EAGLE COUNTY LANDFILL

CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL PLAN

PREPARED FOR:

EAGLE COUNTY LANDFILL
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Date: January 2020
Project No.: 4D25803

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1.0 INTRODUCTION

The Construction Quality Assurance/Quality Control Plan (CQAQCP) dated May 1996 is being updated and revised to reflect a revised leachate holding pond liner design and will apply to the approved Design, Operations and Closure Plan for the Eagle County Landfill located in Eagle County, Colorado. This CQAQCP addresses the quality assurance of the construction and installation of environmental control systems at the Eagle Landfill, including earthen materials (low hydraulic conductivity soils and drainage materials) and man-made materials (geosynthetic clay liner, geomembranes and geotextiles). This CQAQCP is intended to be a "working" document; i.e., one that is updated to reflect changes in specific materials used, in installation practices, or in tests and test methods.

The CQAQCP includes the construction information and procedures for the following systems at the Landfill:

1. Landfill floor and side slope compacted clay liner system.
2. Geomembrane and geotextile installation for the leachate sump.
3. Leachate drain system (from landfill to the leachate sump).
4. Leachate holding pond.
5. Final cover.
6. Surface water drainage.

The scope of this CQAQCP includes the quality assurance applicable to these six landfill systems for the following:

1. Soil excavation and placement.
2. Manufacturing, fabricating, shipping, handling, and installation of the geosynthetic components.

1.1 CONSTRUCTION QUALITY ASSURANCE

Construction quality assurance is defined as follows:

Construction Quality Assurance (CQA) is a planned system of activities that provides the Owner and permitting agency assurance that the facility was constructed as specified in the design. Construction quality assurance includes inspections, verifications, audits, and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance refers to measures taken by the CQA organization to assess if the Installer or Contractor is in compliance with the plans and specifications for a project.

1.2 GENERAL TESTING REQUIREMENTS

This CQAQCP includes references to test procedures of the American Society for Testing and Materials (ASTM), American Concrete Institute (ACI), the National Sanitation Foundation Standard Number 54 Flexible Membrane Liners, and the Geosynthetics Research Institute (GRI).

Unless indicated otherwise, tests will be performed in strict accordance with the referenced test procedure and the description included in this plan. Any deviations to test procedures specified in this plan must be approved, in writing, by the Construction Quality Assurance Engineer (CQAE).

1.3 ORGANIZATION AND USE OF THE CQAQCP

The Construction Quality Assurance/Quality Control Plan is divided into six main sections as follows:

Section 1.0	Introduction
Section 2.0	Survey Requirements
Section 3.0	Earthen Materials
Section 4.0	Geosynthetics
Section 5.0	Pipe
Section 6.0	Concrete

This organization is based on general construction procedures and materials and does not follow the actual sequence of systems as they are constructed within the landfill.

1.3.1 Definition and Responsibility of Parties

The successful completion of the landfill construction is dependent on the interaction of several qualified parties. These parties include those associated with the ownership; design and specification preparation; manufacture, fabrication, transportation, installation, and quality assurance of the geosynthetics; and the placement, testing, and quality assurance of construction of earthen materials.

The Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division (CDPHE) is involved in the review and approval of this CQAQCP, but it is not a party to the actual implementation and day-to-day activities of the plan except that final documentation reports and major design changes will be submitted to the CDPHE.

Within each of the following party descriptions, reference is made to title and, where applicable, to the individuals within that party responsible for carrying out the provisions of this CQAQCP.

1.3.1.1 Construction Quality Assurance Engineer (CQAE)

The Owner/Operator will retain an independent consulting firm to fulfill the role of CQAE. The CQAE will provide overall coordination of documentation submitted in support of this plan. The CQAE will also be responsible for surveying (horizontal and vertical control). The CQAE will prepare the Construction Certification Report which will be submitted to the CDPHE by the Owner/Operator. The term "CQAE" or “Construction Engineer” is used throughout this document when reference is made to fulfillment of this role. The CQAE may assign other members of his staff to the job site during construction activities.

1.3.1.2 Design Engineer

The Design Engineer is the company hired by the Owner/Operator to prepare the Landfill Design, Operations, and Closure Plan. The term "Design Engineer" is used throughout this document to indicate the official representative of the Design Engineer, whether on site or not.

1.3.1.3 Facility Owner/Operator

The landfill property is currently owned and operated by Eagle County making them the Owner/Operator of the landfill facility. The term "Owner/Operator" is used throughout this document to indicate the official representative of the Owner/Operator.

1.3.1.4 General Contractor

The General Contractor's role will be performed by the Owner/Operator or a Contractor that the Owner/Operator hires to furnish overall construction responsibility for the completion of the landfill construction. The General Contractor will also be responsible for hiring of all subcontractors such as the Geosynthetic Installer and the Earthwork Contractor. The term "Contractor" is used throughout this document when reference is made to the tasks and responsibilities of the General Contractor.

1.3.1.5 Geosynthetic Installer

The Geosynthetic Installer is the General Contractor or a subcontractor hired to install the geosynthetic components referenced in this plan. The term "Installer" is used throughout this plan when reference is made to the tasks and responsibilities of the Geosynthetic Installer.

1.3.1.6 Geosynthetic Manufacturers

The Geosynthetic Manufacturers are those hired by the General Contractor to furnish the geosynthetic components referenced in this manual. The terms "Geomembrane Manufacturer", “Geosynthetic Clay Liner (GCL) Manufacturer" and "Geotextile Manufacturer" are used throughout this plan to indicate the specific company supplying these respective materials to the job site. This plan includes specific quality assurance and quality control requirements for the geosynthetic manufacturers in their role of providing the quality control during geosynthetic manufacturing.

1.3.1.7 Resin Supplier

The Resin Supplier is the company or companies selected by the Geosynthetic Manufacturer(s) to furnish the resins used in fabricating the geosynthetic components. The term "Resin Supplier" is used in this manual to denote, individually, each respective supplier. Designations of the specific resin suppliers are not necessary since all communication and responsibilities within this plan are between the respective manufacturers and suppliers.

1.3.1.8 Soils Testing Laboratory

The Soils Testing Laboratory is the independent laboratory hired by the Owner/Operator to perform field and laboratory QA/QC soils tests as indicated in the plan. The term "Soils Testing Laboratory" is used throughout this manual to denote the official representative of the company providing these services. The Soils Testing Laboratory or CQAE will supply technicians as necessary for collection and laboratory analyses of samples and testing of in-place earthen materials.

1.3.2 Organization of the CQAQCP Parties

Overall responsibility for carrying out the provisions of this CQAQCP is with the CQAE. The CQAE may consult the Design Engineer regarding design specifications and/or recommended changes; however, the Design Engineer has no direct responsibilities set forth in this plan.

The Contractor (including any subcontractors that may be brought to the site) will report to the Owner/Operator and the CQAE for matters relating to the CQAQCP. For financial or other issues, the Contractor will report directly to the Owner/Operator.

1.4 MEETINGS

There are two types of meetings which will be required for implementation of this Plan including pre-construction meetings and problem/deficiency meetings:

A pre-construction meeting will be conducted immediately prior to any construction and will be attended by the Owner/Operator and the Contractor along with other appropriate parties such as the Soils Testing Laboratory, and the CQAE. The purpose of this meeting will be to review the project and the CQAQCP as it applies to environmental control system construction and familiarize all parties with their respective responsibilities and interactions.

Problem/deficiency meetings will be conducted, as requested by the Owner/Operator or the CQAE, to work out problems which may arise with the construction or QA/QC testing. The meetings will be attended by appropriate parties.

1.5 DOCUMENTATION

This section describes the types of documentation reports that must be completed by each party that has direct QA/QC responsibility for the landfill construction. The CQAE is responsible for construction documentation and will ensure that other parties to the construction will document their portions of the work.

The documentation of construction quality assurance activities is the most effective method to ensure that the quality assurance requirements have been addressed and satisfied. The documentation process includes:

1. Recognition of construction tasks that should be documented.
2. Assignment of responsibilities for the observation, testing, and documentation of these tasks.
3. Completion of the required forms, data sheets, and reports to provide an accurate record of the work performed during construction.

1.5.1 Daily Construction Reports

A construction report will be completed by the CQAE or the Soils Testing Laboratory each day that they perform work on the site. This summary report will provide a chronological record for identifying and recording other reports, data sheets, forms, and checklists. This report will contain, at a minimum, the following information to be filled out in ink and preferably pre-printed so that the required information is organized in an easily accessible manner:

1. Date, project name, location, and report preparer's name. The number and name of people on site under the direction of the preparer related to QA/QC tasks.
2. Data on weather conditions including temperature, humidity, wind direction and speed, cloud cover, and any precipitation events.
3. Contractor's or Installer's work force, equipment in use and idle, and materials delivered to or removed from the job site.
4. Chronological description of work in progress including any notices to, or requests from, the Contractor and/or the Installer.
5. Results of, or a clear reference to, where the results can be found for testing performed on site by personnel under the direction of the preparer.
6. Laboratory samples collected, marked, and sent to the outside testing laboratories will be clearly indicated in the daily report by direct inclusion or by

reference to the document containing such information. Likewise, reference should be included for any test data submitted by any of the outside testing laboratories.

7. An accurate record of communications with other CQAQCP parties, or any other outside companies, regulatory agencies, or consultants regarding the day's construction activities or any project meetings that are held will be kept.
8. An accurate record of calibrations or standardizations performed on field testing equipment, including actions taken as a result of recalibrations, will also be kept.

1.5.2 Problem/Deficiency Identification and Corrective Action Reports

Problem and/or deficiency and corrective action reports will be completed by the Soils Testing Laboratory and/or the CQAE when any construction material or activity is observed or tested and does not meet the requirements set forth in this plan. These reports are not necessary for a failing field test if corrective action is taken and retesting confirms acceptable properties. These reports should be cross-referenced to the forms, data sheets, checklists, and other reports that contain data or observations leading to the determination of a problem or deficiency. At a minimum, the Problem/Deficiency Identification and Corrective Action Reports will include the following information:

1. A detailed description of the problem or deficiency, including reference to any supplemental data or observations responsible for determining the problem or deficiency.
2. Location of the problem or deficiency, including how and when the problem or deficiency was discovered. In addition, an estimate of how long the problem or deficiency has existed should be included as well as an opinion as to the probable cause of the problem or deficiency.
3. A recommended corrective action for resolving the problem or deficiency should also be included in the report. If the corrective action has already been implemented, then the observations and documentation to show that the problem or deficiency has been resolved should be included. If the problem or deficiency has not been resolved by the end of the day upon which it was discovered, then the report will clearly state that it is an unresolved problem or deficiency.

A problem/deficiency report will be submitted to the CQAE by the end of the working day during which the problem or deficiency occurred. The CQAE will then inform the Owner/Operator as soon as possible. If the problem or deficiency has not been resolved, then the CQAE and the report preparer will discuss the issue with the Owner/Operator, and the Owner/Operator will take the necessary corrective actions to resolve the problem or deficiency as soon as practical.

The CQAE will carefully review all problem/deficiency reports to determine if similar reports on the same problem or deficiency are an indication of a need to make changes to the plans and specifications and/or the CQAQCP. If this situation should develop, a meeting will be held to determine if revisions to the plans or specifications should be made. Any revisions to the plans, specifications or the CQAQCP must be approved by the Owner/Operator and the appropriate parties. The CQAE will also review deficiency reports and actions taken related to contractor field operations. CDPHE will be notified in a timely manner of changes to the design documents. CDPHE approval is required for major changes to plans, specifications and the CQAQCP.

1.5.3 Final Construction Documentation Reports

A Final Construction Documentation Report will be prepared by the CQAE for each distinct portion of completed construction within a cell. The At a minimum, the Final Construction Documentation Report will contain the following information:

1. All correspondence with CDPHE regarding this particular project.
2. The entire CQAQC plan in effect at that time.
3. All documentation of required surveys.
4. A summary of all problem/deficiency reports and resolutions. Include all items considered by the CQAE to be non-conforming to the approved CQAQCP and what each resolution required and how it was employed in the field.
5. All daily reports, field and laboratory results of Soils Testing Laboratory for foundation soils, clay liner soils, and coarse-grained soils for leachate drainage systems.
6. A discussion of changes made to the approved design.
7. Copy of the Geosynthetics Installer's CQAQC plan.
8. All QA laboratory testing results for geosynthetics by manufacturer.
9. All Installer's Daily Reports on panel deployment, seaming repairs and associated testing and calibration data for geomembranes and geotextiles.
10. Geomembrane liner as-built layout plan prepared by the Installer.
11. All QA laboratory test results for geotextiles prepared by the Manufacturer.
12. All shippers' listing of panel or roll numbers, thickness, and dimensions for geomembranes and geotextiles.
13. Any installation acceptance forms completed by Owner/Operator and Installers.
14. Correspondence, with Soils Testing Laboratory, regarding clay liner installation.
15. As-built construction drawings.

The as-built construction drawings shall include, but shall not be limited to:

1. Subgrade excavation contour map illustrating constructed grades and elevations.
2. Top of liner foundation contour map illustrating constructed grades and elevations.
3. Liner seam layout drawings for geomembrane liners.
4. Top of operations layer contour map illustrating constructed grades, elevations, liner terminations, interim termination berms, and locations of interim diversion ditches.
5. Maps as necessary illustrating constructed locations of permanent surface water features, leachate sump risers, haul roads, site wells, gas monitoring probes and fences.
6. Additionally, as-built drawings will show locations of repairs and destructive seam tests on geomembrane components, as well as locations of field soils testing and sampling.

Final construction documentation reports shall be submitted to CDPHE and Eagle County Landfill.

2.0 SURVEY REQUIREMENTS

2.1 SURVEY CONTROL

Vertical and horizontal control has been established for the site as follows:

BASIS OF BEARINGS: Assuming the East line of the N ½ of the Northeast ¼ of Section 11, Township 4 South, Range 837 West of the 6th Principal Meridian bears N 00°14'09" W with all bearings herein relative thereto. Said line being monumented on the North end by an iron rod and 3.25" aluminum cap marked "BUREAU OF LAND MANAGEMENT, T4S, R83W, S2, S1,S11,S12, 1918" and on the South end by an 2" iron pipe and 3.25" aluminum cap marked "NICHOLS ASSOCIATES, INC., LS 12093, NE 1/16, S11, S12, T4S, R83W, 1995".

SITE BENCHMARK: A #5 rebar and 1" plastic cap stamped "KRW CONTROL" lying East of the leachate detention pond. Elevation based on an assumed datum is 7283.87'. Project coordinates being Northing=3941.85, Easting=7441.51.

The CQAE or his subcontractor shall independently verify the accuracy of previously used control for each construction phase

2.2 REQUIRED AS-BUILT SURVEYS

Surveys performed for inclusion in the construction documentation report shall include, but not necessarily be limited to:

1. As-built subgrade excavation contours and grades.
2. As-built top of liner foundation contours and grades.
3. As-built top of growth layer contours and grades
4. As-built top of rooting layer contours and grades.
5. As-built locations of all leachate piping, liner penetrations.
6. As-built locations and extent of all liner and cap components.
7. As-built locations, contours and grades of all engineered surface water diversion features (detention ponds, perimeter channels, culverts, spreaders, etc.).
8. Site boundary location relative to construction. Note that the site boundary survey must be performed by a Colorado registered professional surveyor.

2.3 EXCAVATION SURVEYING

Grade staking will be performed by surveyors under the supervision of the CQAE to establish required elevations for the excavation base The CQAE will document excavation elevations by survey using established vertical control. Vertical elevations of excavation grades will be documented based on a grid spacing of 50 feet or less, and the axes of the tops and toes of slopes will be surveyed on a spacing of 50 feet or less and at changes in direction or grade. Vertical measurements shall be read to the nearest 0.01 foot to establish elevations at a minimum precision of 0.1 foot. Horizontal measurements shall be read to the nearest 0.1 foot to establish locations at a minimum precision of 0.5 foot.

2.4 TOP OF LINER FOUNDATION SURVEYING

The CQAE will document top of liner foundation elevations by survey using established vertical control. Vertical elevations of liner foundation finish grades will be documented based on a grid spacing of 50 feet or less, and the axes of the tops and toes of slopes will be surveyed on a spacing of 50 feet or less and at changes in direction or grade. Vertical survey measurements shall be read to the nearest 0.01-foot to verify that

foundation layer is a minimum of 1.0-foot thick and within a tolerance of ± 0.1 foot. Horizontal measurements shall be read to the nearest 0.1 foot to establish locations at a minimum precision of 0.5 foot.

The liner foundation layer will extend several feet beyond the area of any given module to allow keying of subsequent phases together. The CQAE shall document the extent of the liner foundation construction beyond the module boundary.

2.5 GEOSYNTHETIC LINER SYSTEM SURVEYING

The horizontal extent of all geosynthetic components for the leachate sump and Leachate Holding Pond (LHP) shall be surveyed. Survey measurements shall not be more than 50 feet apart along the edges of the liner system. Survey points shall also be located at each turning point along the edge of liner. The vertical location of the installed synthetic liner system will be derived from the top of liner foundation survey.

2.6 FINAL COVER SURVEYING

The CQAE will document final landfill cover elevations. The surveyor under the supervision of the CQAE will establish vertical elevations of the final cover (top of foundation layer and top of growth layer) to a tolerance of ± 0.1-foot as measured by appropriate surveying methods. It should be noted that the finish grades shown on the final grading plan represent the target for final construction; however, settlement of the landfill mass will occur before, during, and after placement of final cover. Therefore, the final contours of the landfill may be lower than or no more than seven feet higher than the design contours so long as the minimum and maximum design slopes are met. The final cover slopes for the landfill shall be no less than 5% and no greater than 25%.

The CQAE will verify the proper thickness of the foundation layer and growth/rooting zone layer, of the final cover. At the discretion of the CQAE, the foundation layer may be bored to determine thickness, prior to installation of the overlying components. If boring techniques are used, a minimum of one hole shall be bored every 100 feet on a grid to document minimum layer thickness. All borings shall be backfilled throughout the entire depth with bentonite. If the foundation layer thickness is verified by surveying, the survey shall be completed on a grid spacing of 50 feet or less. The top of the cap (top of the growth layer) shall be verified by surveying on a grid spacing of 50 feet or less. Thickness of the landfill cap components shall be measured normal to the final slope configuration. The required minimum total thickness of these layers is 3.5 feet. Design thicknesses for the individual layers are:

- Growth layer (measure only composite of growth/rooting zone layers) 0.5 ft.
- Rooting layer 1.0 ft.
- Barrier layer 1.5 ft.
- Foundation layer 0.5 ft.

2.7 PIPING SURVEYING

The horizontal and vertical locations of all permanent piping for leachate collection and conveyance shall be established by surveyors under the direction of the CQAE. The piping shall include, but not necessarily be limited to the following:

1. Leachate collection sump risers.
2. Leachate management piping including recirculation system piping, force mains and toe drains.

The top of each pipe shall be surveyed on a spacing of 25 feet. In addition, the beginning and ending and all turning points (vertical or horizontal) in each pipe run shall be surveyed. Elevations shall be measured to the nearest 0.01 foot. Horizontal locations shall be measured to the nearest 0.1 foot.

2.8 SURFACE WATER DRAINAGE SURVEYING

The as-built configuration of all man-made permanent surface water drainage features shall be measured by surveying. These features include but are not necessarily limited to the following:

1. Perimeter run on and run off channels.
2. Drainage culverts.
3. Drainage spreader structures.
4. Sedimentation ponds to include topography, inlet riser, spillways, etc.
5. Cap diversion berms.

The flow line of each drainage channel shall be surveyed for horizontal and vertical location on a spacing of 50 feet or less. All turning points in the channels shall also be surveyed. Cross sections of the channels shall be surveyed every 200 feet or less of channel length to verify construction in accordance with the Design Plans and Drawings. Elevations shall be measured to the nearest 0.01 foot. Horizontal locations shall be measured to the nearest 0.1 foot.

2.9 ROAD SURVEYING

The as-built road construction for the proposed access road shall be measured by surveying. For the roads cross-sectional survey, including the center line, each road edge, and associated drainage shall be surveyed 100 feet or less of road. In addition, sufficient cross sections of the road curves shall be surveyed to allow preparation of accurate as-built locations and grades.

3.0 EARTHEN MATERIALS

Section 3.0 of this CQAQCP describes the earthen materials used in constructing the disposal cells for the landfill and surveying requirements for documentation of proper grades and fill thicknesses.

3.1 LOW HYDRAULIC CONDUCTIVITY SOILS

This section includes the QA/QC requirements for placement, backfilling, and compaction of low hydraulic conductivity soils used for constructing the landfill cell. Low hydraulic conductivity soils will generally be select clay soils from excavation within the landfill area and will be used for the following:

1. Backfilling any areas which are over-excavated.
2. Constructing the floor liner, side slope liner, and leachate sump liner.
3. Constructing the low hydraulic conductivity layer of the final cover for the landfill.

Any field tests, soil sample locations, and survey measurements will be recorded in reports by the CQAE or his representative including locations (by site grid station) and elevations of all field tests and laboratory sample points.

In addition to the on-site clay materials, bentonite will be imported to the site for repair of test probe holes installed in the liner during moisture/density testing.

3.1.1 Pre-construction

Low hydraulic conductivity soil placement will be performed in accordance with the construction plans and specifications. The Soils Testing Laboratory and/or CQAE shall document that backfilling and/or recompacting operations are conducted in compliance with the project plans and specifications, and with this CQAQCP.

3.1.2 Materials of Construction

The foundation for the landfill floor (exclusive of the side slopes) will consist of shale bedrock excavated to design grades.

Clay soils used for construction of the required clay material components will be taken from on-site stockpiles or directly from excavation areas for subsequent landfill construction. All clay soils used in liner construction shall meet the required in place compacted hydraulic conductivity specification of $\leq 1x10^{-6}$ cm/sec.

Table 1 Non-Granular Soil Compaction/Moisture Specifications and Minimum Field Test Frequency

Fill Type	*Compaction/Moisture Specification*	*Minimum Test Frequency*
Excavation Base (over-excavation backfill)	92% ASTM D1557 @ ± 4% of optimum moisture	1/300 yds^3 or 2/acre/lift or at least one test per discrete area of backfill whichever is higher
Liner Foundation	92% ASTM D1557 @ ± 4% of optimum moisture	1/300 yds^3 or 2/acre/lift whichever is higher
Cap Foundation	88% ASTM D1557 @ ± 4% of optimum moisture	1/300 yds^3 or 2/acre/lift whichever is higher
Cap Diversion Berms	88% ASTM D1557 @ ± 4% of optimum moisture	1/lift/100 ft of berm
Sediment Pond Embankments	90% ASTM D1557 @ ± 4% of optimum moisture	1/lift of embankment
Culvert Backfill	92% ASTM D1557 @ ± 4% of optimum moisture	1/lift/culvert
Road	92% ASTM D1557 @ ± 4% of optimum moisture	1/300 yds^3 or 2/acre/lift whichever is higher
Anchor Trench Backfill	To be determined by the Design Engineer on a case-by-case basis	To be determined by the Design Engineer on a case-by-case basis
Clay Liner	92% ASTM D1557 @ -2% to +4% of optimum moisture	4/acre/lift

3.1.3 Field Testing Requirements

The following nuclear moisture/density field testing methods will be used by the Soils Testing Laboratory during construction:

Table 2 Nuclear Moisture/Density Field Testing

Parameter	*Method*
Moisture Content	ASTM D6938
Soil Density	ASTM D6938

Test frequencies for performing field moisture/density tests on clay fill for foundation soils and liner shall be a minimum of two field moisture/density tests per acre per compacted lift or not less than one test per 300 cubic yards.

3.1.4 Laboratory Testing Requirements

The Soils Testing Laboratory will conduct periodic laboratory testing on samples from the clay borrow and from the compacted clay liner. The sample method used for collection of undisturbed samples from the compacted clay liner shall be approved by the CQAE. Table 3 presents laboratory test types, methods, and frequencies for low hydraulic conductivity clay fill.

Liner perforations due to nuclear density testing and sampling for hydraulic conductivity testing, shall be backfilled by using powdered or granular bentonite compacted by hand

to achieve continuity of the compacted clay liner at these locations. The CQAE shall be advised of and shall approve methods of backfilling prior to conducting backfilling operations.

Table 3 Laboratory Testing for Compacted Clay

Test	***Method***	***Minimum Frequency***
Standard Proctor or Modified Proctor	ASTM D698 or ASTM D1557	1 per 8,000 yds^3
Atterberg Limits	ASTM D4318	1 per Proctor
Grain Size Analyses	ASTM D422	1 per Proctor
Unified Soil Class.	ASTM D2487	1 per Proctor
Hydraulic Conductivity (on remolded Proctor)	ASTM D5084	1 per Proctor
Hydraulic Conductivity (Shelby or drive tube samples)	ASTM D5084	1/acre/one-foot of liner

3.1.5 Soils Acceptance Criteria

The following acceptance criteria will apply to low hydraulic conductivity compacted clay soil for any of the landfill systems:

1. The soils will be compacted to a density to meet the hydraulic conductivity specification for the system being constructed. Moisture content specifications will be met for all soils; however, moisture content will not be used as the sole criterion for failing a density test.
2. Any soils which do not classify as CL or CH by the Unified Soil Classification system shall be reported immediately to the CQAE.
3. A laboratory determination of hydraulic conductivity greater than $1x10^{-6}$ cm/sec for liners or final cover barrier layer will be reported immediately to the CQAE.
4. If a hydraulic conductivity test fails the specification, at least one additional sample will be collected from the general area (within 25 feet) of the failing test. Based on the initial test and the retest results, the CQAE will determine whether additional tests should be conducted and/or repairs to the liner made to correct the deficiency.

3.1.6 Placement Criteria

The low hydraulic conductivity soils shall be placed with emphasis on the following:

1. Segregation and removal of unsuitable material.
2. Removal of boulders, cobbles, stumps, and roots.
3. Removal of structurally weak material (i.e., organic debris).

Field densities and moisture contents will be measured in areas where low-hydraulic conductivity compacted clay soil has been placed in order to document that the in-place soils are in substantial conformance with the required specifications.

Any backfilling and/or placement of low-hydraulic conductivity soils will be accomplished in accordance with the following requirements:

1. Observed stones greater than four inches in diameter will be removed from this material during soil homogenizing and moisture conditioning.

2. No frozen soils will be used for backfilling. Any frozen soils in the compaction work area will be removed.
3. The loose thickness of layers for clay compaction should be eight inches or less.
4. Clay compaction will be performed on properly homogenized and moisture conditioned soil so as to accomplish continuous and complete layer bonding and continuity of all soil construction joints.
5. Clay soils will be compacted to achieve a hydraulic conductivity of $\leq 1x10^{-6}$ cm/sec.
6. Unacceptable density or moisture content will be reported immediately to the Contractor by the Soils Testing Laboratory. The CQAE shall be notified of any unacceptable densities or moisture contents. Corrective action will consist of moisture conditioning of the soil and/or additional compactive effort as necessary.

3.1.7 Excavation Base Requirements

Excavations shall be observed by the CQAE prior to liner or clay fill construction. The CQAE will document all excavation conditions including but not limited to relative moisture content, material consistency, stability, slope configuration, and that the base area is graded, according to the plans and specifications. Proof-rolling with heavy equipment will be performed to identify any areas of undesirable material or soft foundation soils and will be observed by the CQAE and/or the Soil Testing Laboratory.

Where unacceptable excavation base surface conditions exist, the surface will be re-rolled or over-excavated to reduce the impact of such conditions. When over-excavated, the resulting depression will be backfilled with compacted clay soils. Backfilling will be accomplished in accordance with the field and laboratory testing provisions of Sections 3.1.3 and 3.1.4.

The completed and/or repaired excavation will be surveyed according to the provisions of Section 2.3 to determine that the excavation base is in accordance with the plans and specifications.

3.1.8 Compacted Clay Floor and Side Slope Liner

The final thickness of the compacted clay floor and side slope liner shall be a minimum of one foot when measured normal to the excavation surface. The liner material shall be placed in layers of approximately equal thickness (not to exceed 8 inches loose). Material thicknesses and proper grades shall be verified by surveying as described in Section 2.4.

The liner for each successive module or sub-module within the landfill shall be integrally connected to provide a continuous liner across the landfill floor and side slopes.

During extended periods when liner construction is not being conducted, this leading edge of the compacted clay liner will be covered with a minimum of two feet of loose soil to prevent liner desiccation. Bonding of subsequent liner sections will be accomplished by removing the temporary soil liner cover from a strip of the leading edge of the previous liner and lightly scarifying the surface of the liner. After the surface has been scarified, it will be observed for signs of desiccation and repaired as necessary. The Contractor will, if necessary, moisture-condition surfaces to receive clay fill either by addition of water and additional scarification where desiccated, or by disking to reduce water content.

Prior to placement of the leachate drainage layer, the final surface of the floor and side slope liner shall be smoothed by compaction with a smooth drum roller or other suitable compactor in order to provide a well-draining surface.

3.1.9 Final Cover

The final cover will have a minimum thickness of 3.5 feet measured normal to the slope including a 0.5-foot growth layer overlaying a 1.0-foot rooting zone overlying a 1.5-foot low hydraulic conductivity clay layer overlying a 0.5-foot foundation layer. The thickness of each final cover layer shall be verified as specified in Section 2.6.

The foundation layer consists of a 0.5-foot thick compacted lift of soil which will provide a structural basis for construction of the low hydraulic conductivity layer. No specific compaction/density specification is set forth; however, the CQAE shall approve the compaction methods and effort applied to this layer.

All clay soils used in final cover construction shall meet the required in place compacted hydraulic conductivity specification of $\leq 1x10^{-6}$ cm/sec.

3.1.10 Other Structural Fill

3.1.10.1 Cap Diversion Berms and Riprap Drop Chutes

The soil berms used for diversion of surface water on the landfill cover will be constructed using non-granular soils placed in loose 8-inch maximum lifts and compacted per the specifications outlined in Table 1. The as-built construction of the berms shall be verified by surveying as specified in Section 2.8.

Riprap shall be placed in the drop chutes without damaging the underlying geotextile. Where drop chutes are not parallel to the slope, stones shall be placed at the tops of the chutes to prevent flow of surface runoff parallel to the chute along the cover surface.

3.1.10.2 Sediment Pond Embankment

The sediment pond embankments will be constructed using non-granular soils placed in loose 8-inch maximum lifts and compacted/moisture specifications outlined in Table 1. Prior to constructing the embankments, the area beneath the embankments shall be scarified and proof-rolled to the satisfaction of the CQAE. Field moisture density tests shall be conducted at a rate no less than one test per compacted soil lift per embankment. The as-built construction of the embankments shall be verified by surveying as specified in Section 2.8.

3.1.10.3 Culvert Backfill

Where non-granular soils are used as the backfill for culverts, the fill shall be placed in loose 8-inch maximum lifts and compacted/moisture specifications outlined in Table 1.

3.1.10.4 Road

Where non-granular soils are used as structural fill, the soil shall be placed in loose 8-inch maximum lifts and compacted/moisture specifications outlined in Table 1. The as-built construction of the road shall be verified by surveying as specified in Section 2.9.

3.1.10.5 Anchor Trench Backfill

Non-granular soils used for backfilling of anchor trenches shall be moisture-conditioned and wheel-rolled or compacted with a hand operated compactor in the anchor trench to meet design requirements and to the satisfaction of the CQAE. Care shall be taken to not damage the liner during compaction of the soils. The CQAE shall observe all compaction operations in the anchor trench. There are no prescribed quantitative tests for this material; however, at the discretion of the CQAE, laboratory and field testing may be requested to assess moisture, density, and grain size distribution.

3.1.11 Deficiencies and Resolution

If a deficiency is discovered in the construction work, the CQAE along with the Soils Testing Laboratory will determine the extent and nature of the defect by additional testing, observation, review of data, or other appropriate means and will then inform the Owner/Operator. The Owner/Operator and the CQAE will direct the Contractor to perform the necessary corrective tasks. The Soils Testing Laboratory will retest the previously defective area, as appropriate, to document the success of corrective action.

3.1.12 Documentation Report

Upon completion of the low hydraulic conductivity soil component of the landfill construction, the QA/QC documentation will be gathered, organized, summarized, and presented as a documentation report to be included in an overall documentation report as discussed in Section 1.5.3. This report will contain a summary of the following items:

1. Field moisture and density measurements,
2. Laboratory soil tests,
3. Field survey measurements,
4. Daily reports, and
5. Short summary narrative which describes the construction process of each component.

3.2 GRANULAR SOILS

3.2.1 Pre-Construction

Granular soil placement will be performed in accordance with the construction plans and specifications. The granular soils will be of sufficient consistency to provide compliance with the design specifications. These materials will be imported from outside the waste boundary. Samples of the granular soils will be collected from the supplier for laboratory testing at least 30 days prior to anticipated use to make certain that the material meets specifications stated in Section 3.2.2.

3.2.2 Materials of Construction

Granular soils will be used in construction of the leachate collection sump, sediment pond embankments, spillways, drainage spreaders, drainage channels, pipe bedding, riprap, and as bedding for riprap. Granular soils are also permitted as one alternative for the leachate drainage layer, the other being tire shreds.

3.2.2.1 Leachate Drainage Layer Materials

If the granular soils alternative is selected, the leachate drainage layer shall consist of a sand and/or gravel with and in-place hydraulic conductivity of $1x10^{-2}$ cm/sec or greater

and a maximum particle size of two inches. The leachate drainage layer materials will be poorly graded and be made up of inert stable materials such as silica and quartz. The material and its particle size distribution shall be approved by the CQAE.

Tire shreds may be substituted for the granular leachate drainage layer. Shreds shall have an in-place hydraulic conductivity of $1x10^{-2}$ cm/sec or greater. Before materials for this layer are procured, one sample per material source shall be tested under anticipated construction loads for hydraulic conductivity in substantial conformance to USBR method 5605. Tire shreds must meet the hydraulic conductivity specification under the anticipated loads while maintaining a minimum in-place thickness of 0.5 feet under landfill loads.

3.2.2.2 Leachate Sump and LHP Sump Aggregate Materials

The granular material placed in the leachate sump and LHP sump shall be 1.5-inch concrete aggregate conforming to the ASTM C-33 size #4 specification. This material shall be made up of inert and stable materials such as silica and quartz. The material shall be rounded to sub-rounded.

3.2.2.3 Rip Rap Bedding Materials – Type II

The granular bedding material placed below the rip rap shall meet the gradation requirements specified in Table 4. These specifications shall be verified by a minimum of one test per source of granular bedding conducted per phase of construction in which the material is used.

Table 4 Riprap Bedding Materials

Sieve Size	***Percent Passing By Weight***
3 inch	90 - 100
3/4 inch	20 - 90
#4	0 - 20
#200	0 - 3

3.2.2.4 Rip Rap Materials

Riprap material shall be angular to facilitate interlocking of individual stones. The material shall be inert and have a specific gravity of 2.5 or greater. The rip rap material placed shall meet the requirements for size designation, gradation and intermediate rock dimension specified in Table 5.

Table 5 Riprap Materials

Rip Rap Designation	***Percent Smaller Than Given Size by Weight***	***Intermediate Rock Dimensions (inches)***	***d_{50} (inches)****
Type VL	70 - 100 50 - 70 35- 50 2 - 10	12 9 6 2	6
Type L	70 - 100 50 - 70 35- 50 2 - 10	15 12 9 3	9
Type M	70 - 100 50 - 70 35- 50 2 - 10	21 18 12 4	12

* d_{50} = mean particle size (intermediate dimension) by weight.

3.2.2.5 Pipe Bedding

Pipe bedding shall be constructed for culverts. Pipe bedding shall consist of granular material conforming to the specifications in Table 6. These specifications shall be verified by a minimum of one test per source of pipe bedding conducted per phase of construction in which the material is used. Pipe bedding material shall be approved by the CQAE.

Table 6 Pipe Bedding

Sieve Size	***Mass Percent Passing Square Mesh Sieves***
19 mm (3/4 inch)	100
9.5 mm (3/8 inch)	>90
4.75 mm (#4)	>45
0.147 mm (#100)	<10
0.074 mm (#200)	<5

3.2.3 Testing Requirements

The Soils Testing Laboratory and/or CQAE will be responsible for making sufficient observations of the granular materials during their placement to ensure that materials specifications are met. All field and laboratory test results plus survey results, including locations of field tests and laboratory sample points (by grid station and elevations), will be recorded. The methods and test frequencies for laboratory analyses are presented in Table 7.

Table 7 Minimum Testing Requirements for Granular Materials

Test	*Method*	*Material*	*Frequency*
Grain Size	ASTM D422	Leachate Drain Layer	1 per 3 acres & 1/source
		Sump Aggregate	1 per sump & 1 per source
		Rip Rap Bedding	None Required
		Rip Rap	None Required
		Pipe Bedding	1 per source
Hydraulic Conductivity	ASTM D2434	Leachate Drain Layer	1 per source
		Sump Aggregate	None Required
		Rip Rap Bedding	None Required
		Rip Rap	None Required
		Pipe Bedding	None Required

3.2.3.1 Leachate Drainage Layer Testing

A minimum of one sample shall be collected for grain size analysis for every three acres of leachate drainage material placed and for every different gravel source. A minimum of one sample shall be collected and analyzed for hydraulic conductivity for every source of aggregate used. Grain-size (sieve) and a hydraulic conductivity analyses will be performed according to the provisions of ASTM D422 and ASTM D2434, respectively. The analytical results will be sent to the CQAE who will determine if the material meets the required specifications. The CQAE may require additional testing depending on routine observations of the material being delivered to the site or placed over the liner. The thickness of the leachate drainage layer will be measured as described in Section 2.0.

3.2.3.2 Leachate Sump and LHP Sump Aggregate Testing

A minimum of one sample shall be collected for grain size analysis for each sump. In addition, a minimum of one grain size analysis will be performed on each source of the sump aggregate. The CQAE may require additional testing depending on routine observations of the material being delivered to the site or placed over the liner.

3.2.3.3 Rip Rap Bedding, Pipe Bedding and Rip Rap Testing

No tests are required for these materials; however, the CQAE may require grain size testing based upon physical observations of the materials.

3.2.4 Acceptance Criteria

The acceptance criteria for the granular soils are based on the material specifications, particle size, visual observation, and hydraulic conductivity testing. In addition, the granular soils must consist of inert and stable materials. The CQAE will observe the spreading and grading of the granular material in the leachate sump, LHP sump, and the leachate drainage layer and document that it meets the project specifications. This observation will also be conducted to quickly detect potential and/or actual damage to the underlying geosynthetics upon which the material is being placed. Where damage is suspected, the underlying component surface will be exposed and observed to determine its condition. Actual damage will be fully documented as well as corrective action taken.

3.2.5 Placement Criteria

The following placement criteria will be used by the Contractor while installing the drainage layer or the sump gravel.

1. During placement of the leachate drainage layer over the clay liner, at least 1.5 feet of granular soils shall be maintained between the earth-moving equipment and underlying liner except for during final spreading when a minimum of 0.5 feet separation shall be maintained. Final spreading of the leachate drainage layer shall be conducted using a "light-weight" bulldozer approved by the CQAE.
2. A minimum final thickness of 0.5 feet of drainage material will be placed over the floor liner.
3. During placement of gravel in the leachate sump, a minimum of 1.5 feet of granular material shall be maintained between the earth moving equipment and the underlying liner components.
4. The CQAE will observe the spreading and grading of the granular material in the leachate sump and document that it meets the project specifications. This observation will also be conducted to quickly detect potential and/or actual damage to the underlying geosynthetics upon which the material is being placed. Where damage is suspected, the underlying component surface will be exposed and observed to determine its condition. Actual damage will be fully documented as well as corrective action taken.

3.2.6 Deficiencies and Resolutions

If a deficiency in earthwork is discovered during construction, the Soils Testing Laboratory will immediately determine the extent and nature of the defect by additional testing, observation, review of data, or other appropriate means and will then notify the Contractor and the CQAE of the defect. The Contractor will perform the necessary corrective tasks. The Soils Testing Laboratory will then retest or re-observe the area, to document that the defect has been satisfactorily corrected. Additional work shall not be performed in the area of deficiency until the deficiency is corrected.

3.3.7 Documentation Report

The CQAE will document final elevations and/or thicknesses of the leachate drainage layer according to the requirements set forth in Section 2.5.

Upon completion of the placement and testing of the granular soils, the documentation information will be gathered, organized, summarized, and presented for inclusion in the Final Construction Documentation Report described in Section 1.5.3. The report will include:

1. Soil testing results.
2. Field survey measurements.
3. Daily reports.
4. Short narrative summary which describes the construction process of this component.

4.0 GEOSYNTHETICS

This section of the CQAQCP applies to geosynthetics used in the construction of the leachate sump and LHP liner systems. These components are as follows:

Leachate Sump:

1. 60-mil textured high density polyethylene (HDPE) geomembrane for added containment protection in the leachate sump.
2. 16-oz/yd^2 non-woven geotextile fabric for protection of the geosynthetic liner in the sump.
3. 4-oz/yd^2 non-woven geotextile for separation of refuse from the leachate collection sump gravel.
4. 16-oz/yd^2 non-woven geotextile for separation of riprap from the landfill final cover in drainage drop chutes.

Leachate Holding Pond

1. Geosynthetic clay liner (GCL) as part of the composite liner system.
2. 45-mil reinforced polyethylene (RPE) geomembrane for the primary and secondary liners in the composite liner system.
3. 200-mil thick HDPE geonet drainage layer to function as the leak detection layer between the primary and secondary liners.
4. 12-oz/yd^2 non-woven geotextile for protection of the secondary and primary liners in the LHP leak detection sump.

4.1 HDPE CONSTRUCTION

This section deals with the manufacture and installation of the HDPE geomembrane to be used in the leachate sump liner.

4.1.1 HDPE Manufacturing

The width of the HDPE geomembrane panels shall be optimized to allow for the least number of seams.

Prior to delivery of any geomembrane rolls to the site, the Manufacturer will provide the CQAE with the following information:

1. The resin supplier, supplier location, and brand name.
2. Any test results conducted by the geomembrane and/or resin manufacturer to document the quality of the resin used in the membrane fabrication.
3. The quality control plan that the membrane manufacturer will be using for the membrane being supplied.

Every roll of HDPE geomembrane delivered to the site must be manufactured and inspected by the Manufacturer according to the following requirements:

1. The geomembrane must contain no more than one percent by weight additives, fillers, or extenders, excluding carbon black.
2. The PE resin shall contain no more than two percent recycled polymer by weight. Recycled polymer shall be limited to material generated within the geomembrane manufacturer's plant and from the same grade and type defined in this plan.
3. The geomembrane must have no striations or roughness (inconsistent with the texture), pinholes, or bubbles on the surface.

4. The geomembrane must be free of holes, blisters, undispersed raw materials, or any other sign of contamination by foreign matter.

The geomembrane manufacturer will perform the tests listed in Table 8 at the stated frequencies and will report the results to the CQAE. The Geomembrane Manufacturer will provide certification based on tests performed by the Manufacturer's laboratory, or other outside laboratory contracted by the Manufacturer, that the membrane supplied under this plan will substantially comply with specifications listed in Table 9.

Table 8 Laboratory Testing of HDPE Resin

Property	***Method***	***Frequency***	***Requirements***
Density	ASTM D1505 or D792B	one per batch	Adequate to meet Table 9 requirement.
Melt Flow index	ASTM D1238, Condition E	one per batch	≤1.0 g/10 min.
OIT	ASTM D3895 or ASTM D5885	one per batch	Consistent with geomembrane OIT of 100 min (ASTM D 3895) or 400 min (ASTM D5885)

Table 9 HDPE Geomembrane Specification

Test	***Method***	***Frequency***	***Requirements***
Sheet Thickness	ASTM D5199	one per each 2nd roll (approx. 1/50,000 ft^2)	60 mils ± 5%; the average of all measurements for any roll, not less than 60 mils
Sheet Density	ASTM D792 or D1505	one per each 2nd roll	0.940 - 0.950 g/cm3
Tensile Strength Yield	ASTM D6693	one per roll (approx. 1/25,000 ft^2)	min. 126 lb. per in. width
Elongation at Yield	ASTM D6693	one per roll	min. 13 percent
Elongation at Break	ASTM D6693	one per roll	min. 700 percent
Tear Resistance	ASTM D1004	one per roll	min. 42 lbs.
Puncture Resistance	ASTM D4833	one per roll	min. 108 lbs.
Stress Crack Resistance	ASTM D5397	300 hr.	Per GRI GM10
Carbon Black Content	ASTM D1603	20,000 lb.	2.0-3.0%
Carbon Black Dispersion	ASTM D5596	45,000 lb.	Only near spherical agglomerates, 10 views, 9 in cat. 1 or 2, 1 in cat. 3
OIT	ASTM D3895 or D5885	200,000 lb.	100 minutes (D3895), 400 minutes (D5885)
Oven Aging at 85°C	ASTM D5721	each formulation	55% using ASTM D389, 80% using ASTM D5885
UV Resistance percent retained after 1600 hours	GM 11	each formulation	50% using ASTM D5885

4.1.2 Delivery, Handling, and Storage of Geomembrane Rolls

Transportation of the geomembrane rolls to the job site is the responsibility of the Geomembrane Manufacturer. All on site handling is the responsibility of the Installer. The geomembrane will be protected during shipment from excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. Upon arrival, the Installer shall inspect all materials for defects in the manufacturing process and for damage during transportation. Materials judged by the CQAE to be severely damaged shall be rejected and removed from the site. Minor damage and defects shall be repaired by the Installer.

Geomembrane rolls will be stored on site in a manner, which prevents excessive ultraviolet exposure prior to installation.

The CQAE will be responsible throughout the pre-construction, construction, and post construction periods for observing and documenting that the Installer provides adequate handling equipment for use in moving geomembrane rolls and that the equipment for the moving of the geomembrane rolls preserves the integrity of the geomembrane.

The Installer will be responsible for making certain that the manufacturer, type, and thickness of each roll in a shipment are correct. The CQAE will also maintain a log of geomembrane roll deliveries throughout the construction process. This log shall include, at a minimum, the following:

1. Manufacture date.
2. Date of receipt at the site.
3. Roll and lot batch numbers.

4.1.3 Foundation

The Earthwork Contractor will be responsible for preparing the subgrade according to the Design Plans and Drawings and this CQAQCP.

After the underlying surface has been accepted by the CQAE, it will be the Installer's responsibility to report to the CQAE any change in that surface that may require repair work. The supporting surface will be examined by the Installer and the CQAE to evaluate the surface conditions immediately prior to placement of the HDPE geomembrane. The CQAE and Geosynthetic Installer shall document in the daily report that the foundation layer surface condition is compatible with the geosynthetics to be installed. All observations by the CQAE and Geosynthetics Installer shall be documented in writing.

4.1.4 Placement Criteria

A panel layout drawing will be prepared by the Installer and provided to the CQAE at least three days prior to installation of the geomembrane.

Geomembrane placement will not be conducted at ambient temperatures below 40^{o}F (unless approved by the manufacturer and the CQAE), during precipitation or fog, in ponded water, or during excessive winds. Where adjacent or transverse panels are seamed, temperature effects on these panels should be taken into account to reduce the problem of "fish mouths" which may be encountered in the seaming process.

The CQAE will document the following:

1. The prepared soil surface for the geomembrane has not deteriorated since previous acceptance.

2. The equipment used does not damage the geomembrane by handling, heat, leakage of hydrocarbons, or by any other means.
3. Personnel working on geomembranes do not smoke, wear damaging clothing, or engage in activities that would damage the geomembrane.
4. The method of unrolling the geomembrane does not cause scratches or crimps in the geomembrane.
5. The method and sequencing used to place the rolls minimizes wrinkles and seaming problems.
6. Adequate means are used to prevent uplift by wind while preventing damage to the geomembrane or supporting earthen foundation.
7. Direct contact with the geomembrane will be minimized. The geomembrane will be protected by geotextiles or extra geomembrane materials in areas where excessive traffic is anticipated.
8. Heavy construction equipment shall not be allowed to move directly on any deployed geomembrane. This includes rubber-tired vehicles such as automobiles and pickup trucks but does not include light weight equipment like all-terrain vehicles.
9. The minimum initial lift height of soil placed over geosynthetics shall be no less than 6 inches.
10. Between this value and 12.0 inches, low ground pressure placement equipment shall be used. Ground contact pressure equipment of less than 5.0 psi is required.
11. For lift heights of greater than 12.0 inches, proportionately heavier placement equipment may be used.
12. Construction machinery must not perform sudden starts, stops or sharp turns over the geomembrane.
13. Cover material must be placed from the bottom of slopes to the top.
14. Cover material must be placed in such a manner as not to induce wrinkles in the underlying geomembrane.
15. All equipment that the contractor proposes to use within the geomembrane footprint must be approved by the CQAE.

4.1.5 Construction Field Seams

This section covers quality assurance/quality control procedures for seaming rolls of geomembrane into a continuous liner. This plan requires 100 percent non-destructive testing of all field seams. All seams must be logged by the CQAE or the Installer.

The Installer will provide the CQAE with seam layout drawings for each panel showing each expected seam. The CQAE will review the seam layout drawing and document that it is consistent with accepted practice and the Design Plans and Drawings. No seaming will be performed without the CQAE's approval.

In general, seams should be oriented parallel to the line of maximum slope, so they are oriented along, not across, the slope. In corners and at other odd geometric intersections, the number of seams should be minimized. All horizontal seams across the slope must be approved by the CQAE. Only end-of-panel seams may be approved.

A seam numbering system, that is compatible with the geomembrane roll numbering system, will be agreed upon by the Installer and the CQAE.

Prior to seaming, the seam area shall be clean, free of moisture, dust, dirt, debris of any kind, and foreign material. If seam overlap grinding is required, it shall be performed according to the Manufacturer's instruction within one hour of the seaming operation and in

a way that does not damage the geomembrane. Seams shall be aligned with the fewest possible wrinkles.

4.1.6 Seaming Equipment

Approved processes for field seaming are double-fusion welding and extrusion welding. Double-fusion welding shall be used for all seams except where space and access constraints prohibit its use. Fusion welding application may be impractical where space is limited in some parts of the site. Only apparatus, which have been specifically approved by the CQAE, shall be used. Proposed alternate processes shall be documented and submitted for approval to the CQAE.

Double-fusion welding using a hot wedge seaming device is the preferred method of seaming HDPE geomembrane. The fusion welding apparatus shall be equipped with gauges giving the applicable temperatures and pressures. Prior to installation of any geomembrane material, the Installer shall submit seaming quality control records, including ambient temperatures and applicable apparatus temperatures and pressures and trial seam results to the CQAE. Trial seam results shall be logged by the Installer or the CQAE.

The Installer shall meet the following requirements regarding use, availability, and cleaning of extrusion welding equipment to be used at the site:

1. At least one spare operable double-fusion and extrusion seaming device will be maintained on site at all times.
2. The welding apparatus will be equipped with a continuous temperature monitor in the barrel and at the nozzle.
3. Equipment used for seaming shall not damage the geomembrane.
4. The extruder will be cleaned and purged prior to beginning seaming, and at any time that seaming operations are stopped, until all heat-degraded extrudate has been removed from the barrel.
5. The electric generator for the equipment will be placed on a smooth base in such a way that no damage occurs to the geomembrane.
6. A smooth insulating plate or fabric will be placed beneath hot equipment to protect the geomembrane.

The Installer, and if applicable the Manufacturer, will provide documentation to the CQAE regarding the quality of extrudate used in the welding apparatus. At a minimum, the extrudate should be compatible with the base liner material and contain the same grade and quality of PE resin as used in the base material.

4.1.7 Seamer Qualifications

All personnel performing seaming operations will be qualified by experience and by successfully passing seaming tests for the type of seaming equipment to be used. All seamers must have seaming experience of a minimum of 500,000 ft^2 of polyethylene geomembrane using the same type of equipment to be used on this project. The most experienced on site seamer, the "master seamer" (a seamer that has successfully seamed a minimum of 2,000,000 ft^2 of polyethylene geomembrane using the same type of equipment to be used on this project) will have direct supervisory responsibility at the site over less experienced seamers. The Installer shall provide documentation of the qualifications of the seaming crew to the CQAE.

4.1.8 Weather Conditions During Seaming

The range of weather conditions under which geomembrane seaming can be performed are as follows:

1. Between ambient temperatures of 40^{O}F and 50^{O}F, as measured 6-inches above the sheet, seaming will be performed only if the geomembrane is preheated by either the sun or hot air device, provided there is no excessive ambient cooling resulting from wind conditions.
2. Unless otherwise authorized in writing by the CQAE, no seaming will be attempted at an air temperature colder than 40ºF or warmer than 104ºF as measured 6-inches above the sheet.
3. The geomembrane will be dry and protected from the wind.
4. Seaming will not be performed during any precipitation event.
5. Seaming will not be performed in areas where ponded water has collected beneath the surface of the geomembrane.

The CQAE will document that these requirements are met by the Installer and will document the actual weather conditions during the installation.

4.1.9 Overlapping and Temporary Bond

The CQAE or installer will document the following:

1. The length of the geomembrane overlap.
2. The geomembrane overlap is adequate for the seaming process that is used.
3. Procedures used to temporarily bond adjacent geomembrane rolls shall not damage the geomembrane.

4.1.10 Trial Seams

Trial seams will be made on fragment pieces of membrane to document that the seaming conditions are adequate. Such trial seams will be made at the beginning of each seaming period, and at least once every four hours thereafter, for each seaming apparatus used that day. Each seamer will make at least one trial seam each day. All trial seams will be made under the same conditions as actual seaming work. Trial seams will be logged and documented in the Certification Report.

The trial seams will first be examined for squeeze out, foot print, pressure, and general appearance by the Installer. If a seam fails any of these examinations, a new trial seam will be performed until satisfactory seams are obtained.

The trial seam samples will be a minimum of 3-feet long by 1-foot wide after seaming, with the seam oriented lengthwise and with the overlap described previously.

A minimum of four, 1-inch wide specimens will be cut from each end of each trial seam sample by the Installer. The specimens or "coupons" will be tested for "peel" and “shear” in the field using a calibrated tensiometer. A passing test is when the break is ductile and occurs at the edge or outside the seam but not in the seam. A failure is defined as the seam or weld peeling. Strength values used in the trial seams shall be the same as those used for destructive seams (refer to Table 10 in Section 4.1.13.3). If a specimen fails, the entire trial seam shall be repeated. If the additional specimen fails, the seaming apparatus or seamer shall not be accepted until corrective measures are performed and two successive trail seams are successfully completed. After completion of these tests, the remaining portion of the passing trial seam will be logged and retained for reference

if any further information might be required. The results of all test seams shall be forwarded to the CQAE.

4.1.11 General Seaming Procedures

The general seaming procedures are as follows:

1. Large "fish mouths" (Large fish mouths are of a size that will prevent airtight bonding between geomembrane panels.) or wrinkles at the seam overlaps will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut “fish mouths” or wrinkles shall be seamed, and any portion where the overlap is inadequate will then be patched with an oval patch of the same membrane, extending a minimum of six inches beyond the cut in all directions.
2. For double fusion welding, each overlap and the sheet below the overlap shall be hand-wiped clean immediately prior to welding.
3. On the side slopes seaming will extend into the anchor trenches.
4. At locations where the initial seam cannot be nondestructively tested, the seam will be cap stripped with the same geomembrane material. The CQAE will observe the cap stripping to document the uniformity and completeness of the work.

4.1.12 Nondestructive Testing

Each field seam will be nondestructively tested over the full length of the seam to the extent practical. Any seams, which cannot be effectively tested, will be reported to the CQAE. The purpose of the nondestructive testing is to determine the continuity of the seams.

The method for conducting nondestructive seam testing is pressure testing the open channel between the double fusion welds. GRI method GM6 shall be used to test double fusion welded seams. This method requires the pressurization of the open channel at 27 to 30 psi with a maximum pressure drop of 3 psi over five minutes for 60-mil HDPE.

The vacuum box or the ultrasonic shadow method may be used on extrusion welds in accordance with GRI specifications. Other test methods may be used only upon approval by the CQAE.

The CQAE will perform the following tasks related to seam testing:

1. Observe nondestructive seam testing and examine all seams for squeeze-out, footprint, pressure, and general appearance. Failure of these criteria will be considered as failure of the seam, and repair or reconstruction will be required.
2. Document the location, date, test unit number, name of tester, and outcome of all testing.
3. Inform the Installer of any required repairs.

4.1.13 Destructive Testing

Destructive seam tests shall be conducted throughout the seaming project at locations selected by the CQAE. The tests shall be conducted so that results are obtained prior to covering the geomembrane with another material. The purpose of the tests is to ensure that welds are fully integrated and to evaluate seam strength.

At a minimum, the CQAE or installer shall document, in the daily report, the following information related to all destructive seam samples:

1. The location by seam and sample number of the samples.
2. The results of all field testing of destructive samples

3. Actions taken as a result of testing.
4. Repairs of the sampled seams.

4.1.13.1 Test Location and Frequency

Destructive samples shall be collected at locations specified by the CQAE at a minimum rate of one sample for every 500 feet of seam. The seaming technician shall not be informed in advance of the time when, or locations where, seam samples will be taken.

4.1.13.2 Sampling Procedure

Samples shall be cut by Installer at locations specified by the CQAE. A number shall be assigned to each sample based on the seam number and sample sequence. The sample location and identifier shall be recorded in the daily report.

At each sampling location, two types of samples will be collected. Two sample coupons will be collected for field testing. Each of these coupons shall be 1 inch wide by 12 inches long with the seam centered parallel to the length. The minimum distance between these two coupons shall be 42 inches. If both sample coupons pass the field test described in Section 4.1.13.3, a sample shall be cut from the seam between the locations of the two coupons. This sample shall be cut into three parts and distributed as follows:

1. One portion to the Geosynthetic Quality Assurance Laboratory for testing (12 inches wide by 12 inches long)
2. One portion to the Installer for testing (12 inches wide by 18 inches long)
3. One portion to the CQAE for archive storage (12 inches wide by 12 inches long).

Sample size may vary slightly depending on the needs of each party in the distribution list. Final sizes shall be determined at a Pre-construction meeting.

4.1.13.3 Testing Procedure

Testing shall be conducted for shear and peel. Shear testing applies a tensile stress from the top sheet through the weld and into the bottom sheet. Peel testing peels the top sheet back against the overlapped edge of the bottom sheet in order to observe how separation occurs. The peel test indicates whether or not the sheets are continuously and homogeneously connected through the seam. The specifications for seam strength are presented in Table 10.

Table 10 Seam Strength (ppi) for 60-mil HDPE

Test	***Number of Coupons***	***Method****	***Fusion Weld Strength***	***Extrusion Weld Strength***
Peel	2	ASTM D6392	98	70
Shear	1	ASTM D6392	126	126

* As modified by NSF 54

4.1.13.4 Procedures Following Destructive Test Failure

All acceptable seams must be bounded by two locations from which samples passing destructive tests have been taken. There are two options for mitigation of a failed destructive test:

1. Reconstruct the seam between any two passed test locations; or
2. Trace the welding path to an intermediate location (10 feet maximum from the point of the failed test in each direction) and take a small sample coupon for an

additional field test at each location. If these additional samples pass the tests, then full samples (as described in Section 4.1.13.2) are taken. If these samples pass the tests, then the seam is reconstructed between these locations. If either sample fails, the process is repeated to establish a zone in which the field seam will be reconstructed.

4.1.14 Defects and Repairs

This section applies to all defects including damage during placement and repairs from examinations, tests, or visual observations performed on the geomembrane material and on seams used in joining rolls in the field.

The CQAE will examine each roll for damage after placement but prior to seaming and will determine which rolls or portions of rolls should be rejected, repaired or accepted. Damaged rolls or portions of rolls, which have been rejected, will be marked, and their removal from the site will be recorded by the CQAE.

All seam and non-seam areas of the geomembrane will be examined and documented by the CQAE for identification of defects, holes, blisters, undispersed raw materials, large wrinkles, and any signs of contamination by foreign matter. The surface of the geomembrane will be clean at the time of examination. Each location, which fails examination, will be marked by the CQAE and repaired by the Installer. Work will not proceed in any area where defects are identified until suitable repairs are made.

Several procedures exist for the repair of flawed areas. The final decision as to the appropriate repair procedure will be agreed upon between the Installer and the CQAE prior to commencement of the repair. The following procedures are available:

1. Spot Seaming - used to repair small tears, pinholes, or other minor localized flaws.
2. Patching - used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.
3. Capping - used to repair large lengths of failed seams.
4. Removing the Bad Seam and Replacing with a Strip of New Material Seamed in Place - used for repairing large lengths of fusion seams.
5. Other - as agreed upon by the Installer and the CQAE.

At a minimum the following provisions will be provided for repairs:

1. The geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.
2. Patches or caps will extend at least six inches beyond the edge of the defect, and all corners of patches will be rounded with a radius of three inches minimum.

Each repair will be examined, numbered, and logged by the CQAE.

4.1.15 Placement of Leachate Collection and Drainage Materials

Placement of 16 oz. nonwoven geotextile and granular soils on top of the HDPE geomembranes will be conducted by the Contractor in such a manner as to confirm the following:

1. Slippage of the geosynthetics on the underlying clay liner is minimal.
2. No damage of the geomembrane or underlying clay liner occurs.
3. No excess tensile stresses are imposed on the geosynthetics.
4. Heavy construction equipment shall not be allowed to move directly on any deployed geomembrane. This includes rubber-tired vehicles such as automobiles

and pickup trucks but does not include light weight equipment like all-terrain vehicles.

5. The minimum initial lift height of soil placed over geosynthetics shall be no less than 6 inches.
6. Between this value and 12 inches, low ground pressure placement equipment shall be used. Ground contact pressure equipment of less than 5.0 psi is required.
7. For lift heights of greater than 12 inches, proportionately heavier placement equipment may be used.
8. Construction machinery must not perform sudden starts, stops or sharp turns over the geomembrane.
9. Cover material must be placed from the bottom of slopes to the top.
10. Cover material must be placed in such a manner as not to induce wrinkles in the underlying geomembrane.
11. All equipment that the contractor proposes to use within the geomembrane footprint must be approved by the CQAE.

4.1.16 Anchor Trench System Construction and Backfilling

A trench will be used for anchoring the geosynthetics as indicated on the design plans and drawings. The anchor trench will be excavated to the specifications shown on the Design Plans and Drawings unless otherwise specified by the CQAE. Note that the anchor trench is used for the convenience of construction and securing the liner during construction. The anchor trench is not a required element of the post-construction liner stability.

The anchor trench shall be backfilled with non-granular soil (SC or CL) as approved by the CQAE. The soil shall be placed in maximum 8-inch lifts, moisture conditioned and wheel-rolled with a rubber tire machine or other method approved by the CQAE.

4.2 GEOSYNTHETIC CLAY LINER (GCL)

The GCL used on this project shall be Bentomat ® ST or equal. The GCL shall consist of a layer of natural sodium bentonite clay encapsulated between two geotextiles and shall comply with all of the criteria listed in this section. Only reinforced GCL shall be used. Prior to using an alternate GCL, the Installer must furnish independent test results demonstrating that the proposed alternate material meets all requirements of this specification. The Installer also must obtain prior approval of the alternative GCL by the CQAE.

4.2.1 GCL Properties

The GCL shall substantially comply with the properties shown in Table 11. The minimum acceptable dimensions of full-size GCL panels shall be 150 feet long by 15 feet wide. Short rolls (less than 150 feet but greater than 70 feet) may be supplied at a rate no greater than three rolls per truckload or three rolls per 36,000 ft^2 of GCL, whichever is less. The length of all short rolls shall be clearly marked on the outer packaging.

A 6-inch overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means of facilitating quality assurance during seaming. Lines shall be printed in easily visible, non-toxic ink that does not negatively impact the performance of the GCL.

Table 11 GCL Properties

Material Property	*Test Method*	*Test Frequency*	*Required Values*
Bentonite Swell Index	ASTM D5890	1 per 50 tons	24 mL/2g min.
Bentonite Fluid Loss	ASTM D5891	1 per 50 tons	18 mL max.
Bentonite Mass/Area	ASTM D5993	40,000 ft^2	0.75 lb/ft^2
GCL Grab Strength	ASTM D4632	200,000 ft^2	90 lbs
GCL Peel Strength	ASTM D4632	40,000 ft^2	15 lbs
GCL Index Flux	ASTM D5887	Weekly	1×10^{-8} $m^3/m^2/sec$
GCL Permeability	ASTM D5084	Weekly	5×10^{-9} cm/sec
GCL Hydrated Internal Shear Strength	ASTM D5321	Periodic	500 lb/ft^2

4.2.2 GCL Materials, Manufacturing, and Installation

The GCL Installer shall provide the CQAE with the following:

1. A conceptual description of the proposed placement of GCL panels over the area of installation.
2. GCL Manufacturer's quality control plan for documenting compliance with this document.
3. A representative sample of the GCL material.
4. A project reference list for GCL construction (upon request).
5. Manufacturer's QAQC certifications to verify that the materials supplied are in accordance with the Design Plans and Drawings and this CQAQCP (upon shipment).

The GCL Manufacturer shall provide the Contractor or other designated party with manufacturing QAQC certifications for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL Manufacturer and shall include:

1. Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the swell index and fluid loss specifications in Table 11.
2. Manufacturer's test data for the finished GCL product of bentonite mass/area, GCL tensile and peel strength demonstrating compliance with the specifications in Table 11.
3. GCL lot and roll numbers supplied for the project and corresponding shipping information.
4. Manufacturer's test data for finished GCL product for index flux, permeability, and hydrated internal shear strength showing compliance with the specifications in Table 11.

4.2.3 GCL Product Labeling

Prior to shipment, the GCL Manufacturer shall label each roll in a manner that clearly identifies the following information:

1. Product identification including Manufacturer's name, address, brand name, and product code.
2. Lot number and roll number.
3. Roll length, width, and height.

4.2.4 GCL Product Packaging

The GCL shall be wound around a rigid core whose diameter is sufficient to facilitate handling with mechanized equipment. The core is not necessarily intended to support the roll for lifting but shall be sufficiently strong to prevent collapse during transit.

All rolls shall be labeled and packaged in materials that are resistant to photo degradation by ultraviolet light.

4.2.5 Accessory Bentonite

The granular bentonite used for seaming and penetration sealing shall be made from the same natural sodium bentonite material as used in the manufacture of the GCL.

4.2.6 GCL Shipping and Handling

The Manufacturer assumes responsibility for initial loading of the GCL. Shipping will be the responsibility of the party arranging for the freight transportation. Unloading, on site handling, and storage of the GCL are the responsibility of the Installer or the Installer's designated representative.

A visual inspection of each roll shall be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging shall be marked and set aside for further inspection. The packaging shall be repaired as necessary to protect the GCL from damage during storage and handling.

The party responsible for unloading the GCL shall contact the Manufacturer prior to shipment to ascertain the appropriateness of proposed unloading methods and equipment.

4.2.7 GCL Storage

Storage of the GCL rolls shall be the responsibility of the Installer. A level, dry, well-drained, and dedicated storage area shall be selected at the job site outside of high traffic areas. Rolls shall be stored in a manner that prevents sliding or rolling from the stacks. Stacks shall be no higher than four rolls. All stored GCL and accessory bentonite shall be covered with plastic sheeting or tarpaulins until their installation. The integrity and legality of the roll labels shall be preserved during storage.

4.2.8 GCL Installation

GCL rolls shall be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging shall be carefully removed without damaging the GCL. The non-woven side of the GCL shall be placed up.

Equipment that could potentially damage the GCL or subgrade shall not be allowed to travel directly on it. Care shall be taken to minimize dragging GCL across the subgrade. At the direction of the CQAE, a temporary geosynthetic slip sheet shall be used when necessary to reduce friction during GCL placement.

The GCL shall be placed so that longitudinal panel seams are parallel to the direction of the slope. Seams shall be located at least three feet from the toe and crest of slopes steeper than 5:1. All GCL panels shall lie flat on the underlying surface with no wrinkles or folds.

Only as much GCL shall be deployed as can be covered with geomembrane at the end of the working day unless otherwise approved by the CQAE. If premature hydration of the GCL occurs, (i.e., prior to covering the GCL), the CQAE shall determine whether or not the GCL shall be replaced.

The GCL Installer must have installed at least 500,000 ft^2 of GCL or must provide the CQAE with satisfactory evidence that the GCL will be installed in a competent and professional manner.

4.2.9 GCL Seaming

The GCL seams are constructed by overlapping their adjacent edges. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. The minimum dimension of the longitudinal panel overlap shall be six inches for the finished (i.e. bentonite enhanced) seam. The minimum overlap at the end of roll seams shall be 24 inches. The panel seams shall be shingled in the direction of the grade.

Granular bentonite shall be used to enhance the seams. The underlying edge of the overlap panel shall be exposed, and a continuous fillet of granular sodium bentonite shall be applied along a zone defined by the edge of the underlying panel and the 6-inch line. The bentonite shall be applied by the Installer at a minimum rate of 0.25 pound per linear foot of seam.

In the leachate sump areas where two thicknesses of GCL are placed, the seams of the top layer shall be offset from underlying layer seams by at least 24 inches. The contractor shall use a smooth HDPE slip sheet as necessary to facilitate positioning the top GCL layer over the underlying later. The GCL shall be cut with a sharp utility knife. Cuts shall be smooth and clean.

4.2.10 GCL Damage Repair

If a GCL panel is torn, punctured, perforated, etc. during installation, it shall be replaced or repaired per the direction of the CQAE. Patches shall be sized so that a minimum 12-inch overlap is achieved around the damaged area. Prior to placement of the patch, dry bentonite shall be placed around the damaged area. If there is no potential for dislodging the patch during covering operations, the patch shall be secured to the damaged area using appropriate adhesive per CQAE approval.

4.2.11 Field Reporting and Documentation

Documenting and reporting methods will be implemented to systematically record results of on-site monitoring. A photo log will be created containing photos of all phases of the GCL installation.

4.3 REINFORCED POLYETHYLENE GEOMEMBRANE

The reinforced polyethylene geomembrane (RPE) used on this project shall be 45-mil or equal.

4.3.1 RPE Manufacturing

1. Prior to delivery of any RPE geomembrane panels to the site, the Manufacturer will provide the CQAE with the following information: The resin supplier, supplier location, and brand name

2. Any test results conducted by the geomembrane and/or resin manufacturer to document the quality of the resin used in the membrane fabrication
3. The QC plan that the geomembrane manufacturer will be using for the geomembrane being supplied.

Every panel of RPE geomembrane delivered to the site must be manufactured and inspected by the Manufacturer according to the following requirements:

1. The materials used for the geomembrane must consist of first-quality 100% virgin products designed and manufactured specifically for the purpose of this work, which must have been satisfactorily demonstrated to be suitable and durable for such purposes.
2. The geomembrane must be free from holes, pin holes, bubbles, blisters, excessive gels, undispersed resins, and/or carbon black, or contamination by foreign matter.
3. The geomembrane must be composed of a heavy encapsulated 1300 denier polyester bi-directional reinforcement.
4. All factory seams must have a minimum seam width of 1.5 inch scrim to scrim.

The RPE Geomembrane Manufacturer will perform the tests listed in Table 12 at the frequency of one test per every 100,000 feet of material and will report the results to the CQAE. The RPE Geomembrane Manufacturer will provide certification based on tests performed by the Manufacturer's laboratory, or other outside laboratory contracted by the Manufacturer, that the membrane supplied under this plan will substantially comply with specifications listed in Table 12.

4.3.2 Delivery, Handling, and Storage of RPE Geomembrane Rolls

1. Transportation of the RPE geomembrane panels to the job site is the responsibility of the Geomembrane Manufacturer. All on site handling is the responsibility of the Installer. The geomembrane will be protected during shipment from excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. Upon arrival, the Installer shall inspect all materials for defects in the manufacturing process and for damage during transportation. Materials judged by the CQAE to be severely damaged shall be rejected and removed from the site. Minor damage and defects shall be repaired by the Installer.
2. The Installer will be responsible for making certain that the Manufacturer, geomembrane type, and thickness of each panel in a shipment are correct. The CQAE will also maintain a log of geomembrane panel deliveries throughout the construction process. This log shall include, at a minimum, the following:
3. Manufacture date
4. Date of receipt at the site
5. Panel and lot batch numbers.
6. The CQAE will be responsible throughout the pre-construction, construction, and post construction periods for observing and documenting the handling and storage of the RPE geomembrane to ensure that the integrity of the material is preserved. The CQAE will ensure the following:
7. Fabricated panels (accordion-folded in one direction, rolled in the other direction) will be unloaded from trucks in such a way that no damage occurs to the geomembrane.
8. Fabricated panels accordion folded in both directions will not be used.
9. Fabricated panels on pallets will be moved by forklifts.

10. Folds of fabricated panels shall be examined for damage, particularly at kinks in the folds.
11. All material will be stored on smooth clean dry level surfaces such that it will not be damaged, become dirty, or get wet internally.
12. Depending on the timeline of the project, material shall be stored in a safe central location then staged at appropriate intermediate locations for deployment.
13. Fabricated panels will ultimately be placed in the correct location and in the correct orientation for deployment as shown on the protective packaging or in contained deployment instructions.

4.3.3 Foundation

The Earthwork Contractor will be responsible for preparing the subgrade according to the Design Plans and Drawings and this CQAQCP.

After the underlying surface has been accepted by the CQAE, it will be the Installer's responsibility to report to the CQAE any change in that surface that may require repair work. The supporting surface will be examined by the Installer and the CQAE to evaluate the surface conditions immediately prior to placement of the RPE geomembrane. The CQAE and Installer shall document in the daily report that the subgrade surface condition is compatible with the geosynthetics to be installed. All observations by the CQAE and Geomembrane Installer shall be documented. It is the Earthwork Contractor's responsibility to maintain the subgrade surface in a condition acceptable to the CQAE and Geomembrane Installer for geomembrane installation.

The RPE geomembrane must not be susceptible to differential settlement and there shall be no standing water on the subgrade when the liner is placed.

4.3.4 Placement Criteria

A panel layout and deployment instructions will be prepared by the Installer and provided to the CQAE at least ten calendar days prior to installation of the RPE geomembrane. Panels shall by unrolled and unfolded as indicated in the instructions. Unfolding shall be done with a person every 15 to 30 feet, depending on the size/weight of the panel.

RPE geomembrane placement must not be conducted during strong or gusty winds or during precipitation events and lightning storms. The CQAE will perform/document the following:

1. Evaluate and document weather conditions for geomembrane placement and inform MCSWM and the Installer when weather conditions do not meet specifications, so a determination of installation can be made.
2. Monitor and document geomembrane placement as well as conditions of panels as placed:
3. Noting panel defects, tears, or other deformities
4. Measuring in-place panel dimensions
5. Recording panel numbers.
6. Document that the equipment used does not damage the geomembrane by handling, heat, leakage of hydrocarbons, or by any other means.
7. Document that the prepared soil surface for the geomembrane has not deteriorated since previous acceptance.
8. Document that personnel working on geomembranes do not smoke, wear damaging clothing, or engage in activities that would damage the geomembrane.
9. Document that adequate means are used to prevent uplift by wind while preventing damage to the geomembrane or supporting earthen foundation.

10. Document that the direct contact with the geomembrane will be minimized. The geomembrane will be protected by geotextiles or extra geomembrane materials in areas where excessive traffic is anticipated.
11. Document that the heavy construction equipment shall not be allowed to move directly on any deployed geomembrane. This includes rubber tired vehicles such as automobiles and pickup trucks but does not include lightweight equipment like all-terrain vehicles.
12. Document that the construction machinery must not perform sudden starts, stops, or sharp turns over the geomembrane.
13. Document that the cover material, if applicable, must be placed from the bottom of slopes to the top.
14. Document that the cover material must be placed in such a manner as not to induce wrinkles in the underlying geomembrane.
15. Document all equipment that the contractor proposes to use within the geomembrane footprint is approved by the CQAE.

4.3.5 Geomembrane Seaming

All welding shall be completed by the Geosynthetic Manufacturer prior to delivery of the geomembrane on site.

Welding should be done as uniformly and consistently as possible. The objective is to melt the two surfaces and to allow them to cool and solidify as one integral body. When the weld is sectioned there should not be a well-defined interface, nor should there be any particulates or voids along the weld line. There should be no crimps due to overheating. The adjacent geomembrane should not be overheated and oxidized such that it becomes brittle. The cross sections of welds shall be examined for symmetry, lack of crimping (overheating), and the presence of voids and foreign particulates. If voids and particulates are present, the weld will be rejected.

The Geosynthetic Manufacturer is responsible to complete their own fabrication seam QA/QC during manufacturing. The contractor shall submit the Geosynthetic Manufacturer's QA/QC procedures to the CQAE. The contractor must submit the Geosynthetic Manufacturers QA/QC seam test results, certifications, and test reports for all welds completed by the Geosynthetic Manufacturers to the CQAE.

If field seaming is necessary, all personnel performing seaming operations must be qualified by experience and by successfully passing seaming tests for the type of seaming equipment to be used. All seamers must have seaming experience of a minimum of 500,000 ft^2 of RPE geomembrane using the same type of equipment to be used on this project. The most experience on-site seamer, the "master seamer" (a seamer who has successfully seamed a minimum of 2,000,000 ft^2 of RPE geomembrane using the same type of equipment to be used on this project) will have direct supervisory responsibility at the site over less experienced seamers. The Installer shall provide documentation of the qualifications of the seaming crew to the CQAE.

4.3.6 Defects and Repairs

This section applies to all defects including damage during placement and repairs from examinations, tests, or visual observations performed on the RPE geomembrane material and on field seams.

All areas of the RPE geomembrane will be visually observed and documented by the CQAE for identification of defects, holes, blisters, undispersed raw materials, large wrinkles, and any signs of contamination by foreign matter. The surface of the

geomembrane will be clean at the time of visual observation. Each location that fails visual observation will be marked by the CQAE and repaired by the Installer. Work will not proceed in any area where defects are identified until suitable repairs are made.

Several procedures exist for the repair of flawed areas. The final decision as to the appropriate repair procedure will be agreed upon between the Installer and the CQAE prior to commencement of the repair. The following procedures are available:

1. All non-penetrating linear flaws less than 0.125 inches wide may be repaired with no more than one extrusion bead of the same base polymer as the geomembrane.
2. Penetrating holes less than 0.125 inches in diameter that do not expose scrim yarns may also be repaired with no more than one bead application.
3. Holes that expose scrim yarns and those that are more than 0.125 inches in diameter shall be patched with the same geomembrane with patch yards oriented in the same direction as in the geomembrane. The patch shall extend at least three inches from the edge of the nearest damage if the damaged area is less than one inch in diameter. When damage exceeds one inch in diameter, the patch shall extend at least six inches from the nearest damage.

Under no circumstances will parallel and overlapping beads be used to fill in a flawed area or a gap. All patch extrusion welds shall be vacuum box tested and hot air patches can be either air lanced or vacuum tested and the results recorded.

Each repair will be examined, numbered, and logged by the CQAE following these procedures:

1. Performing systematic visual observation of the entire surface of the RPE geomembrane to locate and document defects and indicate for each defect the type of repair that is required
2. Monitoring and recording the repair of defects and the non-destructive testing of all repairs
3. Recording the location and the nature of all defect repairs.

4.3.7 RPE Geomembrane Electronic Leak Location Survey

An electronic leak location survey of the geomembrane may be performed at the option of the Owner and CQAE. QA associated with an electronic leak location survey would include the following:

1. Determination of the suitability of site conditions for the survey
2. Performance of the survey in accordance with ASTM D 7007 (water and soil-covered liners) to identify potential leak locations of the installed geomembrane
3. Potential leak locations would be marked with flags, paint, or other means to clearly locate the areas. Location coordinates would be recorded
4. Observation and documentation of repairs in accordance with project specifications, as applicable
5. Following repairs to initially identified perforations, the area at and generally around the repair will be re-surveyed to determine repair success. This process will be repeated until all identified perforations have been repaired and successfully re-tested.

4.3.8 Field Reporting and Documentation

Documenting and reporting methods will be implemented to allow the systematic recording of results of on-site monitoring and testing. Reporting forms will be used for

panel placement. Unique identifying numbers will be assigned to each panel and used to reference panel location.

An Installer's certificate of subgrade acceptance will be obtained prior to panel placement. Panel location diagrams will be kept showing locations of all panels. These diagrams will be updated on a daily basis.

Table 12 Material Properties - 45 mil RPE Geomembrane

Property	***Test Method***	***Minimum Roll Averages***	***Typical Roll Averages***
Thickness	ASTM D5199	40 mil	45 mil
Weight	ASTM D751	190 lbf/msf 27.4 oz/yd^2	202 lbf/msf 29.1 oz/yd^2
Construction			
Ply Adhesion	ASTM D6636	24 lbf/in or FTB	43 lbf/in Or FTB
Tensile Strength – lbf/in	ASTM D7003	182 MD 180 TD	202 MD 200 TD
Tensile Elongation at Break % (Film Break)	ASTM D7003	312 MD 278 TD	347 MD 309 TD
Tensile Elongation at Break % (Scrim Break)	ASTM D7003	30 MD 30 TD	32 MD 35 TD
Tongue Tear Strength – lbf	ASTM D5884	104 MD 99 TD	116 MD 110 TD
Grab Tensile – lbf (Scrim Break)	ASTM D7004	307 MD 296 TD	341 MD 329 TD
Grab Tensile Elongation at Break % (Scrim Break)	ASTM D7004	25 MD 25TD	27 MD 28 TD
High Pressure OIT (HPOIT)	ASTM D5885	400 min	> 2200 min
Puncture Resistance	ASTM D4833	130 lbf	145 lbf
Oven Aging at 85°C[2] Standard OIT High Pressure OIT	ASTM D 7238	35% 60%	each formulation
UV Resistance[2] High Pressure OIT	ASTM D 7238	35%	each formulation
Maximum Static Use Temperature		180 °F	
Minimum Static Use Temperature		-70 °F	
Manufacturer Seam Testing			
Peel Strength (ppi)[1]	ASTM D 7747	100	Per 750 feet of lineal seam
Shear Strength (ppi)[1]	ASTM D 7747	20	
Air Lance Test[1]	ASTM D4437	Apparent failure	100% of seam

[1] No more than 2 patches per 100 feet of seam
[2] Derived from Geosynthetic Research Institute Test Method GM25

4.4 HDPE GEONET (LEAK DETECTION LAYER)

The leak detection layer in the LHP shall consist of HDPE bi-planer 200-mil thick geonet placed between the secondary and primary liners. The following sections summarize the quality assurance plan for the geogrid installation.

4.4.1 HDPE Geonet Rolls and Panels

CQA monitoring for the rolls and panels includes:

1. Monitoring and documenting the unloading of trucks delivering geonet rolls to the site
2. Monitoring and documenting the handling and onsite storage procedures and location of geonet rolls
3. Review of the Manufacturer's quality assurance testing for conformance with specifications summarized in Table 13.
4. Visual review and marking of the geonet as it is unrolled and deployed at the job site for uniformity, damage, and imperfections.

4.4.2 Geonet Placement

Quality assurance monitoring for geonet placement includes:

1. Monitoring and documenting geonet placement as well as condition of material as placed, including the following:
2. Noting defects, tears, or other deformities;
3. Orientation of panels as placed;
4. Anchorage procedures;
5. Documentation that cover materials are placed in a manner that prevents damage to the geonet; and
6. Documentation that each component of the geonet is secured to like components of adjacent panels.
7. Adjacent panels shall be overlapped a minimum of 4-inches and the geonet fastened together with contrasting color plastic fasteners, placed at 5-foot intervals.
8. Adjoining geonet rolls (end to end) along the roll width shall be shingled down in the direction of the slope, with the up-gradient roll overlapping the down-gradient roll a minimum of 12-inches across the roll width. The geonet shall be tied every 12-inches across the roll width and every 6-inches in the anchor trench or as specified by the CQAE.

Table 13 Geonet Material Properties

Property	***Test Method***	***Required Value***	***Minimum Test Frequency***
Density	ASTM D1505	0.94 g/cm^3 min.	1/50,000 ft^2, min. 1 per resin batch
Thickness	ASTM D5199	250 mil	
Carbon Black Content	ASTM D4218	2% - 3%	
Tensile Strength	ASTM D7179	55 ppi	

4.5 GEOTEXTILES

Geotextiles covered under this section will be used in the following applications:

1. 4-oz/yd^2 (minimum) nonwoven geotextile for filtration/separation layer on top of the leachate sump.
2. 12-oz/yd^2 non-woven geotextile for protection of the secondary and primary liners in the LHP leak detection sump.
3. 16-oz/yd^2 nonwoven geotextile for protective layer over the geomembrane.
4. 16-oz/yd^2 (minimum) nonwoven geotextile for a separation layer between riprap and landfill final cover for drainage drop chutes.

4.5.1 Manufacturing

The geotextiles shall be manufactured from polypropylene resin. The geotextiles will be supplied to the site in factory rolls. The minimum requirements for the geotextiles are presented in Table 14.

Table 14 Minimum Properties for Non-Woven Geotextiles

Property	***Test Method***	***4 oz/sy***	***12 oz/sy***	***16 oz/sy***	***Minimum Test Frequency***
Mass per Unit Area (oz/sy)	ASTM D5261	4	12	16	1/100,000 ft^2, min. 1 per resin lot
Grab Strength (lb.)	ASTM D4632	100	320	390	
UV Resistance (% retained after 500 hrs.)	ASTM D4355	>70	>70	>70	

Quality control testing will be performed by the Geotextile Manufacturer to demonstrate compliance with the stated test methods. Prior to delivery of any geotextile rolls to the site, the Geotextile Manufacturer will provide the CQAE with the following information:

1. Test results conducted by the geotextile and/or resin manufacturer to document the quality of the resin used in geotextile fabrication.
2. The resin supplier, supplier location, and brand name.
3. The quality control plan that the Geotextile Manufacturer will be using for the geotextile being supplied.

Every roll delivered to the site must be manufactured and inspected by the Geotextile Manufacturer according to the following requirements:

1. First quality resins must be used containing no more than two percent recycled material by weight as determined by thermo-gravimetric analysis. Recycled polymer will be limited to material generated within the Geotextile Manufacturer's plant and from the same grade and type resin defined in this plan.
2. The geotextile must contain no needles used in punching.
3. The geotextile must be free of holes and any other signs of contamination by foreign matter.

The Geotextile Manufacturer will provide certification, based on tests performed by the Manufacturer's laboratory or other outside laboratory contracted by the Manufacturer, that the geotextile supplied under this plan meets the stated specifications.

4.5.2 Delivery, Handling, and Storage of Geotextile Rolls

Transportation of the geotextile rolls to the job site is the responsibility of the Geotextile Manufacturer. All on site handling is the responsibility of the Installer. The geotextile will be protected during shipment from excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. Upon receipt of material shipments at the site, the Installer shall inspect all materials for defects in the manufacturing process and for damage during transportation. Materials judged to be severely damaged shall be rejected and removed from the site. Minor damage and defects shall be repaired by the Installer. The geotextile rolls will be stored on site in a manner, which prevents excessive ultraviolet exposure prior to installation.

The CQAE will be responsible throughout the pre-construction and construction periods for observing and documenting that the Installer uses adequate handling equipment for moving the geotextile rolls.

The CQAE will be responsible for making certain that the manufacturer, type, and thickness of each roll in a shipment is correct. The CQAE will also maintain a log of the geotextile roll delivered throughout the construction process. This log shall include, at a minimum the following:

1. Manufacture date.
2. Date of receipt at the site.
3. Roll and lot batch numbers.

4.5.3 Placement Criteria

The Installer will handle all geotextiles in such a manner to ensure that they are not damaged in any way. The CQAE will observe and document that all of the following steps are performed by the Installer.

1. In the presence of wind, all geotextiles will be secured by suitable methods, which are protective of the geotextile and the underlying geomembrane.
2. On side slopes, the geotextile shall be rolled down the slope in such a manner as to continually keep the geotextile in tension.
3. Geotextiles will be cut using only approved geotextile cutters. If the geotextile is already in place at the time of cutting, special care shall be taken to prevent damage to the underlying geomembrane.
4. The Installer will take necessary precautions to prevent damage to the GCL and geomembrane liners during placement of the geotextile.
5. During placement of the geotextile over the geomembrane, care will be taken not to entrap foreign matter or excessive moisture between the geotextile and geomembrane.
6. A visual inspection of the geotextile will be carried out over the entire surface after installation by the Installer, to ensure that no potentially harmful foreign objects such as needles are present. In addition, the CQAE may undertake a sweep of the entire surface after installation using a metal detector. All such foreign objects or material shall be removed.

4.5.4 Seams and Overlaps

The following requirements will be used with regard to seaming and overlapping of geotextile rolls:

1. Geotextile seams will be continuously welded or sewn and will be overlapped a minimum of three inches prior to seaming. Spot seaming will not be allowed.
2. Horizontal seams on the landfill side slopes (except as part of a patch) will be allowed only at the approval of the CQAE.

3. The Installer will pay particular attention to seams to ensure that no earthen materials are inadvertently trapped beneath the geotextile.
4. Any sewing will be performed using polypropylene thread manufactured of the same base material as the geotextile. The thread shall be resistant to degradation by ultraviolet radiation.

The CQAE will observe and document that the Installer follows all of the seaming and overlapping protocol. The CQAE will perform a final geotextile examination after installation of the geotextile layer has been completed to detect the presence of holes or tears and to examine seams for tension due to excessive stretching of the fabric during installation. Repairs will be made for areas not conforming to acceptable practices.

4.5.5 Defects and Repairs

This section applies to all defects including damage during placement and repairs undertaken based on defects detected during examinations, tests, or visual observations performed on the geotextile material and on seams used in joining rolls in the field.

The CQAE will examine each roll for damage after placement, but prior to seaming, and will determine which rolls or portions of rolls should be rejected, repaired, or accepted. Damaged rolls or portions of rolls, which have been rejected, will be marked, and their removal from the site will be recorded by the CQAE.

All seam and non-seam areas of the geotextiles will be examined and documented by the CQAE for identification of defects, holes, undispersed raw materials, large wrinkles, and any signs of contamination by foreign matter. The surface of the geotextiles will be clean at the time of examination.

Each location, which fails examination, will be marked by the CQAE and repaired by the Installer. Work will not proceed in an area where defects are identified until suitable repairs are made. Each repair will be examined, numbered, and logged by the CQAE.

Any holes or tears in the geotextile will be reported to the CQAE and repaired as follows:

1. A patch made from the same geotextile will be sewed, welded or heat-bonded in place, with a 3-inch minimum overlap in all directions.
2. Care will be taken to remove any soil or other material, which may have penetrated a torn geotextile.

4.5.6 Placement of Soil Materials

Placement of soil materials on top of the geotextile will be performed by the Contractor in such a manner as to confirm the following:

1. Damage of the underlying geotextile or geomembrane does not occur.
2. Slippage of the geotextile on the underlying geomembrane is minimal.
3. No excess tensile stresses are imposed on the geotextile or geomembrane.

If there will be an extended time delay between placement of the geotextiles and the start of the installation of the overlying material, the Owner/Operator shall make provisions, approved in advance, to protect the geotextile against excessive exposure to ultraviolet radiation.

5.0 PIPE

This section of the CQAQCP applies to High Density Polyethylene (HDPE) pipes used at the landfill. Generally, specifications (i.e., material, size, etc.) for pipe and/or culvert used at the landfill are noted in the construction drawings. The CQAE will be responsible to ensure that all pipes and/or culverts meet the requirements of the Design Plans and Drawings and this CQAQCP.

5.1 HDPE PIPE

HDPE pipe manufacture and workmanship shall comply with ASTM D3035 and F714. Pipe joining shall be by butt fusion welding or by electro-fusion coupling. The HDPE pipe coupling system shall be approved by the CQAE prior to installation of the pipe. The pipe shall be leak tested to a minimum of 45 psi for at least ten minutes. The maximum allowable pressure drop is 3 psi over 10 minutes. The testing procedures shall be previously approved by the CQAE.

HDPE Pipe installed in the leachate collection sump shall be placed on two, 60-mil HDPE rub sheets. The pipe shall be backfilled in the sump area with 1 1/2 –inch concrete aggregate. Local grades are to be adjusted to support the pipe at the bends. At the access point, the pipe is to be encased in a 36” galvanized CMP pipe with the annulus filled with hydrated bentonite.

5.2 SMOOTH INTERIOR CORRUGATED POLYETHYLENE PIPE

5.2.1 Culvert Manufacturing

Culvert pipe used on the project shall be high-density polyethylene corrugated pipe with an integrally formed smooth interior and hydraulic characteristics as specified in the Design and Construction drawings.

Requirements for test methods, dimensions, and markings are those found in AASHTO Designations M252 and M294.

Pipe and fittings shall be made of polyethylene compounds, which meet or exceed the requirements of Type 111, Category 4 or 5, Grade P33 or P34, Class C per ASTM D1248 with the applicable requirements defined in ASTM D1248. Clean reworked material may be used.

Minimum parallel plate pipe stiffness values, per ASTM test Method D2412, shall be as indicated in Table 15.

Table 15 Minimum HDPE Culvert Pipe Stiffness

Diameter (inches)	***Pipe Stiffness (psi)***
18	56
24	50
30	46
36	40
42	35
48	35
60	30

The nominal size for the pipe and fittings is based on the nominal inside diameter of the pipe. Corrugated fittings shall be either molded or fabricated by the manufacturer. Fittings supplied by manufacturers other than the supplier of the pipe shall not be permitted without the approval of the CQAE.

Joints shall be made with split couplings, corrugated to engage the pipe corrugations, and shall engage a minimum of four corrugations, two on each side of the pipe joint. A neoprene gasket shall be utilized with each coupling to provide a soil-tight joint.

A manufacturers' certification that the product was manufactured, tested, and supplied in accordance with this specification shall be furnished to the CQAE.

5.2.2 Culvert Placement

Installation shall be in accordance with ASTM Recommended Practice D2321 or as specified by the CQAE.

Pipe bedding (see Section 3.2.2.5) shall be used as the bedding and envelope material around the culvert. Testing requirements for the pipe bedding are also provided in Section 3.2.3.3. Soil used as the backfill material above the bedding shall be approved by the CQAE and shall be compacted to a minimum of 92% of maximum modified Proctor density at ± 4% of optimum moisture content. The soil shall be compacted in lifts not greater than eight inches thick (loose). The soil shall extend above the pipe to the recommended minimum height of cover. At least one moisture density test shall be conducted per lift of soil per culvert installation.

Culverts shall be placed based on elevations specified on the Construction Drawings or as otherwise indicated by the CQAE based on field conditions.

5.2.3 Acceptance Criteria

The pipe and fittings shall be free of foreign inclusions and visible defects. Holes in the corrugation crests or sidewalls shall be considered unacceptable. The ends of the pipe shall be cut squarely and cleanly so as not to adversely affect joining. All joints shall be observed and accepted by the CQAE prior to backfilling around the culvert.

Survey of the inlet and outlet inverts of the culverts shall be conducted to the nearest 0.1 foot vertical and 0.5 foot horizontal. Survey of the cover thickness (as specified on the Design and Construction Drawings) shall verify conformance to the same tolerance as the inlet and outlet survey.

6.0 CONCRETE

This section of the CQAQCP applies to concrete used at the landfill. Generally, specifications (i.e., material, size, etc.) for concrete used at the landfill are noted in the construction drawings. The CQAE will be responsible to ensure that all concrete and concrete structures meet the requirements of the Design Plans and Drawings and this CQAQCP.

6.1 CONCRETE STRUCTURES

This section covers cast-in-place concrete, including furnishing materials, transporting, placing, finishing, curing, and other appurtenant items of construction. Concrete, concrete structures and workmanship shall comply with ACI standard specifications 301, 304-309 and 318.

6.2 SUBMITTALS

A proposed mix design shall be submitted to the CQAE prior to commencing concrete work and obtain CQAE approval. Certified test reports describing proposed concrete mix design, including:

1. Fine aggregates - Source, type, gradation, deleterious substances, and bulk specific gravity on the basis of weight of saturated surface - dry aggregate (ASTM C128).
2. Coarse aggregate - Source, type, gradation, deleterious substances, and bulk specific gravity on the basis of weight of saturated surface-dry aggregate (ASTM C217).
3. Ratio of fine to total aggregates.
4. Weight (surface dry) of each aggregate per cubic yard.
5. Total water content in gallons per cubic yard and proposed source.
6. Slump on which design is based.
7. Brand, type, and quantity of cement.
8. Brand, type, and quantity of admixtures.
9. Air content.
10. Two (2) sets of compression test cylinders, two (2) cylinders per set, Shall be made for each proposed mix. Test one (1) set of two (2) cylinders at age seven (7) days and other set at twenty-eight (28) days.

6.3. JOB CONDITIONS

Do not place concrete during rain, sleet, or snow unless adequate protection is provided and CQAE approval is obtained. Do not allow rainwater to increase mixing water or damage surface finish.

Cold Weather Concreting: Conform to ACI 306, "Cold Weather Concreting". Temperature of concrete when placed shall not be less than following:

Table 16: Required Concrete Temperature for Cold Weather Concrete Placement

Air Temp. $^{o}F.$	*Concrete Temperature $^{o}F.$*	
	Sections with least dimensions under 12"	***Sections with least dimension 12" and over***
30 to 45	$60^{0}F$	$50^{o}F$
0 to 30	$65^{0}F$	$55^{0}F$
Below 0	$70^{0}F$	$60^{0}F$

When placed, heated concrete shall not be warmer than eighty degrees Fahrenheit ($80^{0}F$). Prior to placing concrete, all ice, snow, and surface and subsurface frost shall be removed; and the temperature of the surfaces to be in contact with the new concrete shall be raised above thirty-five degrees Fahrenheit ($35^{0}F$). Protect concrete from freezing during specified curing period.

Hot Weather Concreting - Conform to ACI 305*,"* Hot Weather Concreting". Temperature of concrete, when placed, shall not exceed eighty-five degrees Fahrenheit. Do not use cement which has reached a temperature of one hundred seventy degrees Fahrenheit ($170^{0}F$) or more.

6.4 INSTALLATION

Remove any hardened concrete and foreign material from inner surface of conveying equipment. Prepare subgrades in accordance with ACI 301, Chapter 11. Moisten subgrade prior to placement but do not cause water to pond, muddy conditions, or cause soft spots to appear.

On all surfaces not exposed to view such as surfaces in contact with earth, remove all fins and other surface projections and fill all tie holes with patching mortar. On all exposed surfaces use form facing to produce a smooth, hard, uniform surface, keep number of seams to a minimum, remove all fins and projections, fill all tie holes with patching mortar and repair and patch all defects.

6.5 ACCEPTANCE CRITERIA

The concrete structures shall be free of foreign inclusions and visible defects. Holes in the surface shall be considered unacceptable. All faces of the structure shall be observed and accepted by the CQAE prior to backfilling.

Survey of all critical design points shall be conducted to the nearest 0.1 foot vertical and horizontal.