust or mud inhibits examination.

3. Repair Procedures

The CQA Engineer will monitor that any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, is repaired by the Installer in accordance with the Construction Documents. 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 Engineer.

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

- a. surfaces of the geomembrane which are to be repaired are abraded no more than one hour prior to the repair;
- b. all surfaces are clean and dry at the time of the repair;
- c. 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

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

4. Verification of Repairs

Each repair will be numbered and logged by the CQA Engineer. The CQA Engineer 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 Engineer. The CQA Engineer will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

Q. LEAK LOCATION SURVEY (IF APPLICABLE)

1. If performed, Leak Location Survey(s) on the landfill bottom geomembrane liner will be observed and documented by the CQA Engineer. The work will be performed according to this CQA Plan.
2. The CQA Engineer will verify that the Leak Location Contractor has the following qualifications for conducting the Leak Location Survey:
 - a. Completion of the Liner Integrity Survey/Assessment (LISA) training course conducted by TRI Environmental of Austin, Texas (or equivalent).
 - b. The leak location surveys must be supervised by a professional or technician with a minimum of three (3) years and 5,000,000 square feet of geomembrane installation and CQA experience.
 - c. The leak location supervisor must be on site full-time during the performance of the Leak Location Survey.
3. Leak Location Survey(s) will meet the requirements of:
 - a. ASTM D6747 – Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes; and
 - b. ASTM D7007 – Standard Practices for Locating Leaks in Geomembranes Covered with Water or Earth Materials.

The selected method will have the goal of identifying minimum 1-inch dimension penetrations in the geomembrane, unless otherwise specified in this CQA Plan.

4. The CQA Engineer will confirm and document that the Leak Location Survey is conducted after the protective cover materials are installed over the geomembrane liner to detect holes resulting from construction damage during placement of the protective cover layer.

5. The CQA Engineer will document the Leak Location Contractor's site inspection prior to commencing the survey to confirm all site preparations are completed and the site conditions are appropriate for conducting the Leak Location Survey. Any issues or concerns with the site conditions will be reported to the Contractor, the Geosynthetics Installers, Georgia Power, and documented by the CQA Engineer.
6. Leak Location Contractor will mark the locations of all identified or indicated leaks with flags, spray paint, or written coordinates. All liner repairs will be completed, observed, and documented by the CQA Engineer.
7. The CQA Engineer will include the Leak Location Contractor's report in the project Construction Certification Report.

7. LEACHATE COLLECTION GEOCOMPOSITE DRAINAGE MEDIA (GDM)

A. GENERAL

The CQA Engineer will certify that the leachate collection geocomposite drainage media (GDM) materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. GDM MANUFACTURER AND INSTALLER

1. The CQA Engineer will review and verify the following submittals from the GDM manufacturer:
 - A. Production Certification,
 - B. Material Certification, and
 - C. Test Data for Material.
2. The CQA Engineer will review and verify the following information prior to installation:
 - A. Qualifications of installer superintendent, foreman, and field crew.
 - B. Six sets of field installation drawings.

C. CONFORMANCE TESTING

CQA Conformance Testing will be performed by the CQA Engineer according to the following table:

GDM Conformance Testing Requirements

<u>Properties</u>	<u>Qualifier</u>	<u>Minimum MQC Test Frequency</u>	<u>Minimum CQA Test Frequency</u>	<u>Units</u>	<u>Specified Values⁽¹⁾</u>	<u>Test Method</u>
Geonet Component: (HDPE, bi-planar/bi-axial)						
Polymer composition	Minimum	--	--	%	95 polyethylene by weight	Certification
Polymer density	Minimum	1 per 50,000 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	--	mil	300 ⁽³⁾	ASTM D5199
Tensile Strength	Minimum	1 per 50,000 ft ²	--	lb/in.	75	ASTM D7179

Properties	Qualifier	Minimum MQC Test Frequency	Minimum CQA Test Frequency	Units	Specified Values ⁽¹⁾	Test Method
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	--	oz/yd ²	8	ASTM D5261
Apparent opening size	Maximum	1 per 540,000 ft ²	--	mm	O ₉₅ ≤ 0.21 mm	ASTM D4751
Permittivity	Minimum	1 per 540,000 ft ²	--	sec-1	1.3	ASTM D4491
Grab strength	Minimum	1 per 90,000 ft ²	--	lb	200	ASTM D4632 ⁽²⁾
Tear strength	Minimum	1 per 90,000 ft ²	--	lb	75	ASTM D4533 ⁽²⁾
CBR (static) puncture strength	Minimum	1 per 540,000 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	1.4 x 10 ⁻³	ASTM D4716
Ply Adhesion	Minimum	1 per 50,000 ft ²	1 per 100,000 ft ²	lb/in.	1.0	ASTM D7005
Interface Shear Strength ⁽⁵⁾ (with protective layer)	Minimum	1 per 50,000 ft ²	1 test per 10 acres (min. 2 per project)	deg.	23	ASTM D5321

Notes:

in – inch yd² – square yard mm – millimeter oz – ounce cm – centimeter
 lb – pounds psi – pounds per square inch m – meter N/A – Not Applicable

- All values represent minimum average roll values.
- Minimum value measured in machine and cross-machine direction.
- Nominal thickness may be reduced to 250 mil, provided the transmissivity requirements are met.
- Transmissivity testing will be performed as described below:
 Conduct CQA testing for transmissivity at the confining pressure of 12,980 PSF at a hydraulic gradient equal to 0.02 for 100 hours. The boundary conditions are “Granular Drainage Layer” stone on top and the specified geomembrane on the bottom of the GDM. The minimum required transmissivity tested under these conditions will be 1.4x10⁻³ m²/sec (tests between two steel plates are not acceptable).
- Degree is shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combinations that provide satisfactory factors of safety may be approved by the Design Engineer. The minimum shear strength required is 23 deg.

D. INSTALLATION

- The CQA Engineer will verify that the installation of the GDM proceeds after he has provided certification of the geomembrane or a section thereof.
- The CQA Engineer will monitor the installation of the GDM to verify there is no damage to the geomembrane liner. Should the geomembrane liner be damaged the CQA Engineer will inform the Contractor and document the repairs done.

3. The CQA Engineer will verify that adjacent rolls of GDM overlap a distance of at least three (3) inches and are secured using polyethylene ties every ten (10) feet for adjacent rolls and five (5) feet at end seams.
4. The CQA Engineer will verify that the overlaying GDM geotextile, where applicable, extends at least six (6) inches past the geonet joint and is permanently bonded by heat bonding or sewing.
5. The CQA Engineer will verify that any GDM that is torn, crushed, or punctured is repaired or replaced by the Contractor according to this CQA Plan.
6. The CQA Engineer will be present during all installation operations and will verify that all work is in accordance with the CQA Plan and technical specifications.
7. At the conclusion of this activity, the CQA Engineer will provide a written certification that the work has been installed according to plans and technical specifications.

8. PROTECTIVE FILTER SAND

A. GENERAL

The CQA Engineer will certify the protective filter sand materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. MATERIALS

1. The protective filter sand layer will be a loose granular material resulting from the disintegration of rocks, will be capable of 100% passing through a $\frac{1}{4}$ -inch screen and will generally conform to the gradation of Georgia DOT 10 NS or 10SM sand. The protective sand layer material will contain no aggregate rocks, debris, plant material, material with sharp edges, lignite, coal, ash, or carbonaceous material. By-products of industrial processes, with the exception of quarry grinding operations, will not be accepted.
2. The protective filter layer will consist of a material with a permeability equal to or greater than 1×10^{-2} cm/sec for Cells No. 5 through 8 and 1×10^{-3} cm/sec for Cells 9 and 10.
3. Construction Quality Assurance Testing will meet the minimum requirements for the protective filter sand and granular drainage layers as follows:

Test	Minimum Frequency
Grain Size to No. 200 Sieve (ASTM D 422)	1 per material per acre
Permeability* (ASTM D 2434)	1 per material per 5,000 cy
Carbonate Content (ASTM D3042)	1 per material per 10,000 cy

*does not include NSA R-2 material

C. STOCKPILING AND MATERIAL APPROVAL

1. All material to be used as protective filter sand will be approved in advance by the CQA Engineer. The CQA Engineer must verify that the sand and the stone meet all the material requirements.
2. Verification can be accomplished during excavation and stockpiling or prior to use at existing stockpiles.
3. The CQA Engineer will prepare reports of all testing, analysis, and verification.

D. CONSTRUCTION

The CQA Engineer will verify the following information:

1. Approved material was used to construct the protective filter sand layer.
2. The protective sand layer was constructed in accordance with the approved permit drawings, technical specifications, and this CQA Plan.
3. The underlying geosynthetics were not damaged during placement of the protective filter sand layer.
4. The protective filter sand layer was placed from the toe of the slope up.
5. The required protective filter sand layer thickness was achieved.

9. LEACHATE COLLECTION SYSTEM TRENCHES

A. GENERAL

The CQA Engineer will certify the leachate collection system trench materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. MATERIALS

The CQA Engineer will verify that the leachate collection system trench materials delivered to the site are as follows:

1. Leachate collection piping in accordance with the leachate piping technical specifications and this CQA Plan.
2. Gravel for leachate pipe encasement and for the leachate sump will be in accordance with the gravel technical specifications and this CQA Plan.
3. Cushion Geotextile will be a non-woven geotextile of polypropylene fibers or polyester yarns suitable for separation and cushioning. The cushion geotextile will be in accordance with the cushion technical specifications and this CQA Plan.

The CQA Engineer will verify that all materials provided are those specified or are equal and are in accordance with the approved permit drawings, technical specifications, and this CQA Plan.

C. INSTALLATION

1. The CQA Engineer will verify and document that the installation of the leachate collection system proceeds after he/she has received/reviewed all of the destructive test results of the geomembrane liner and has reviewed and approved the geomembrane liner as-built survey.
2. The CQA Engineer will verify there is no damage to the underlying geosynthetic materials during the installation of the leachate collection system. If the CQA Engineer notices damage of the underlying geosynthetics, the CQA Engineer will inform the Contractor and will verify that the Contractor makes the required repairs.
3. The CQA Engineer will be present during all phases of the leachate collection system construction and will verify that all work is in accordance with the approved permit drawings, technical specifications and this CQA Plan.

D. QUALITY ASSURANCE

The CQA Engineer will document and verify that the following submittals are provided and that the materials meet and are installed in accordance with the technical specifications and this CQA Plan.

1. HIGH DENSITY POLYETHYLENE PIPE

- a. Submittals required for pipe:
 - i. Compliance with applicable ASTM standard
 - ii. Unit weight
 - iii. Diameter and SDR
 - iv. Physical dimensions
 - v. Method of jointing with instructions
 - vi. Nominal pipe joint lengths
 - vii. Recommended bedding and installation details
 - viii. Instructions and tables or information on strength of each pipe type versus bury
 - ix. Conditions of depth and traffic loadings
 - x. Certification by manufacturer that material properties meet the values listed in the material properties sheet.
 - xi. Perforation diameter and spacing
- b. The CQA Engineer will document and verify that the manufacturer certifies that the pipe supplied is represented by the quality assurance data.
- c. The CQA Engineer will inform the Contractor when the pipe does not meet appropriate ASTM Standards.
- d. The CQA Engineer will provide results of any samples taken for testing.
- e. The CQA Engineer will witness and verify that jointing and installation are in accordance with manufacturer's recommendations and this CQA Plan.
- f. The CQA Engineer will verify that leachate conduits external to the collection system are tested and demonstrated to be leak-proof.

2. PIPE ENCASEMENT GRAVEL

- a. The CQA Engineer will review the Contractor's submittals on gravel for conformity to technical specifications including quarry's certification of gradation.
- b. Construction Quality Control Testing will meet the minimum requirements for the encasement gravel as follows:

Test	Minimum Frequency
Grain Size (ASTM D 422)	2 per project per material
Carbonate Content (ASTM D3042)	1 per material per 10,000 cy

- c. The CQA Engineer will inform the Contractor when the gravel does not meet the requirements of this CQA Plan or the technical specifications.
- d. The CQA Engineer will provide results of any samples taken for testing.
- e. The CQA Engineer will verify that the gravel encasement is in accordance with the technical specifications and this CQA Plan.

3. CUSHION GEOTEXTILE

- a. The CQA Engineer will review the Contractor's submittals on geotextile for conformity to technical specifications.
- b. The CQA Engineer will inform the Contractor when the geotextile does not meet technical specifications.
- c. The CQA Engineer will verify that the geotextile is in accordance with the technical specifications and this CQA Plan.
- d. The CQA Engineer will provide results of any samples taken for testing.

10. TESTING OF PIPING SYSTEMS

A. GENERAL

1. The CQA Engineer will observe and document leak testing of leachate manholes, force mains, and non-perforated gravity piping.
2. If the specified rate of leakage is exceeded during the test, the CQA Engineer will document that the Contractor located the points of excessive leakage, instituted appropriate measure of correction, and observed all re-tests, until test requirements are met.
3. The CQA Engineer will observe and confirm that:
 - a. Hydrostatic testing is performed on force mains and pressure leachate piping.
 - b. Exfiltration testing is performed on manholes and gravity leachate piping.

B. EXFILTRATION TESTING

1. The CQA Engineer will verify and document that the exfiltration tests on all manholes and gravity leachate piping are conducted according to the following procedures:
 - a. Plug each end of section or all openings to manhole to be tested with watertight bulkheads.
 - b. Insert in each bulkhead at the top of the pipeline a two (2") inch diameter pipe with 90° elbow that will extend four (4') feet vertically above the top of the pipeline or above the groundwater line, whichever is higher. Manhole will be tested at full depth with the water level at the cover ring.
 - c. The elevations of the top of the two (2") inch diameter pipe at each bulkhead will be the same.
 - d. Fill the pipeline with clear water until the water level is at the top of the two (2") inch diameter pipe at the upper end of section or at the manhole ring.
 - e. Maintain the water level by adding accurately measured amounts of water for a period of thirty minutes, not allowing the lower pipe to overflow.
 - f. The maximum length of a section of pipeline to be tested by means of an exfiltration test at one time will be limited to 1,000 linear feet.
 - g. The maximum permissible leakage determined by exfiltration will be the rate of 25 gallons per in. inside diameter of pipe per mile of pipe per 24 hours, inclusive

of all appurtenances within the section such as manholes, valves, etc. The length of pipe used in the computation will be the horizontal distance between manhole centerlines of the section being tested. The maximum permissible leakage rate for manholes tested alone will be 0.01 gallons per vertical foot per day.

- h. Once exfiltration is found to be within allowable limits, remove all bulkheads.

C. HYDROSTATIC TESTING

1. The CQA Engineer will observe and document all hydrostatic tests for the following piping systems:
 - a. All pressure leachate piping and force mains.
 - b. Do not test piping systems with water where water testing will be harmful to the system operation, such as for air and gas piping systems.
 - a. All piping that will be considered inaccessible or impossible to repair after the completion of the work will be hydrostatically tested while still accessible.
 - i. Examples of such piping are those near or under basins, paved roads, concrete structures, and concrete foundation.
 - c. The CQA Engineer will document that all piping have reaction blocking (thrust blocks) in place before testing.
2. The CQA Engineer will verify and document that the hydrostatic tests are conducted according to the following procedures:
 - a. Each section of pressure pipe or force main will be filled slowly with water and the specified test pressure, measured at the point of the lowest elevation, will be applied to the pipe in a satisfactory manner. The Contractor will furnish all test water and test equipment.
 - b. Before applying the specified test pressure, all air will be expelled from the pipe. To accomplish this, taps will be made, if necessary, at points of highest elevation, and afterward tightly plugged.
 - c. The test pressure will be maintained for a sufficient length of time prior to the test to allow for thorough examination of joints and elimination of leakage where necessary. The pipeline will be made watertight under the test pressure.
 - d. The Contractor and the CQA Engineer will inspect all exposed pipes, fittings, valves, hydrants, and joints during the test. Any cracked or defective pipes, fittings, valves, or hydrants discovered in consequence of this pressure test will

be removed and replaced with sound material and the test will be repeated to the satisfaction of the CQA Engineer.

- e. Hydrostatic test pressures will be as follows:

System	Pressure Test Rating (psi)
Miscellaneous Pressure Pipe	100
Pressure Leachate Piping (force main)	100
Secondary Containment Piping	Max. Pressure Plus 10 psi

- The test section will be pressurized to the required test pressure.
- The test will be conducted for a minimum of one (1) hour.
- The test section will not be accepted if it has any observed leakage or the test pressure drops more than one (1) psi during the leakage test.

11. FINAL COVER SYSTEM LOW-PERMEABILITY SOIL LAYER (INFILTRATION LAYER)

A. GENERAL

The CQA Engineer will confirm and certify that the material used to construct the final cover low-permeability soil layer is in accordance with the approved closure plan, technical specifications, and this CQA Plan.

B. MINIMUM REQUIREMENTS

The low-permeability soil layer material will consist of cohesive soils capable of being placed and compacted to meet the permeability criterion of $k \leq 1 \times 10^{-5}$ cm/sec.

C. PRE-CONSTRUCTION MATERIAL EVALUATION

1. All material to be used to construct the final cover low-permeability soil layer will be sampled and tested by the CQA Engineer in advance of being placed. Such testing can be performed during excavation of the borrow area or from existing stockpiles.
2. The procedure for pre-construction testing of material to be used for low-permeability soil layer on the final cover system is outlined below:
 - a. The CQA Engineer will visually examine each load of soil either at the borrow source or the stockpile area. Soil that does not meet the requirements in the CQA Plan or the technical specification for low-permeability soil layer material will be rejected or routed to separate stockpiles.
 - b. The following tests will be performed at the frequencies listed in the CCR Landfill Final Cover Soil Layer Construction Quality Assurance Testing Requirements Table in Section 11.F. of this plan, prior to placement of any low-permeability soil layer material:
 - i. Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures, ASTM D2216.
 - ii. Method for Particle - Size Analysis of Soils, ASTM D422 (Mechanical Sieve Method Only).
 - iii. Test Method for Liquid Limit, and Plasticity Index of Soils, ASTM D4318,
 - iv. Moisture-Density Curve (ASTM D698), and
 - v. One (1) sample for every 10,000 cubic yards of material stockpiled will be selected for remolded permeability testing (ASTM D5084 - *Measurement*

of Permeability of Saturated Porous Materials using a Flexible Wall Permeameter).

3. Reports for low-permeability soil layer will be prepared by the CQA Engineer and will include:
 - a. Summary of laboratory test data, and
 - b. A summary of construction, sampling and testing method, and recommendations for placement of the final cover low-permeability soil layer.

D. TEST PAD FOR LOW-PERMEABILITY SOIL LAYER

1. The CQA Engineer will document the construction of a test pad prior to or coinciding with, the beginning of construction of the final cover low-permeability soil layer component.
2. The CQA Engineer will sample and test soil samples obtained from the constructed test pad to confirm that the material used, and the Contractors' placement and compaction methods used can consistently produce a final cover low-permeability soil layer that meets the requirements of the CQA Plan and the technical specifications.
3. The CQA Engineer will confirm that the Contractor uses the same placement and compaction methods, equipment, and material to construct the remaining final cover low-permeability soil layer.

E. CONSTRUCTION

1. Only soil from a source previously sampled, tested and confirmed to meet the requirements of this CQA Plan and the technical specifications will be used in construction of the low-permeability soil layer. The CQA Engineer will notify the Contractor when material does not meet the requirements of the technical specification and will document that this material will not be used for final cover low-permeability soil layer construction.
2. The CQA Engineer will complete all required field density and moisture content tests before the overlying lift of final cover low-permeability soil is placed.
3. The CQA Engineer will observe and document that the Contractor completes all prior lift surface preparation (e.g., wetting, drying, scarification, etc.) before placement of subsequent lifts.
4. The CQA Engineer will observe and document that loose lift thicknesses do not exceed 10" (unless otherwise required in the technical specifications) for a final 6" compacted lift thickness.
5. The CQA Engineer will check each lift visually for rocks, debris, plant materials, and other foreign material, as well as particle sizes or clods that exceed the requirements set forth

in this CQA Plan. The CQA Engineer will inform the Contractor if such materials are found and will document their removal.

6. The CQA Engineer will observe and document that the exposed surface of the final cover low-permeability soil layer is rolled with a smooth drum roller or equivalent at the end of each work day or when required to protect the compacted soil from adverse weather conditions.
7. The CQA Engineer will observe and document that the exposed surface of the final cover low-permeability soil layer is reasonably free of rock, rock fragments, or loose materials. The CQA Engineer will observe and document that rock or other materials protruding more than ¼-inch and other loose materials are removed, all cracks or voids filled, and the surface made uniform.
8. As-built certification surveys will be performed on the low-permeability soil layer prior to installing the overlying geosynthetics materials. Due to settlement and consolidation of underlying CCR, which may occur during final cover system construction, the as-built certification points may not accurately provide actual thickness of the low-permeability soil layer. In such cases, the CQA Engineer will perform hand augers to confirm that the required thickness of the low-permeability soil layer has been achieved. Results of the thickness confirmation borings will be documented by the CQA Engineer in the CQA Construction Certification Report. All holes will be patched with sodium bentonite pellets, mixed with low-permeability soils in the holes, hydrated and compacted.
9. The CQA Engineer will observe and document that the surface on which the geosynthetics is to be placed is maintained in a firm, clean, dry, and smooth condition before and during the geosynthetics installation. Additionally, the CQA Engineer will inform the Contractor when desiccation cracking is excessive and will document that all desiccation cracks are repaired.
10. The CQA Engineer will inspect the final cover low-permeability soil layer and certify that it is constructed in accordance with the approved permit, the technical specifications and this CQA Plan.

F. SAMPLING AND TESTING

1. Construction Quality Control sampling and testing will meet the minimum requirements indicated in the Table below.
2. The CQA Engineer or his /her representative will randomly determine the location of each test. All holes will be filled with a mixture of low-permeability soil and sodium bentonite pellets hydrated and compacted in the holes.

CCR Landfill Final Cover Soil Layer Construction Quality Assurance Testing Requirements			
Item	Testing	Frequency	Minimum Criteria
Soil Layer Borrow Source	Grain Size (sieves only) (ASTM D422)	1,000 yd ³	<2" (99.8% of all tests) and <1/4" (top 6", 99% of all tests) $k \leq 1.0 \times 10^{-5}$ cm/sec
	Moisture Content (ASTM D2216)	2,000 yd ³	
	Atterberg Limits (ASTM D4318)	5,000 yd ³	
	Moisture-Density Curve (ASTM D698)	5,000 yd ³ and all changes in material	
	Permeability (remold) (ASTM D5084)	10,000 yd ³	
Soil Layer During Construction	Density/Moisture-Nuclear, Drive-Cylinders, or Sand Cone (ASTM D6938, D2937 or D1556)	1 test/10,000 sf/lift	≥95% Standard Proctor
Laboratory Testing on Undisturbed Samples of the Constructed Soil Layer	Undisturbed Permeability (ASTM D5084)	1 test/40,000 sf/lift	$k \leq 1.0 \times 10^{-5}$ cm/sec
	Dry Density (ASTM D6938)		
	Moisture Content (ASTM D2216)		
	Atterberg Limits (ASTM D4318)		

3. The CQA Engineer will follow this procedure in the event of a density or permeability test failure. If the density does not meet minimum requirements of the CQA Plan, recompaction of the failed area (minimum 100 feet x 100 feet) will be performed and retested until the

area meets or exceeds requirements outlined in the CQA Plan. If a permeability sample fails to meet the minimum permeability requirements outlined in the CQA Plan, the area of failing permeability (minimum 40,000 sf) will be reconstructed. Optionally, at least four (4) replicate samples will be obtained in the immediate vicinity of the failed test. Should the replicate samples confirm the failure of the low-permeability soil layer to meet the requirements set forth in this CQA Plan, the area of failure will be localized according to the results of the replicate samples and reconstructed in accordance with the CQA Plan. All areas of reconstruction will be retested as outlined in the CQA Plan.

12. FINAL COVER SYSTEM GEOMEMBRANE

A. GENERAL

The CQA Engineer will certify the final cover system geomembrane materials and installation are in accordance with the approved permit, technical specifications, and this CQA Plan.

B. MATERIAL

1. The final cover system geomembrane will be a minimum 40-mil Textured Linear Low-Density Polyethylene (LLDPE) supplied and installed by firms approved by Georgia Power.
2. Seams for providing watertight joints will be extrusion or double hot wedge fusion seams.
3. The textured material will have an interface shear resistance (friction angle plus cohesion) with contiguous final cover system components of 24.8 degrees or as directed by the Design Engineer. This interface shear is the minimum shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combinations that provide satisfactory factors of safety may be approved by the Design Engineer. The interface shear strength will be determined by direct shear testing conducted at loads directed by the Design Engineer.
4. Manufacturer Quality Control will confirm that the material meets the minimum physical properties of a 40-mil thick textured LLDPE geomembrane as listed in the latest version of GRI-GM17, "*Test methods, test properties and testing frequency for Linear Low-Density Polyethylene (LLDPE) smooth and textured geomembrane*".

C. GEOMEMBRANE MANUFACTURER AND INSTALLER

1. The Geomembrane Installer will submit the following documents as obtained from the Geomembrane Manufacturer to the CQA Engineer:
 - a. Production Certification, including project references,
 - b. Testing Program of Compound Ingredients,
 - c. Material Certification, and
 - d. Test Data for Material and Resin

All of the above submittals will be reviewed and retained by the CQA Engineer.

2. The Geomembrane Installer will submit the following documents to the CQA Engineer 14 days prior to installation:
 - a. Qualifications of Geomembrane Installer Superintendent and Foreman,

- b. Resumes of Geomembrane Contractor field crew, and
- c. Six (6) sets of proposed geomembrane panel layout drawings.

D. TRANSPORTATION, HANDLING, AND STORAGE

1. The CQA Engineer will monitor the transportation, handling, and storage of the geomembrane on the Project site. Upon delivery at the site, the Contractor, Installer, and CQA Engineer 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 Engineer will indicate to the Construction Manager:
 - a. 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
 - b. rolls that include minor and repairable flaws that do not compromise geomembrane quality.
2. The CQA Engineer 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.

E. GEOMEMBRANE SUBGRADE SURFACES AND ANCHOR TRENCHES

1. Geomembrane Subgrade Surfaces

The CQA Engineer will monitor, verify, and document that the subgrade surface on which the geomembrane will be placed (e.g., top of infiltration layer surface) is constructed in accordance with the Construction 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 Engineer and the Installer will jointly verify that the surface on which the geomembrane will be installed is acceptable. The Contractor will comply with the subgrade preparation and acceptance requirements identified in the Construction Documents. The CQA Engineer 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 Engineer and Purchaser to indicate the parties' concurrence that the surface is ready for deployment of geomembrane). Additionally, the surface will contain no ruts or loose stones larger than the maximum rut depth and loose stone size specified in the Construction Documents for geomembrane subgrade surfaces. The CQA Engineer 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 completed in accordance with the requirements of the Construction Documents.

F. GEOMEMBRANE INSTALLATION

1. A pre-deployment CQA meeting will be held prior to installation. The Contractor, the Geomembrane Installer, the CQA Engineer, the CQA Engineer, and a representative of Georgia Power will be in attendance. The following issues will be discussed and agreed upon by all parties and will be included in a report in the CQA documentation.
 - a. Testing of welds
 - b. Characteristics of a "good" weld, and
 - c. Repair procedures
2. The CQA Engineer will obtain samples of the geomembrane rolls from the manufacturing plant prior to shipment to the site.
3. Random samples must be representative of the material supplied and exclude the outer wrap of geomembrane. Samples should be full roll width and at least two (2) feet long.
4. The laboratory testing of the samples selected will be coordinated by the CQA Engineer and will confirm conformance with the properties listed in the table below:

Geomembrane Conformance Testing Requirements

TEST NAME	TEST METHOD	MINIMUM CQA TESTING FREQUENCY and ACCEPTANCE CRITERIA ⁽¹⁾
Thickness	ASTM D 5994	1 per roll
Density	ASTM D 1505 or ASTM D 792	1/100,000 ft ²
Asperity Height	ASTM D7466	
Thickness	ASTM D 5994	
Tensile Strength at Yield	ASTM D 6693, Type IV	
Tensile Strength at Break		
Elongation at Yield		
Elongation at Break		
Carbon Black Content	ASTM D 1603 or ASTM D 4218	1/100,000 ft ²
Carbon Black Dispersion	ASTM D5596	

TEST NAME	TEST METHOD	MINIMUM CQA TESTING FREQUENCY and ACCEPTANCE CRITERIA ⁽¹⁾
Tear Resistance	ASTM D1004 (Die C Puncture)	
Puncture Resistance	ASTM D4833	1/100,000 ft ²
Interface Shear Strength ⁽²⁾ (with geocomposite and infiltration soil layer)	ASTM D5321	1 per 10 acres (minimum 2 per project) per interface

Notes:

⁽¹⁾ Acceptance Criteria will be per the latest version of GRI-GM17, "Test methods, test properties and testing frequency for Linear Low-Density Polyethylene (LLDPE) Smooth and Textured Geomembrane" found at: <https://geosynthetic-institute.org/grispecs/gm17.pdf>

⁽²⁾ Testing parameters for interface shear strengths are provided in Section 12. B.3.

5. The CQA Engineer will review the geomembrane thickness of each roll made for the project prior to shipment. Material that does not fall within acceptable thickness criteria will be rejected.
6. The CQA Engineer will mark all areas where grinding is considered to be excessive. The location and repair method for the excessive grinding will be recorded in the daily field reports.
7. Overheating of the geomembrane during welding will be monitored by the CQA Engineer. At the discretion of the CQA Engineer, coupons will be cut from the end of the extrusion seams and the bottom side of the seam will be observed for visible warping or deformation. The location and repair method of overheated areas will be recorded in the daily field reports. The method of repair will be determined in the field by the CQA Engineer.
8. During seaming, the CQA Engineer will observe the seams for the following:
 - a. proper preparation,
 - b. grinding technique, where applicable, and
 - c. overheating.
9. The CQA Engineer will observe the geomembrane during the coolest part of the day to check for slack. Any areas where excessive "trampolining" occurs will be marked by the CQA Engineer for repair by the Geomembrane Installer.

10. The CQA Engineer will mark all areas where the geomembrane indicates a protrusion from the final cover low-permeability soil layer. The method of repair will be determined in the field by the CQA Engineer.

G. FIELD PANEL IDENTIFICATION

1. A field panel is a piece of geomembrane larger than approximately 100 square feet (ft²) 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 Engineer will verify that each field panel is given an "identification code" (number or letter-number) that will:
 - a. be selected as simple and logical as possible;
 - b. be substantially consistent with the as-built layout plan; and
 - c. allow tracing of the Manufacturer's roll numbers to the field panel identification code.
2. The CQA Engineer 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.

H. FIELD PANEL PLACEMENT

1. The CQA Engineer will monitor that field panels are installed substantially at the location indicated in the Installer's layout plan, as approved, or modified. The CQA Engineer will record the field panel identification code, Manufacturer's roll number, location, date of installation, time of installation, and dimensions of each field panel.
2. The CQA Engineer will monitor that geomembrane placement does not proceed:
 - a. at an ambient temperature below 40°F or above 104°F unless authorized by the Design Engineer; or
 - b. 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.
3. The CQA Engineer will monitor that the above conditions are fulfilled and that the supporting soil has not been damaged by adverse weather conditions. The CQA Engineer will monitor geomembrane deployment for conformance with the Construction Documents, including that:
 - a. the geomembrane is deployed under acceptable temperature and weather conditions;
 - b. any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means;

- c. the prepared surface underlying the geomembrane has not deteriorated since previous acceptance and is still acceptable immediately prior to geomembrane placement;
 - d. any geosynthetic elements immediately underlying the geomembrane are clean and free of foreign objects or debris;
 - e. all personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane;
 - f. the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting subbase;
 - g. the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);
 - h. adequate temporary loading and/or anchoring (e.g., sandbags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind; and
 - i. 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.
4. The CQA Engineer will observe the geomembrane panels, after placement and prior to seaming, for damage. The CQA Engineer 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 Engineer. CQA for geomembrane repairs will be in accordance with Section P of this Section.

I. PANEL LAYOUT

1. The CQA Engineer will review the panel layout drawing previously submitted to the Construction Manager by the Installer and verify that:
- a. seams are generally oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope;
 - b. the number of seams is minimized in corners and odd-shaped geometric locations;
 - c. a seam numbering system is used that is compatible with the field panel identification numbering system and is agreed upon by the CQA Engineer and the Installer prior to any seaming; and
 - d. the panel layout is consistent with accepted state of practice.

J. SEAM PREPARATION

1. To confirm conformance with the Construction Documents, the CQA Engineer will monitor that:
 - a. prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
 - b. seams are overlapped in accordance with the requirements of the Construction Documents;
 - c. if seam overlap grinding is required, the process is completed according to the Geosynthetics Manufacturer's instructions or the Construction Documents, whichever is the more stringent, prior to the seaming operation, and in a way that does not damage the geomembrane;
 - d. the grind depth is constructed in accordance with the requirements of the Construction Documents;
 - e. grinding marks do not appear beyond the extrudate after it is placed; and
 - f. seams are aligned with the fewest possible number of wrinkles and fishmouths.

K. OVERLAPPING AND TEMPORARY BONDING

1. The CQA Engineer will monitor that:
 - a. 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;
 - b. no solvent or adhesive is used; and
 - c. 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.

L. TEST SEAMS

1. The CQA Engineer will document and verify that the Geomembrane Installer performs a test seam for each welding machine in use every 4-5 hours, or at a minimum prior to start of construction work, and at midday. At least one test seam will be made for each machine in use for each seam. Should any post-production test seam fail, the immediate prior production seam will be sampled for destructive testing in accordance with Section M below. The test seam should be approximately 5 feet long. The CQA Engineer will sample the test seam from the center 3 feet of the test sample.

- a. The date, time, and equipment, as well as welding temperature and seaming parameters, will be recorded for each test seam.
 - b. A minimum of five (5) specimens for peel and for shear from each sample will be tested for the properties listed in the latest version of GRI-GM19, "*Standard Technical Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*" in accordance with test method ASTM D6392. Testing will be performed in the field by the Geomembrane Installer under full-time observation by the CQA Engineer.
 - c. Untested portions of the test seam will be retained by the CQA Engineer for the project record and future testing as required.
2. All test seams must pass field-testing before production seaming is performed by the Geomembrane Installer.

M. FIELD DESTRUCTIVE TESTING

1. The Geomembrane Installer will obtain approximately 12" x 48" samples of field seams, suitable for testing, as indicated in the table below. The date, time, equipment, and seam number will be marked on each sample and recorded by the CQA Engineer.

Field Seam Testing Requirements

TEST NAME	TEST METHOD	AVERAGE TESTING FREQUENCY AND ACCEPTANCE CRITERIA ⁽³⁾
Seam Peel Strength	ASTM D 6392 ⁽¹⁾	1 test per 500 feet of seam
Seam Shear Strength	ASTM D 6392 ⁽²⁾	1 test per 500 feet of seam

Notes:

- (1) For double wedge fusion seams, both tracks will be tested in peel.
 - (2) For shear tests, the sheet will yield before failure of the seams.
 - (3) Acceptance Criteria per latest version of GRI-GM19, "*Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*", see <https://geosynthetic-institute.org/grispecs/gm19a.pdf>
2. Samples retained will be tested in the field by the geomembrane installer. A minimum of five (5) specimens from each sample for peel and for shear will be tested for the properties listed above and in the latest version of GRI-GM19, "*Standard Technical Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane*" in accordance with test method ASTM D6392.

3. The CQA Engineer or Georgia Power may require additional random samples to be taken for testing in areas that visually appear defective and not in accordance with this CQA Plan.

N. NON-DESTRUCTIVE TESTING

1. The Geomembrane Installer is responsible for the completion of non-destructive testing of the entire length of all field seams, verifying that said seam is airtight. Said testing can be a vacuum test, pressure test, or approved equal and will be described by the Geomembrane Installer and verified by the CQA Engineer in advance.
2. The CQA Engineer 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 Engineer 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 Engineer will monitor that the Installer performs continuity testing as the seaming work progresses, not at the completion of all field seaming. The CQA Engineer will:
 - a. monitor nondestructive testing;
 - b. document the results of the nondestructive testing; and
 - c. inform the Contractor and Construction Manager of any non-conformance.
3. The CQA Engineer will monitor that the Installer performs any required seam repairs in accordance with the Construction Documents. The CQA Engineer will:
 - a. observe the repair procedures;
 - b. observe the re-testing procedures; and
 - c. document the results.
4. 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 Engineer.

O. DESTRUCTIVE LABORATORY TESTING

1. Destructive seam samples will be laboratory tested by the CQA Engineer. Testing frequency will be a minimum average frequency of one (1) sample per 500 linear feet of field seam.
 - a. Test samples will be at least 12 inches x 36 inches. A minimum of five (5) specimens will be tested for the properties listed in the latest version of GRI-GM19, *"Standard Technical Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane"* in accordance with

test method ASTM D6392. These test samples will be taken at the same locations as the contractor's destructive testing samples.

- b. Acceptance Criteria for the destructive test will be according to the latest version of GRI-GM19, *"Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane"*; found at <https://geosynthetic-institute.org/grispecs/gm19a.pdf>. All laboratory specimens of geomembrane will be conditioned for a minimum of one (1) hour prior to testing at the standard atmosphere, that is, air maintained at a relative humidity of 65 ±5% and a temperature of 21°C ± 2°C (70°C ± 3.5°F).
 - c. Peel tests will be performed on both sides of a double-wedge fusion seam.
2. The load and elongation at failure will be measured for each specimen. The CQA Engineer will describe the type of failure for each specimen and record the presence of any disbonding, delamination, foreign material in the bond area, etc.
 3. The average values of each set of five (5) specimens for peel and for shear must meet the requirements in this CQA Plan, and four of the five specimen tests must meet the requirements in this CQA Plan for the seam to be considered a passing seam. If the average of the five specimens is adequate, but one of the specimens is failing, values for the failing specimen must be at least 80 percent of the values required for the seam for the sample to pass. A maximum of one non-film tear bond failure out of five tests is acceptable provided the destructive sample meets strength requirements discussed above. If unresolved discrepancies exist between the CQA Engineer and Contractor's test results, the archived sample may be tested by the CQA Engineer. Samples that do not pass the shear and peel tests will be resampled from locations at least 10 feet on each side of the original location. These two re-test samples must pass both shear and peel testing. If these two samples do not pass, then additional samples will continue to be obtained until the questionable seam area is defined.
 4. Seams represented by a failing destructive field or laboratory test sample will be cut out and replaced or covered with a geomembrane strip and the seam bounded by supplemental passing field and laboratory destructive test samples at both ends.
 5. The CQA Engineer will verify and document that the strength and other properties of the textured 40-mil thick LLDPE geomembrane seams meet or exceed the requirements set forth in the latest version of GRI-GM19, *"Standard Technical Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane"*.

P. DEFECTS AND REPAIRS

1. The CQA Engineer will monitor, verify, and document that geomembrane defects are addressed, and repairs are made, in accordance with the Construction Documents and that CQA activities are performed as described in the subsections below.

2. All seams and non-seam areas of the geomembrane will be examined by the CQA Engineer 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 Engineer will request that the Contractor broom or wash the geomembrane surface if the amount of dust or mud inhibits examination.

3. Repair Procedures

The CQA Engineer will monitor that any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, is repaired by the Installer in accordance with the Construction Documents. 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 Engineer.

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

- a. surfaces of the geomembrane which are to be repaired are abraded no more than one hour prior to the repair;
- b. all surfaces are clean and dry at the time of the repair;
- c. 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
- d. the geomembrane below large caps is appropriately cut to avoid water or gas collection between the two sheets.

4. Verification of Repairs

Each repair will be numbered and logged by the CQA Engineer. The CQA Engineer 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 Engineer. The CQA Engineer will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

13. FINAL COVER SYSTEM GEOCOMPOSITE DRAINAGE MEDIA (GDM)

A. GENERAL

The CQA Engineer will certify the final cover system geocomposite drainage media (GDM) materials and installation are in accordance with the plans, technical specifications, and this CQA Plan.

B. GDM MANUFACTURER AND INSTALLER

1. The CQA Engineer will review and verify the following submittals from the GDM Manufacturer:
 - a. Production Certification,
 - b. Material Certification, and
 - c. Test Data for Material.
2. The CQA Engineer will review and verify the following documents prior to installation:
 - a. Qualifications of the GDM installer superintendent, foreman, and field crew, and
 - b. Six (6) sets of field installation drawings.

C. CONFORMANCE TESTING

Conformance Testing will be performed by the CQA Engineer according to the following table:

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	--	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	--	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	--	oz/yd ²	8	ASTM D5261
Apparent opening size	Maximum	1 per 540,000 ft ²	--	mm	O ₉₅ ≤ 0.21 mm	ASTM D4751

Properties	Qualifier	Minimum MQC Test Frequency	Minimum CQA Test Frequency	Units	Specified Values⁽¹⁾	Test Method
Permittivity	Minimum	1 per 540,000 ft ²	--	sec-1	1.3	ASTM D4491
Grab strength	Minimum	1 per 90,000 ft ²	--	lb	200	ASTM D4632 ⁽²⁾
Tear strength	Minimum	1 per 90,000 ft ²	--	lb	75	ASTM D4533 ⁽²⁾
CBR (static) puncture strength	Minimum	1 per 540,000 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	5.0 x 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
Interface Shear Strength ⁽⁵⁾ (with protective layer)	Minimum	1 per 50,000 ft ²	1 test per 10 acres (min. 2 per project)	deg.	23	ASTM D5321

Notes:

in – inch yd² – 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. Transmissivity testing will be performed as described below:
Conduct CQA testing for transmissivity at the confining pressure of 250 PSF at a hydraulic gradient equal to 0.33. The boundary conditions are “Protective Cover” soils on top and the specified geomembrane on the bottom of the GDM. The minimum required transmissivity tested under these conditions will be 5x10⁻⁴ m²/sec (testing between two steel plates is not acceptable).
5. The GDM will have an interface shear resistance (friction angle plus cohesion) with contiguous final cover system components of 24.8 deg. (per ASTM D5321). This is the minimum shear strength represented by a friction angle with an adhesion = 0 psf. Equivalent strength combinations that provide satisfactory factors of safety may be approved by the Design Engineer. The interface shear strength will be determined by direct shear testing conducted at the confining pressure of 250 psf or as directed by the Design Engineer.

D. INSTALLATION

1. The CQA Engineer will verify that the installation of the GDM proceeds after he has provided certification of the geomembrane or a section thereof.
2. The CQA Engineer will monitor the installation of the GDM to verify there is no damage to the final cover system geomembrane. Should the final cover system geomembrane be damaged, the CQA Engineer will inform the Contractor and document the repairs done.
3. The CQA Engineer will verify that adjacent rolls of GDM:
 - a. Overlap a distance of at least three (3) inches; and
 - b. Are secured using polyethylene ties as follows:

- i. every ten (10) feet for adjacent rolls, and
 - ii. every five (5) feet at end seams.
- 4. The CQA Engineer will verify that the overlaying geotextile, where applicable, extends at least six (6) inches past the geonet joint and is permanently bonded by heat bonding or sewing.
- 5. The CQA Engineer will verify that any GDM that is torn, crushed, or punctured is repaired or replaced by the GDM Installer according to this CQA Plan.
- 6. The CQA Engineer will be present during all placement operations and will verify that all work is in accordance with this CQA Plan.
- 7. At the conclusion of this activity, the CQA Engineer will provide a written certification that the work has been installed according to this CQA Plan.

14. FINAL COVER SYSTEM PROTECTIVE SOIL COVER

A. GENERAL

The CQA Engineer will verify that the final cover system protective soil cover material and installation is placed in accordance with the approved plans, technical specifications, and this CQA Plan.

B. MATERIAL

1. Soil that meets all of the following requirements will be classified as select soil fill for use in the construction of the final cover protective soil cover for the final cover system.
 - a. Soil will be classified according to the Unified Soil Classification System (USCS) as ML, MH, CH, CL or SC. (ASTM D2487). Liquid limit, plasticity index (PI), and percent passing the No. 200 sieve will be considered for proper classification.
 - b. Select soil fill materials will be reasonably free of ferrous, and/or calcareous concretions and nodules, refuse roots, or other deleterious substances.
 - c. The soil cover will be uniform, smooth, and substantially free of debris, rock, plant materials, and other foreign material larger than two (2) inches. The material will contain no sharp edges.
2. The top six (6) inches of the final cover system protective soil cover must be capable of supporting the growth of grass. The soils noted in 14.B.1.a. can be expanded to include SM and SP soils in the top six (6) inches of cover.

C. STOCKPILING AND MATERIAL APPROVAL

1. All material to be used as final cover system protective soil cover will be approved in advance by the CQA Engineer. The CQA Engineer must verify the soil meets all the material requirements.
2. Verification can be accomplished during excavation and stockpiling or prior to use at existing stockpiles.
3. The CQA Engineer will prepare reports of all testing, analysis, and verification.

D. CONSTRUCTION

1. The CQA Engineer will provide verification of the following information:
 - a. The approved stockpiled material was used to construct the final cover system protective soil cover.

- b. The final cover system protective soil cover was constructed in accordance with this CQA Plan.
 - c. The geomembrane and GDM were not damaged during the construction of the final cover system protective soil cover.
 - d. The final cover system protective soil cover thickness has been achieved and verified.
2. The final cover system protective cover material will be spread and compacted using low ground pressure equipment such as a CAT D6 low ground pressure (LGP) bulldozer or similar equipment.
3. Material will be spread by pushing “up-slope”, and the CQA Engineer will verify that the protective soil cover was not pushed down any side slopes of the landfill final cover system.
4. The final cover system protective soil cover material thickness will be at least 12 inches thick at all times during spreading and compaction.

E. SAMPLING AND TESTING

Construction quality assurance testing will meet the minimum requirements listed in the table below.

Final Cover System Protective Soil Cover Quality Assurance Testing Requirements			
Item	Test Method	Minimum Frequency	Minimum Criteria
Borrow Source	Grain Size ASTM D422 with Hydrometer	5,000 cy	See Note ⁽¹⁾ below
	Atterberg Limits ASTM D4318	5,000 cy	
	Moisture – Density ASTM D698	5,000 cy	
	Remolded Permeability ⁽²⁾ ASTM D5084	10,000 cy	7.5x10 ⁻⁵ cm/sec or less
Construction	Density and Moisture (ASTM D6938, 1556, or 2937)	1 test/20,000 ft ² of planar final cover system surface area	90% of Maximum Dry Density and 0% to 2% of the Optimum Moisture Content per ASTM 698 – Standard Proctor Test

Notes:

- ⁽¹⁾ Acceptable soils include those classified according to the Unified Soil Classification System (USCS) as SC, ML or CL (ASTM 02487). Liquid limit, plasticity index (PI), and gradation will be considered for proper classification.
- ⁽²⁾ Remold sample to 90% of Maximum Dry Density and 0% to 2% of the Optimum Moisture Content per ASTM 698 – Standard Proctor Test.

15. CERTIFICATION

The CQA Engineer will provide, within 30 days of completion of cell construction or closure activities, written certification that the liner and leachate collection system, final cover, access roads, ditches, sediment ponds, and other associated ancillary facilities for the particular landfill area were constructed according to the approved permit drawings, technical specifications, and this CQA Plan. Said certification will have the CQA Engineer's seal as a professional engineer registered in the State of Georgia.