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CATEGORY I LANDFILL, CELL 4
MATERIAL SPECIFICATIONS AND
CONSTRUCTION QUALITY ASSURANCE PLAN

ASARCO EL PASO SMELTER REMEDIATION SITE

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TABLE OF CONTENTS

TABLES

1. INTRODUCTION

1.1 Purpose

This Material Specifications and Construction Quality Assurance (CQA) Plan (Plan) establishes the material requirements; construction installation requirements; quality control (QC) program; and quality assurance (QA) monitoring, testing, documentation, and reporting procedures that will be used during construction of the soils and geosynthetics components of the liner system and final cover system for the Category I Landfill (Cell 4) at the ASARCO El Paso Smelter Remediation Site in El Paso, Texas. It also includes CQA procedures related to survey control.

This Plan addresses the following major components of the liner system and final cover system:

- structural fill for the perimeter berm, interphase berm, prepared subgrade for the geomembrane liner, and anchor trench backfill;

- soil components of the liner system and final cover system: leachate collection sump aggregate, liner system protective cover, final cover surface layer, and final cover isolation layer; and

- geosynthetic components of the liner system and stormwater drainage system: geomembranes, geosynthetic clay liners (GCLs), geocomposites, and geotextiles.

This Plan was developed based on technical guidance published by the Texas Commission on Environmental Quality (TCEQ) for CQA of liner systems and final cover systems for municipal solid waste landfills ("Liner Construction and Testing Handbook," TCEQ Municipal Solid Waste Division, July 1993; "Final Cover System Construction and Testing," draft, TCEQ Municipal Solid Waste Division, April, 1998) and also considers the technical guidance presented by the U.S. Environmental Protection Agency (EPA) for CQA of waste containment facilities ("Quality Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, October 1993).

1.2 Definitions of Quality Assurance and Quality Control

In the context of this document, it is important to distinguish between CQA and construction/manufacturer QC. These terms are defined as follows:

- Construction Quality Assurance (CQA). CQA refers to means and actions employed by CQA personnel to provide confidence that an item or service meets the conformance requirements for liner system and final cover system component production and installation described in this Plan, contractual and regulatory requirements, and

construction-level project plans, and will perform satisfactorily in service. CQA is provided by a party independent of production and installation.

- Construction Quality Control (CQC). CQC refers to those actions which provide a means to measure and control the characteristics of an item or service to contractual and regulatory requirements. Thus, CQC refers to those actions taken by Manufacturers or Installers to ensure that the materials and the workmanship meet the requirements of the construction-level project plans and specifications. In the case of soils, CQC is combined with CQA and is provided by the CQA Consultant. In the case of geosynthetics, CQC is provided by the Manufacturers and Installers of the various geosynthetics.

1.3 Description of Project Parties

The project parties who may be involved in liner and final cover system construction are described below.

- Owner. The Owner owns and/or is responsible for overall management of the facility and to comply with the provisions of the permit and of applicable state and federal regulations. In this Plan, the term "Owner" refers specifically to the Texas Custodial Trust.

- Design Engineer. The Design Engineer is a Texas licensed Professional Engineer (P.E.) responsible for the design of the liner system and final cover system and preparation of the construction-level project plans and specifications.

- Project Manager. The Project Manager is the official representative of the Owner. A key role of the Project Manager is to oversee CQA and CQC, hire CQA/CQC consultants and surveyors, manage contractor bidding and procurement, and review/approve project expenditures. Typically the Project Manager also serves as a liaison between all parties involved in construction, to help ensure that lines of communication are maintained. Accordingly, in this Plan, the term "Project Manager" applies equally to "Construction Coordinator", i.e., the individual in charge of coordinating field activities.

- Earthwork Contractor. The Earthwork Contractor is responsible for the preparation of the liner system and final cover system subgrade and placement of the soils components of the liner system and final cover system and associated structures.

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

- Geosynthetics Manufacturer. The Geosynthetics (e.g., Geomembrane, Geotextile, Geocomposite (i.e., bonded geonet-geotextile combination), and Geosynthetic Clay Liner) Manufacturer (Manufacturer) is responsible for the production of materials such as the geomembrane and geonet rolls from resin, geotextile rolls from fiber, geocomposite rolls (bonding of geotextile and geonet), and geosynthetic clay liner rolls (bonding of geotextile and bentonite).

- Geosynthetics Installer. The Geosynthetics Installer (Installer) is responsible for field handling, storing, placing, seaming, loading (against wind), and other aspects of the geosynthetics installation. The Installer may also be responsible for transportation of these materials to the site and for construction of the anchor trenches.

- Soils CQA Consultant. The Soils CQA Consultant is a party, independent from the Owner, Earthwork Contractor, Manufacturer, and Installer, that is responsible for observing, testing and documenting activities related to the CQA of the earthworks at the site. The Soils CQA Consultant includes the Soils CQA Engineer, a Texas licensed P.E. who is responsible for issuing a signed and sealed final CQA report for soils.

- Geosynthetics CQA Consultant. The Geosynthetics CQA Consultant is a party, independent from the Owner, Earthwork Contractor, Manufacturer, and Installer, that is responsible for observing, testing, and documenting activities related to the CQA of the geosynthetics. The Geosynthetics CQA Consultant includes the Geosynthetics CQA Engineer, a Texas licensed P.E. who is responsible for issuing a signed and sealed final CQA report for geosynthetics. Soils CQA services and the Geosynthetics CQA services may be provided by the same firm.

- Geosynthetics CQA Laboratory. The Geosynthetics CQA Laboratory is a party, independent from the Owner, Earthwork Contractor, Manufacturer, and Installer, that is responsible for conducting tests on samples of geosynthetics.

- Soils CQA Laboratory. The Soils CQA Laboratory is a party, independent from the Owner, Earthwork Contractor, Manufacturer, and Installer, that is responsible for conducting tests in the field and/or in the laboratory on samples of soils.

- CQA Surveyor. The CQA Surveyor is a party, independent from the Owner, Earthwork Contractor, Manufacturer, and Installer, that is responsible for conducting field surveys to collect data to verify the as-built locations of the work. The CQA Surveyor includes the Texas licensed Professional Land Surveyor, who is responsible for issuing signed and sealed final Record Drawings.

Each of the construction activities could be carried out by separate project parties selected by the Owner.

1.4 Qualification of Project Parties

The following qualifications will be required of all parties involved with the design, manufacture, installation, transportation, and CQA of all liner system and final cover system materials on behalf of the Owner.

- Design Engineer. The Design Engineer will be a Texas licensed P.E. and will have a history that demonstrates familiarity and experience with geosynthetics and/or soils, as appropriate, including detailed design methods and procedures.

- Earthwork Contractor. Qualifications of the Earthwork Contractor are specific to the construction contract. The Earthwork Contractor will have a demonstrated history of successful earthworks construction.

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

- Manufacturer. The Manufacturer will be able to provide sufficient production capacity and qualified personnel to meet the demands of the project. The Geomembrane Manufacturer, in particular, will be pre-qualified and approved by the Owner.

  All personnel responsible for the loading, transport, and unloading of the geosynthetics must be fully aware of the consequences of damage to the geosynthetics and be familiar with the handling and transport constraints required by the Manufacturer.

- Geosynthetics Installer. The Geosynthetics Installer will be trained and qualified to install geosynthetics. The Geomembrane Installer, in particular, will be pre-qualified and approved by the Manufacturer and the Owner.

  In addition, the following qualifications will apply to the Geomembrane Installer's personnel:
  - All Geomembrane Installer personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests. The most experienced seamer, the "Master Seamer", will provide direct supervision, as required, over less experienced seamers. No field seaming will take place without the Master Seamer being present.
  - The Geomembrane Installer will provide the Project Manager with a list of proposed seaming personnel and their professional records. This document will be reviewed by the Project Manager and the Geosynthetics CQA Consultant. Any

proposed seaming personnel deemed insufficiently experienced will not be accepted by the Project Manager or will be invited to pass a seaming test.

- The Geomembrane Installer will designate one representative as his Superintendent, who will represent the Installer at all site meetings and be responsible for acting as the Installer's spokesman on site. This Superintendent will be pre-qualified for this role, on the basis of experience, management ability, and authority. His appointment will be approved by the Project Manager and the Geosynthetics CQA Consultant.

- Soils CQA Consultant. The Soils CQA Consultant will be experienced in providing CQA services for soils, including both low-permeability and high-permeability soils, for waste containment facilities or similar applications. The Soils CQA Consultant will be experienced in the preparation of QA documentation including QA forms, reports, certifications, and plans. The Soils CQA Engineer will be a Texas licensed P.E. and will have experience in providing soils CQA services for waste containment facilities. The Soils CQA Site Manager will be specifically experienced in the installation of soils and will be trained by the Soils CQA Consultant in the duties of a Soils CQA Site Manager. Soils CQA Monitors will be QA personnel who have been specifically trained in QA of soils. A qualified person may act as the CQA Engineer, Site Manager, and/or Monitor.

  At the outset of the project the Soils CQA Consultant will provide the Owner, in writing, with resumes of personnel to be involved in the project, including the Soils CQA Engineer, Soils CQA Site Manager, and Soils CQA Monitors, summarizing their qualifications and including information on P.E. licensure of the Soils CQA Engineer. A Soils CQA Consultant who is already pre-qualified through prior work for the Owner need only submit resumes of proposed CQA personnel.

- Geosynthetics CQA Consultant. The Geosynthetics CQA Consultant will be experienced in providing CQA services for geosynthetics, including polyethylene geomembranes, geocomposites, geotextiles, and geosynthetic clay liners, for waste containment facilities or similar applications. The Geosynthetics CQA Consultant will be experienced in the preparation of CQA documentation including CQA forms, reports, certifications, and plans. The Geosynthetics CQA Engineer will be a Texas licensed P.E. and will have experience in providing geosynthetics CQA services for waste containment facilities. The Geosynthetics CQA Site Manager will be specifically experienced in the installation of geosynthetics and will be trained by the Geosynthetics CQA Consultant in the duties of a Geosynthetics CQA Site Manager. Geosynthetics CQA Monitors will be QA personnel who have been specifically trained in QA of geosynthetics. A qualified person may act as the CQA Engineer, Site Manager, and/or Monitor.

At the outset of the project the Geosynthetics CQA Consultant will provide the Owner, in writing, with resumes of personnel to be involved in the project, including the Geosynthetics CQA Engineer, Geosynthetics CQA Site Manager, and Geosynthetics CQA Monitors, summarizing their qualifications and including information on P.E. licensure of the Geosynthetics CQA Engineer.

- Soils CQA Laboratory. The Soils CQA Laboratory will have experience in the physical testing of soils and will be familiar with and properly equipped to perform the geotechnical testing required by this Plan, including the capability to follow the required tests (i.e., ASTM methods).

- Geosynthetics CQA Laboratory. The Geosynthetics CQA Laboratory will have experience in testing the types of geosynthetics to be used on the project. The Geosynthetics CQA Laboratory will be familiar with and properly equipped to perform the testing required by this Plan, including the capability to follow the required test methods (i.e., American Society for Testing and Materials (ASTM) and Geosynthetic Research Institute (GRI) methods). The Geosynthetics CQA Laboratory will be capable of providing test results within approximately 24 hours of receipt of samples and will maintain that standard throughout the installation.

- CQA Surveyor. The CQA Surveying will be performed under the direct supervision of a Texas licensed Professional Land Surveyor. The survey crew will be properly equipped to perform the necessary surveying activities and will consist of a qualified crew chief experienced in the provision of surveying required by this Plan and as many surveying crew members as needed to satisfactorily undertake the work.

- Project Manager. The selection of the Project Manager is the direct responsibility of the Owner. Qualifications for this position are therefore determined by the Owner independently of this Plan.

1.5 Duties of CQA Personnel

1.5.1 Overview

The personnel of each CQA Consultant (Soils and Geosynthetics) include:

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

In the remainder of this Plan, the term "CQA personnel" refers collectively to either the CQA Engineer or technicians (CQA Site Manager and CQA Monitor(s) working on site under direction of the CQA Engineer). The number of personnel required depends on the scope of the construction project and schedule. At a minimum, a CQA Engineer is required. The CQA Engineer can also fill the roles of the CQA Site Manager and CQA Monitors. In addition, the CQA Site Manager can fill the roles of Site Manager and CQA Monitor.

The duties of the CQA personnel are to execute the CQA requirements detailed throughout this Plan. Subsequently in this Plan, the roles of the Soils CQA Consultant and Geosynthetics CQA Consultant are described separately, since these roles may be filled by one or two consultants. The CQA duties are summarized below in the remainder of this section.

1.5.2 CQA Engineer(s)

The general responsibilities and duties of the Soils and Geosynthetics CQA Engineer(s) include the following:

- review relevant construction-level project plans and specifications;
- be familiar with other site-specific documentation, including bid documents, proposed layouts, soils and groundwater investigation reports if relevant, and Geosynthetics Manufacturer's and Installer's literature as relevant;
- attend appropriate project meetings (e.g., Pre-Construction Meeting, select Progress Meetings);
- administer the CQA program (i.e., assign and manage CQA personnel, check CQA field reports, and provide engineering review of CQA related issues);
- conduct periodic site visits as construction progresses to be fully knowledgeable of the construction methods and performance; as a minimum, a site visit should coincide with each significant construction element;
- review changes to the design, plans, and specifications;
- review Record Drawing(s) and related as-built information provided by the CQA Surveyor (e.g., thickness verifications, slopes, etc.); and
- oversee preparation of and sign and P.E. seal the Final CQA Report.

1.5.3 CQA Site Manager(s)

The general responsibilities and duties of the Soils and Geosynthetics CQA Site Manager(s) include the following:

- act as the on-site (resident) representative of the CQA Consultant;
- familiarize CQA Monitors with the site and the CQA requirements for the project;
- manage the daily activities of the CQA Monitors;

- attend CQA-related meetings (i.e., Pre-Construction, Progress, and Problem or Work Deficiency Meetings);
- oversee ongoing preparation of Record Drawing(s) and related as-built information provided by the CQA Surveyor (e.g., thickness verifications, slopes, etc.);
- assign locations for testing and sampling or delegate responsibility to CQA Monitors;
- verify the calibration documentation and condition of on-site CQA equipment;
- oversee collection and shipping of all laboratory test samples;
- review results of laboratory testing and make appropriate recommendations;
- review CQA Monitors' logs;
- prepare a brief daily field report and log in the daily field report any relevant observations reported by the CQA Monitors;
- designate a CQA Monitor to act on his behalf whenever he/she is absent from the site while operations are ongoing;
- report relevant observations and any unresolved deviations from the Plan to the Project Manager; and
- assist the CQA Engineer with preparation of the Final CQA Report.

In addition, the Soils CQA Site Manager:

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

In addition, the Geosynthetics CQA Site Manager:

- performs the site visit and review of manufacturing plant facilities, methods, and quality control (optional, as directed by the Owner);
- reviews all Supplier, Manufacturer, and Installer certifications and documentation and makes appropriate recommendations;
- reviews the Installer's personnel qualifications for conformance with those pre-approved for work on site; and
- notes any on-site activities that could result in damage to the geosynthetics.

1.5.4 CQA Monitor(s)

The duties of the CQA Monitors include, as assigned by the CQA Site Manager: monitoring, logging, and/or documenting appropriate operations. The duties to be performed, and operations to be monitored by the Soils CQA Monitors include:

- soils delivery, dumping, and placement;
- soils moisture content and moisture conditioning, if required;
- compaction of soils and in-situ testing of compacted density and moisture content;
- collection of samples for laboratory testing for moisture/density relationships, permeability, and other testing as outlined in the specifications;
- operations to protect completed areas before the covering materials are placed;
- measurement of loose and compacted lift thickness;
- verification of bonds between lifts;
- observation of equipment type, number of passes, and equipment contact pressure;
- examination of the soil surface for signs of excessive wetting, desiccation, or other disturbance prior to placement of any cover materials; and
- scarification, rewetting, recompaction, or proof rolling required to repair deteriorated areas.

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

- material delivery;
- unloading and on-site transport and storage;
- on-site conformance testing to verify thickness of geomembranes and geocomposites when required;
- marking samples for conformance testing;
- sampling for conformance testing by the Geosynthetics CQA Laboratory;
- all placement operations;
- condition of panels as placed;
- all joining and/or seaming operations, including the following that are specific to geomembranes:
  - trial seams;
  - seam preparation;
  - seaming;
  - nondestructive seam testing;
  - sampling for destructive testing;
  - field tensiometer testing;
  - laboratory sample marking; and
  - repair operations.

In addition to these specific duties, all CQA Monitors will take note of any on-site activities that could result in damage to the soils or geosynthetics components of the liner system and final cover system. Any observations so noted will be reported as soon as possible to the CQA Site Manager.

1.6 Scope of CQA

The scope of this Plan includes the CQA of the soil and geosynthetic components of the perimeter berm, interphase berm, liner system, final cover system, and stormwater drainage layer for the Category I Landfill. Unless otherwise noted in this Plan, full-time CQA is required for each component specified herein.

1.7 Applicable References

Organizations whose standards may be referenced in the Plan are as follows:

- ASTM - American Society for Testing and Materials; and
- GRI - Geosynthetic Research Institute.

Any reference to standards of any society, institute, association, or governmental agency will pertain to the edition in effect as of the date of this Plan, unless stated otherwise.

2. SITE AND PROJECT CONTROL

2.1 Pre-Construction Meeting

Prior to initiating construction activities at the site, a Pre-Construction Meeting will be held at the site. The meeting will be attended by the CQA Engineer(s), Soils CQA Site Manager, Geosynthetics CQA Site Manager, Earthwork Contractor, Installer(s), and Project Manager, as appropriate for the construction activity. If desired, a separate Soils Pre-Construction Meeting and Geosynthetics Pre-Construction meeting can be held, each to be attended by the appropriate parties.

The purpose of this meeting is to begin planning for coordination of tasks, to present the schedule and sequence of work, to discuss anticipated problems that might cause difficulties and delays in construction, and present the procedures for review and approval of clarifications and changes to the project documents.

The Pre-Construction Meeting should consider the following scope:

- communicate to all parties any relevant documents;
- review the project-specific Plan;
- make any appropriate modifications to the Plan;
- review critical design details of the project;
- review the responsibilities of each party;
- review lines of authority and communication;
- establish work area security and safety protocol;
- review methods for documenting and reporting, and for distributing documents and reports;
- select testing equipment and review protocols for testing and placement of soil and geosynthetics materials;
- establish protocols for handling deficiencies, repairs, and retesting;
- review the time schedule for all operations;
- establish soil stockpiling locations;
- establish rules for writing on the geomembrane, i.e., who is authorized to write, what can be written and in which color;
- outline procedures for packaging and storing archive samples;
- review panel layout and numbering systems for panels and seams;
- establish procedures for use of the extrusion welding apparatus;
- establish procedures for use of the fusion welding apparatus, if applicable;
- finalize field cutout sample sizes;
- review seam testing procedures;

- review repair procedures; and
- conduct a site tour after the meeting review the project features, clarify site conditions, and review material storage locations.

Items discussed during the Pre-Construction Meeting will be documented by a person designated at the beginning of the meeting, and the meeting minutes will be distributed to all relevant parties.

2.2 Progress Meetings

A weekly progress meeting will be held between the Soils and/or Geosynthetics CQA Site Managers, Earthwork Contractor, Installer's superintendent, Project Manager, and any other concerned parties. This meeting will discuss current progress, planned activities for the next week, and any CQA issues, concerns, new business, or revisions to the work. The meeting will be documented by a person designated at the meeting and minutes will be transmitted to affected parties. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties.

Informal daily progress meetings may be held between select CQA personnel and the Contractor and/or Installer prior to the start of work or following the completion of work. The purpose of these informal meetings is to review the previous day's activities, review the upcoming day's activities and identify any needs or potential construction problems. Major items discussed during these meetings will be documented in the CQA Site Manager’s (or designee’s) daily field reports.

2.3 Problem or Work Deficiency Meetings

A special meeting will be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting will be attended by the affected contractor(s), Project Manager, and appropriate CQA Site Manager(s). If the problem may require a design modification, the Design Engineer should also be available. The purpose of these meetings will be to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions; and
- implement an action plan to resolve the problem or deficiency.

The meeting will be documented by a person designated at the meeting and minutes will be transmitted to affected parties.

2.4 Project Control Visits

Periodically, the construction site will be visited by the CQA Engineer(s). When appropriate, the visit should be coordinated with a similar visit by the Design Engineer. Project-specific plant visits for the manufacture and fabrication of the geomembrane, as well as the other geosynthetics, are optional. These plant visits will be carried out at the discretion of the Owner, by the Owner or his designated alternate.

2.5 Drawing, Specification, and Plan Clarifications and Changes

Clarifications and/or changes to the design (drawings, specifications, and/or Plan) may be necessary during construction. In such cases, the CQA personnel will notify the CQA Engineer, who will in turn notify the Project Manager. After discussion between these parties about the need to consider a clarification or change, the CQA personnel will prepare written information describing the proposed change and rationale for the request. The Project Manager will determine whether the changes are relatively minor changes, or whether they are more substantial changes.

For minor changes to the design, the Project Manager and Design Engineer will consider the change and will then notify the CQA personnel of their acceptance or rejection of proposed change. The minor change will then be documented in the Final CQA Report (e.g., narrative description, as-built detail, etc., as appropriate). Examples of minor changes include revisions to specified test methods (e.g., ASTM, GRI) and material properties to reflect the current industry standard and state of practice.

More substantial design changes will be made only with the written agreement of the Project Manager and Design Engineer. After the change is approved, the change as implemented will be documented in the Final CQA Report (e.g., narrative description, as-built detail, etc., as appropriate).

3. STRUCTURAL FILL

3.1 Introduction

This section addresses the material specifications and applicable CQA requirements for the structural fill that will be used to construct the perimeter berm, interphase berm, prepared subgrade, and anchor trench backfill. The following topics are discussed in the remainder of this section:

- Structural Fill Material Specifications;
- Pre-Construction CQA Evaluation of Material Sources;
- Field CQA Evaluation/Monitoring During Construction;
- Field CQA Testing of Work Product;
- Deficiencies, Problems, and Repairs; and
- Structural Fill Documentation.

3.2 Structural Fill Specifications

3.2.1 Material Requirements

Structural fill will consist of relatively homogeneous, granular materials that are free of debris, foreign objects, and organics. Gravels, sands, and broken concrete meeting the material requirements for structural fill are presented in Table 1 are acceptable. All exposed reinforcing steel will be cut and removed from the broken concrete.

3.2.2 Moisture-Density Target Compaction Requirements

Each lift of structural fill will be compacted to within the required range of moisture content and density as follows:

GW, GP, SW, and SP Materials

- For perimeter berm, interphase berm, and prepared subgrade, lifts will be compacted to at least 95% of maximum dry density, as determined by modified Proctor test results (ASTM D 1557) or AASHTO T 180, Method D on the proposed material during the pre-construction testing program.

- For anchor trench backfill, lifts will be compacted to at least 90% of the modified Proctor maximum dry density, as determined by modified Proctor test results (ASTM D 1557) or AASHTO T 180, Method D on the proposed material during the pre-construction testing program.

GM, GC, SM, and SC Materials

- For perimeter berm, interphase berm, and prepared subgrade, lifts will be compacted to at least 90% of maximum dry density and -2 to +2 percentage points from optimum water content, as determined by modified Proctor test results (ASTM D 1557) or AASHTO T 180, Method D on the proposed material during the pre-construction testing program.

- For anchor trench backfill, lifts will be compacted to at least 90% of the modified Proctor maximum dry density, as determined by modified Proctor test results (ASTM D 1557) or AASHTO T 180, Method D on the proposed material during the pre-construction testing program.

3.3 Pre-Construction CQA Evaluation of Material Sources

Prior to construction of the structural fill, CQA personnel will obtain a soil sample from the proposed source(s). Each source will be evaluated for potential use as structural fill by performing the pre-construction laboratory tests presented in Table 2.

3.4 Field CQA Evaluation/Monitoring During Construction

CQA personnel will be on-site at all times when structural fill construction is ongoing so that all relevant activities can be observed and documented. CQA personnel will visually monitor and document that construction of the structural fill is in accordance with the specifications and requirements set forth previously in this Plan. These observations will include, but not be limited to:

- visual inspection of the subgrade for evidence that it is free of debris, organic matter, standing (ponded) water, and excessive moisture;

- continuous visual inspection during subgrade proof-rolling for evidence (e.g., lack of excessive pumping, rutting, deflection of subgrade surface, etc.) that the subgrade provides sufficient foundation to place and construct structural fill;

- appropriate field tests (e.g., pocket penetrometer, nuclear density tests, etc.) in suspect soil areas, as necessary;

- over-excavation of unsuitable subgrade and replacement of the unsuitable material with structural fill;

- scarifying of the subgrade surface prior to placing the first lift of structural fill (not required for anchor trench backfill);

- visual observation of the granular material for consistency of particle size distribution, appearance, moisture content, and other physical properties with the material approved during the pre-construction qualifying process;

- thickness of the loosely-placed soil lift and the compacted soil lift for evidence that the loose lift thickness is no greater than 8 inches; if the required density is being obtained, the lift thickness may be increased to 12 inches;

- type and level of compactive effort, including type and weight of compactor and number of passes;

- method of bonding lifts together;

- soil moisture conditioning as needed to adjust the in-place moisture content to within specified limits;

- areas where excess moisture or insufficient moisture may have occurred;

- preparation of the top lift of structural fill with materials free from large stone, rock, and broken concrete or other materials that significantly affect scarifying, compacting, and finishing the surface of the structural fill; and

- preparation of the top surface of structural fill used to construct the prepared subgrade (if needed) by rolling it so that it is relatively smooth and uniform and free of rocks, protrusions, or particles greater than 3/8-inch in diameter that could damage the overlying geomembrane liner and maintaining it until it is covered by the geomembrane.

3.5 Field CQA Testing of Work Product

3.5.1 Routine Field Testing

Field testing (e.g., in-situ density and moisture content testing) of structural fill will be performed by CQA personnel during construction to evaluate the Contractor's work product with respect to the requirements set forth in this Plan. The test methods and frequencies for routine CQA field testing of the structural fill are given in Table 3. Sampling and test locations will be selected by CQA personnel.

3.5.2 Special Testing

A special testing frequency will be implemented at the discretion of CQA personnel when observations indicate potential problems, or as requested by the Project Manager. Additional testing for suspected areas will be considered when:

- the fill materials differ substantially from those specified or from the materials evaluated during pre-construction testing;
- the lift thickness is greater than specified;
- the material is at improper and/or highly variable moisture content;
- fewer than the anticipated number of roller passes are made; or
- the degree of compaction is doubtful.

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

- adverse weather conditions;
- breakdown of equipment;
- at the start and finish of grading;
- if the material fails to meet specification requirements;
- the work area is reduced; or
- as otherwise requested by the Project Manager.

3.5.3 Perforations

Perforations are holes in the structural fill that must be filled, and may include, but are not limited to, the following:

- survey stakes;
- nuclear density test probe locations; and
- sand cone test locations or other density verification test methods.

All perforations of the structural fill will be backfilled by CQA personnel with structural fill and compacted in-place with a tamping rod. CQA personnel will also verify that perforations made by the Contractor are backfilled by the Contractor.

3.6 Deficiencies, Problems, and Repairs

If a deficiency or noncompliance with the structural fill is discovered, CQA personnel will promptly evaluate the extent and nature of the defect. The extent of the deficient material or constructed area will be evaluated by additional tests, observations, a review of records, or other means deemed appropriate.

Sections of structural fill that do not pass the required field tests will be reworked as appropriate (e.g., water added, additional compaction passes, etc.) and retested until the section in question does pass. If a failure occurs, the failing area will be defined. This will be accomplished by performing additional tests between the failed test and the nearest adjacent passing test locations. If those additional tests pass, then the area between the failed test and the additional passing tests must be reworked and retested until passing. If the additional tests fail, then additional tests must be performed halfway between the initial additional tests and the adjacent passing tests to further define the failing area. This procedure must be repeated until the failing area is defined, reworked, and retested with passing results. All field moisture-density results will be reported whether they indicate passing or failing values. The Project Manager will be made aware of any significant recurring deficiencies, problems, or non-conformance with the specifications.

3.7 Structural Fill Documentation

The Soils CQA Consultant will document that the CQA requirements associated with the structural fill have been addressed and satisfied. This includes the following required types of documentation:

- daily field report;
- photographic log; and
- structural fill data sheets.

Details of the required contents of each of the above types of documentation are provided in Section 12 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes structural fill documentation will be prepared by the Soils CQA Consultant. Contents of the Final CQA Report are presented in Section 12.6 of this Plan.

TABLE 1
MATERIAL SPECIFICATIONS FOR STRUCTURAL FILL

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD
Unified Soil Classification	Classification	--	GW, GP, GM, GC, SW, SP, SM, SC	ASTM D 2487
Maximum Particle Size	Maximum	Inch	3 (perimeter and interphase berms) 3/8 (prepared subgrade, anchor trench backfill)	ASTM D 422 or ASTM C 136
Percent Passing #200 Sieve	Maximum	Percent	30	ASTM D 422 or ASTM D 1140
Liquid Limit (LL)	Maximum	Percent	45	ASTM D 4318
Plasticity Index (PI)	Maximum	Percent	15	
In-Situ As-Compacted Moisture Content and Dry Density	Range	Percent	See Section 3.2.2	ASTM D 1557 or AASHTO T 180, Method D[(1)]

Note:
(1) Use ASTM D 1557 for materials with 30% or less particles by weight retained on the ¾-inch sieve. For materials with more than 30% particles retained on the ¾-inch sieve, use AASHTO T 180, Method D corrected with AASHTO T 224 for the maximum density determinations.

TABLE 2
PRE-CONSTRUCTION TESTING REQUIREMENTS FOR STRUCTURAL FILL

TEST	METHOD	MINIMUM FREQUENCY OF TESTING
Particle Size Analysis (sieve)	ASTM D 422 or ASTM C 136	1 test per 2,500 yd^3 or change of material
Atterberg Limits	ASTM D 4318	1 test per 2,500 yd^3 or change of material
Unified Soil Classification	ASTM D 2487	1 test per 2,500 yd^3 or change of material
Natural (as-received) Moisture Content	ASTM D 2216	1 test per 2,500 yd^3 or change of material
Moisture Content and Dry Density Relationship	ASTM D 1557 or AASHTO T 180, Method D(1)	1 test per 2,500 yd^3 or change of material

Note:
(1) Use ASTM D 1557 for materials with 30% or less particles by weight retained on the ¾-inch sieve. For materials with more than 30% particles retained on the ¾-inch sieve, use AASHTO T 180, Method D corrected with AASHTO T 224 for the maximum density determinations.

TABLE 3
FIELD CQA TESTING REQUIREMENTS FOR STRUCTURAL FILL

TEST	METHOD	MINIMUM FREQUENCY OF TESTING
In-Place Density and In-Place Moisture Content (Nuclear Gauge)	ASTM D 2922 ASTM D 3017	1 per 1,000 yd^3 of placed fill
Oven Moisture Content	ASTM D 2216	As necessary to verify nuclear gauge density results
In-Place Density (Sand Cone, Rubber Balloon, or Drive Cylinder Method)	ASTM D 1556 or ASTM D 2167 or ASTM 2937	As necessary to verify nuclear gauge density results

4. GRAVEL

4.1 Introduction

This section addresses the material specifications and applicable CQA requirements for the gravel component of the leachate collection system. The following topics are discussed in the remainder of this section:

- Gravel Material Specifications;
- Pre-Construction CQA Evaluation of Material Sources;
- Field CQA Evaluation/Monitoring During Construction;
- Deficiencies, Problems, and Repairs; and
- Gravel Documentation.

4.2 Gravel Specifications

Gravel will meet the material requirements presented in Table 4.

4.3 Pre-Construction CQA Evaluation of Material Sources

Prior to installation of the gravel, CQA personnel will obtain gravel samples from the proposed source(s)/supplier(s). Each source will be evaluated for potential use as gravel by performing the pre-construction laboratory tests presented in Table 5.

4.4 Field CQA Evaluation/Monitoring During Construction

CQA personnel will be on-site at all times when gravel construction is ongoing so that all relevant activities can be observed and documented. CQA personnel will visually monitor and document that construction of the gravel is in accordance with the specifications and requirements set forth in this Plan. These observations will include, but not be limited to:

- visual observation of the granular material for consistency of particle size distribution, shape, color, and appearance with the material approved during the pre-construction qualifying process;

- monitoring the thickness and dimensions of the placed material for compliance with the drawings and engineering details; and

- documenting the construction equipment used during placement of the material and verifying that only low-ground pressure equipment traverses over geosynthetics-lined areas until the specified material thickness above the geosynthetics is attained; and

- verifying that the materials are placed in a manner that minimizes excessive wrinkles and tensile stresses in underlying geosynthetics.

4.5 Deficiencies, Problems, and Repairs

If a deficiency or noncompliance with the gravel is discovered, CQA personnel will promptly evaluate the extent and nature of the defect. The extent of the deficient material will be evaluated by additional tests, observations, a review of records, or other means deemed appropriate. The deficient material will be removed and replaced with material meeting the specifications. The Project Manager will be made aware of any significant recurring deficiencies, problems, or non-conformance with the specifications.

4.6 Gravel Documentation

The Soils CQA Consultant will document that the CQA requirements associated with the gravel have been addressed and satisfied. This includes the following required types of documentation:

- daily field report;
- photographic log; and
- gravel laboratory test results.

Details of the required contents of each of the above types of documentation are provided in Section 12 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes gravel documentation will be prepared by the Soils CQA Consultant. Contents of the Final CQA Report are presented in Section 12.6 of this Plan.

TABLE 4
MATERIAL SPECIFICATIONS FOR GRAVEL

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD
Maximum Particle Size	Maximum	Inch	2	ASTM D 422 or ASTM C 136
Percent Passing 3/8 Inch Sieve	Maximum	Percent	5	
Percent Passing #200 Sieve	Maximum	Percent	3	

TABLE 5
PRE-CONSTRUCTION TESTING REQUIREMENTS FOR GRAVEL

TEST	METHOD	MINIMUM FREQUENCY OF TESTING
Particle Size Analysis (sieve)	ASTM D 422 or ASTM C 136	1 test per 2,500 yd^3 or change of material

5. PROTECTIVE COVER

5.1 Introduction

This section addresses the material specifications and applicable CQA requirements for the protective cover that will be placed over the geomembrane and geocomposite drainage layer components of the liner system. The following topics are discussed in the remainder of this section:

- Protective Cover Material Specifications;
- Pre-Construction CQA Evaluation of Material Sources;
- Field CQA Evaluation/Monitoring During Construction;
- Deficiencies, Problems, and Repairs; and
- Protective Cover Documentation.

5.2 Protective Cover Specifications

Protective cover will consist of fine-grained to coarse-grained soils or impacted granular materials meeting the material requirements presented in Table 6. Protective cover placed directly over the geomembrane on the side slope should have relatively smooth (rounded or sub-rounded) particles without sharp edges, based on visual inspection.

5.3 Pre-Construction CQA Evaluation of Material Sources

Prior to construction of the protective cover, CQA personnel will obtain protective cover samples from the proposed source(s). Each source will be evaluated for potential use as protective cover by performing the pre-construction laboratory tests presented in Table 7.

5.4 Field CQA Evaluation/Monitoring During Construction

Protective cover will be placed over the liner system on the floor of the landfill during landfill construction and may be advanced incrementally up the side slope of the liner system by the Contractor as the as waste is disposed. The protective cover will be placed as expeditiously as practical to protect the liner system geosynthetics.

CQA personnel will be on-site at all times when protective cover construction is ongoing, so that all relevant activities can be observed and documented. CQA personnel will visually monitor and document that construction of the protective cover is in accordance with the specifications and requirements set forth in this Plan. These observations will include, but not be limited to:

- verifying that material placed over the geosynthetic components does not contain large particles that could damage the geosynthetics and that any identified oversized particles are removed;

- monitoring the thickness and dimensions of the placed material for compliance with the drawings and engineering details; and

- documenting the construction equipment used during placement of the materials and verifying that only low-ground pressure equipment traverses over geosynthetic-lined areas until sufficient soil thickness above the geosynthetics is attained; and

- verifying that the materials are placed in a manner that minimizes excessive wrinkles and tensile stresses in underlying geosynthetics.

5.5 Deficiencies, Problems, and Repairs

If a deficiency or noncompliance with the protective cover is discovered, CQA personnel will promptly evaluate the extent and nature of the defect. The extent of the deficient material will be evaluated by additional tests, observations, a review of records, or other means deemed appropriate. The deficient material will be removed and replaced with material meeting the specifications. The Project Manager will be made aware of any significant recurring deficiencies, problems, or non-conformance with the specifications.

5.6 Protective Cover Documentation

The Soils CQA Consultant will document that the CQA requirements associated with the protective cover have been addressed and satisfied. This includes the following required types of documentation:

- daily field report;
- photographic log; and
- protective cover laboratory test results.

Details of the required contents of each of the above types of documentation are provided in Section 12 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes protective cover documentation will be prepared by the Soils CQA Consultant. Contents of the Final CQA Report are presented in Section 12.6 of this Plan.

TABLE 6
MATERIAL SPECIFICATIONS FOR PROTECTIVE COVER

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD
Maximum Particle Size	Maximum	Inch	3/8 (0-12 inches above geosynthetics, side slope) 2 (0-12 inches above geosynthetics, floor) 6 (12-24 inches above geosynthetics)	ASTM D 422 or ASTM C 136

TABLE 7
PRE-CONSTRUCTION TESTING REQUIREMENTS FOR PROTECTIVE COVER

TEST	METHOD	MINIMUM FREQUENCY OF TESTING
Particle Size Analysis (sieve)	ASTM D 422 or ASTM C 136	1 test per 2,500 yd^3 or change of material

6. FINAL COVER SYSTEM

6.1 Introduction

This section addresses the material specifications and applicable CQA requirements for the final cover system. The final cover system consists of a 1-foot thick soil/gravel surface layer overlying a 2-foot thick soil/slag isolation layer. The following topics are discussed in the remainder of this section:

- Final Cover Material Specifications;
- Pre-Construction CQA Evaluation of Material Sources;
- Field CQA Evaluation/Monitoring During Construction; and
- Deficiencies, Problems, and Repairs; and
- Final Cover Documentation.

6.2 Final Cover Specifications

Final cover materials will meet the requirements presented in Table 8. The slag in the isolation layer may be replaced by on-site granular materials (i.e., gravel, cobbles).

The surface layer of the final cover system will be permanently seeded with a mixture of native and/or naturalized species recommended for the local climatic conditions and soil type. The goal of the vegetation program is to develop vegetation over 10% of the final cover system. Seeding will be conducted at the time period appropriate for vegetation establishment. Mulch may be added to the surface layer material to encourage initial vegetative growth.

6.3 Pre-Construction CQA Evaluation of Material Sources

Prior to construction of the final cover, CQA personnel will obtain final cover samples from the proposed source(s). Each source will be evaluated for potential use as final cover by performing the pre-construction laboratory tests presented in Table 9.

6.4 Field CQA Evaluation/Monitoring During Construction

CQA personnel will be on-site when final cover system construction is ongoing, so that all relevant activities can be observed and documented. CQA personnel will visually monitor and document that construction of the final cover system is in accordance with the specifications and requirements set forth in this Plan. These observations will include, but not be limited to:

- visual observation of the material for consistency of particle size distribution, appearance, moisture content, and other physical properties with the material approved during the pre-construction qualifying process; and

- documenting the construction equipment used during placement of the materials and monitoring the thickness of compacted lifts.

6.5 Deficiencies, Problems, and Repairs

If a deficiency or noncompliance with the final cover is discovered, CQA personnel will promptly evaluate the extent and nature of the defect. The extent of the deficient material will be evaluated by additional tests, observations, a review of records, or other means deemed appropriate. The deficient material will be removed and replaced with material meeting the specifications. The Project Manager will be made aware of any significant recurring deficiencies, problems, or non-conformance with the specifications.

6.6 Final Cover Documentation

The Soils CQA Consultant will document that the CQA requirements associated with the final cover system have been addressed and satisfied. This includes the following required types of documentation:

- daily field report;
- photographic log; and
- final cover laboratory data sheets.

Details of the required contents of each of the above types of documentation are provided in Section 12 of this Plan. Upon completion of all required final cover system construction, a Final CQA Report that includes final cover system documentation will be prepared by the Soils CQA Consultant. Contents of the Final CQA Report are presented in Section 12.6 of this Plan.

TABLE 8
MATERIAL SPECIFICATIONS FOR FINAL COVER

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD
Unified Soil Classification	Classification	--	Well graded GM, GC, SM, or SC	ASTM D 2487
Maximum Particle Size	Maximum	Inch	6	ASTM D 422 or ASTM C 136
Percent Particles Coarser than 0.6 Inch (Surface Layer)	Minimum	Percent	25	ASTM D 422 or ASTM C 136

TABLE 9
PRE-CONSTRUCTION TESTING REQUIREMENTS FOR FINAL COVER

TEST	METHOD	MINIMUM FREQUENCY OF TESTING
Particle Size Analysis (sieve)	ASTM D 422 or ASTM C 136	1 test per 5,000 yd^3 or change of material
Atterberg Limits	ASTM D 4318	1 test per 5,000 yd^3 or change of material
Unified Soil Classification	ASTM D 2487	1 test per 5,000 yd^3 or change of material

7. GEOMEMBRANES

7.1 Introduction

This section addresses the material specifications and CQA requirements for the geomembrane component of the liner system (40-mil linear low density polyethylene (LLDPE) or 60-mil high-density polyethylene (HDPE)). The following topics are discussed in the remainder of this section:

- Geomembrane Material Specifications;
- Pre-Installation CQA Evaluation of Material Sources;
- Material CQA Conformance Testing;
- Field CQA Evaluation/Monitoring During Construction;
- Field CQA Testing of Work Product;
- Deficiencies, Problems, and Repairs; and
- Geomembrane Documentation.

7.2 Geomembrane Specifications

7.2.1 Geomembrane Material Requirements

The LLDPE geomembrane resin properties will meet the requirements set forth in the GRI Test Method GM-17, including a resin density (ASTM D 1505 or ASTM D 792, Method B) generally in the range of 0.926 g/cc or lower and a melt flow index (ASTM D 1238) of less than 1.0 g/10 min. Test standards for measuring resin density and melt flow index are given in GRI GM-17.

The HDPE geomembrane resin properties will meet the requirements set forth in the GRI Test Method GM-13, including a resin density (ASTM D 1505 or ASTM D 792, Method B) generally in the range of 0.932 g/cc or higher and a melt flow index (ASTM D 1238) of less than 1.0 g/10 min.

Material requirements for the 40-mil HDPE geomembrane liner and the 60-mil HDPE textured geomembrane liner are presented in Tables 10a and 10b, respectively.

Interface shear strength requirements for the geomembrane and adjacent materials are presented in Table 11.

Seam strength requirements for the constructed geomembrane are presented in Table 12.

7.2.2 Geomembrane MQC

The Geomembrane Manufacturer will implement a Manufacturer's quality control (MQC) program for materials related to geomembrane manufacturing, which will include MQC sampling and testing to demonstrate the geomembrane quality and suitability for use. The required MQC tests, methods, and frequencies are presented in Tables 10a and 10b.

7.3 Pre-Installation Evaluation of Material Sources

Prior to installation of any geomembrane, the Geomembrane Manufacturer will provide CQA personnel with the required MQC information including:

- Written certification, signed by a responsible party employed by the Manufacturer. The Manufacturer will guarantee the specified roll values are met for physical, mechanical, and environmental properties corresponding to the test procedures for the required geomembrane properties listed in the specifications.

- MQC certificates with test results signed by a responsible party employed by the Manufacturer. Each quality control certificate will include date, roll identification numbers, testing procedures, and results of quality control tests performed using the methods specified and at the required frequencies given in the specifications.

- Certification statement from the Resin Supplier stating that the resin properties are met for the specified test procedures and properties listed in the specifications.

- Copies of dated quality control certificates issued by the Resin Supplier for the resin density and melt flow index at the minimum frequency of one per each resin lot for the resin used in geomembrane production.

CQA personnel will examine all Manufacturer's certifications to verify that the property values listed on the certifications meet or exceed the specifications and that proper and complete documentation has been provided for all geomembrane to be used at the site. CQA personnel will report any deviations from the above requirements to the Installer and Project Manager prior to installation of the geomembrane. Any sample that does not comply with the requirements will result in rejection of the roll from which the sample was obtained and in additional testing of rolls from the same lot or batch until a pattern of acceptable test results is established.

7.4 Material CQA Conformance Testing

Conformance testing requirements for the geomembrane are presented in Table 13. Conformance testing will be performed by an independent, third-party laboratory. Conformance sampling may be performed either at the manufacturing plant or upon delivery of rolls to the site, as requested

by the Project Manager. Conformance samples will be taken across the entire roll width. All conformance test results will be reviewed by CQA personnel prior to deployment of the material. Any nonconformance will be immediately reported to the Project Manager. When a sample fails a conformance test, the material from the lot represented by the failing test should be considered out-of-specification and rejected.

Additional conformance samples may be taken to isolate the portion of the lot not meeting the specifications. To isolate the out-of-specification material, two additional conformance samples should be taken from the closest numerical roll numbers to the failing sample. If both samples pass, only the initial failed roll will be rejected. If any one of the additional tests fails, then the entire lot will be rejected or the procedure will be repeated with additional tests to further bracket the failing rolls within the lot.

7.5 Field CQA Evaluation/Monitoring During Installation

7.5.1 General

Prior to construction, CQA personnel and the Project Manager will review the proposed panel layout plan prepared by the Installer. The purpose of the review is to become familiar with the proposed orientation of the panels, the general installation sequencing, and the quantities of materials needed for the job, and to assess whether the proposed installation layout complies with the specifications.

7.5.2 Transportation, Handling, and Storage

The geomembrane will be shipped in rolls with weather-resistant opaque wrappings, and each roll will be labeled with the Manufacturer's name and product identification. During unloading and storage, geomembrane will be handled to minimize damage. The geomembrane will also be stored in a manner that minimizes damage. CQA personnel will inspect the geomembrane rolls prior to use. Any damaged rolls will be repaired or replaced by the Installer.

7.5.3 Condition of Geomembrane Subgrade

Prior to deployment of geomembrane, CQA personnel will observe the work area and verify that the top of the subgrade surface has been fully approved. The subgrade will be relatively smooth and uniform and free of irregularities, dimples, loose soil, or abrupt changes in grade. It is the responsibility of CQA personnel to provide subgrade acceptance forms to the Installer and verify that they have been signed by CQA personnel and the Installer prior to deployment.

7.5.4 Field Panel Identification

Each field panel will be given an identification code, which will be used for CQA records. CQA personnel will monitor field panel placement and will record the field panel identification code,

Manufacturer's roll number, location, date of installation, and dimensions of each field panel. CQA personnel will label each panel in the field with its panel identification number using a semi-permanent marker (e.g., paint stick).

7.5.5 Geomembrane Deployment

CQA personnel will monitor geomembrane deployment and verify compliance with the following:

- ambient temperatures are within the required limits and wind is not excessive;
- any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;
- the surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement, without excessive moisture (e.g., dew, ponding, etc.);
- anchor trench is of the proper dimensions and in suitable condition, without loose soils underlying the geomembrane;
- personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;
- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;
- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);
- adequate temporary loading and/or anchoring (e.g., sand bags) has been placed to prevent uplift by wind; and
- direct contact with the geomembrane is minimized in areas where excessive traffic may be expected (e.g., the geomembrane is protected by geosynthetics, extra geomembrane, or other suitable materials).

CQA personnel will observe the geomembrane panels after placement and prior to seaming for evidence of damage and will advise the Installer which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked, and their removal from the work area will be recorded by CQA personnel.

7.5.6 Field Panel Seaming

7.5.6.1 Panel Layout

Seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 feet beyond the toe of the slope or areas of potential stress concentrations, unless otherwise authorized by the CQA Engineer. A seam numbering system compatible with the field panel identification numbering system will be utilized.

7.5.6.2 Seaming Equipment and Products

Extrusion Weld Process

CQA personnel will perform the following activities during the extrusion welding process:

- verify and document that the extrusion-welding apparatus is permanently marked with an identification number;
- verify that the extrusion-welding apparatus is equipped with gauges giving the temperature in the apparatus and at the nozzle;
- verify that the extrudate is comprised of the same resin as the geomembrane sheeting;
- monitor extrudate temperatures, ambient temperatures, and geomembrane sheet temperatures at appropriate intervals;
- verify that a suitable number of spare operable seaming apparatus are maintained on site;
- verify that the extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;
- confirm that the electric generator is placed on a smooth base such that no damage occurs to the geomembrane; and
- confirm that a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage.

Fusion Process

CQA personnel will perform the following activities during the fusion welding process:

- verify and document that the fusion-welding apparatus is a self-propelled device and that it is permanently marked with an identification number;
- verify that the fusion-welding apparatus is equipped with gauges giving the applicable temperatures and welding speed;
- verify that a suitable number of spare operable seaming apparatus are maintained on site;
- confirm that the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;
- confirm that, for cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to welding;
- verify that a smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and
- verify that a movable protective layer is used, as necessary, directly below each overlap of geomembrane that is to be seamed to prevent build-up of moisture between the sheets.

7.5.6.3 Seam Preparation

CQA personnel will monitor that:

- weather conditions for seaming are within the limits required by the specifications, unless authorized by the CQA Engineer;
- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
- seams are overlapped a minimum of 3 inches or as recommended by the Manufacturer;
- if seam overlap grinding is required, the process is completed according to the Manufacturer's instructions and/or the specifications, whichever is the more stringent, prior to the seaming operation, and in a way that does not damage the geomembrane;
- the grind depth will not exceed 10 percent of the geomembrane thickness;
- grinding marks will not appear beyond the extrudate after it is placed; and
- seams are aligned with the fewest possible number of wrinkles and “fishmouths”.

7.5.6.4 Overlapping and Temporary Bonding

CQA personnel will monitor that:

- the panels of geomembrane have a finished overlap of a minimum of 3 inches (or as otherwise recommended by the Manufacturer) for both extrusion and fusion welding, but in any event sufficient overlap will be provided to allow peel tests to be performed on the seam;

- no solvent or adhesive is used; and

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

7.5.7 Material Placement Over Geomembrane

The Installer and Contractor will take necessary precautions to prevent damage to the geomembrane during placement of overlying materials. Unapproved equipment will not be operated directly on the geomembrane. Equipment or vehicles will not be operated above the geosynthetics unless the equipment or vehicles meets the following ground pressure requirements and the corresponding minimum thickness of soil is present overlying the geosynthetics.

Allowable Equipment Ground Pressure (psi)	Minimum Thickness of Soil Overlying Geosynthetics (in.)
<5	12
<10	18
<20	24
>20	36

7.6 Field CQA Testing of Work Product

7.6.1 Trial Seams

Trial seam testing will be performed by the Installer. CQA personnel will observe and document the Installer's trial seam testing procedures and verify that they are in accordance with the specifications. CQA personnel will document identification numbers of trial seam samples and record results. Each sample will also be marked with the date, time, machine temperature(s), setting(s), number of seaming unit, and name of seaming technician.

7.6.2 Nondestructive Seam Testing

Nondestructive field seam testing will be performed on all seams by the Installer to check the continuity of seams. During the Installer's nondestructive testing of field seams, CQA personnel will confirm that seams are tested over their full length using either the vacuum test (ASTM D 5641) for extrusion seams or the air pressure test (ASTM D 5820) for double fusion seams. CQA personnel will also continuously monitor nondestructive testing and document the results, including at a minimum the following information:

- test location;
- date;
- test unit number;
- name of tester; and
- results of all testing.

CQA personnel will notify the Installer of any required repairs. Any required seam repairs identified as a result of failed nondestructive seam testing will be made by the Installer in accordance with the specifications, and CQA personnel will:

- observe the repair procedures;
- observe the retesting procedures; and
- document the results with the same information as above for the initial test.

All seams which cannot be nondestructively tested will be overlain (capped) with the same synthetic liner.

7.6.3 Destructive Testing

7.6.3.1 Location and Frequency

CQA personnel will select all destructive seam test sample locations in order to accomplish the sampling and testing frequencies given in Table 12. Sample locations will be established by CQA personnel according to the guidelines given below.

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

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

7.6.3.2 Sampling Procedures

The Installer will cut the destructive samples at the locations designated by CQA personnel, under observation of the CQA personnel when possible. CQA personnel will mark each sample accordingly and record the sample location. At a given sampling location, two types of samples will be taken: (i) field test samples; and (ii) laboratory test samples. A minimum of two field samples (i.e., test strips) should be taken for field testing. Each of these test strips should typically be 1 inch wide by 12 inches long, with the seam centered parallel to the width. The distance between these two specimens should typically be 42 inches. If both specimens pass the field test described in this Section, a full laboratory destructive sample will be taken for testing by the independent, third-party CQA Geosynthetics Testing Laboratory, as follows:

- The full destructive sample should be located between the two field test strips. The sample should typically be 12 inches wide by 42 inches long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:
  - one 12 inch by 12 inch portion will be retained by the Installer;
  - one 12 inch by 12 inch portion will be archived by CQA personnel; and
  - one 12 inch by 18 inch portion will be forwarded immediately by CQA personnel to the CQA Geosynthetics Testing Laboratory.

All holes in the geomembrane resulting from destructive seam test sampling will be immediately repaired by the Installer in accordance with repair procedures described in the specifications. The continuity of the new seams in the repaired area will be nondestructively tested.

7.6.3.3 Field Testing

The test strips will be tested in the field by the Installer, using a gauged tensiometer. CQA personnel will observe the field tests and mark all samples and portions of samples with their test number. CQA personnel will also document using the appropriate standardized field forms: the date, number of seaming unit, seaming technician identification, destructive sampling, and pass or fail description.

7.6.3.4 Laboratory Testing

Destructive test samples will be tested by the independent, third-party Geosynthetics Testing Laboratory. The methods are given in Table 12. Results will be reviewed by CQA personnel as soon as they become available. The CQA Engineer and Project Manager will be notified of any inconsistencies or nonconformances.

7.6.3.5 Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test was conducted in the field or by the Geosynthetics Testing Laboratory. CQA personnel will monitor that the Installer follows one of two options or between points defined by CQA personnel to represent conditions of the failed seam (e.g., the extent of seams between passing test locations):

- The Installer may reconstruct the entire seams (e.g., remove the old seams and re-seam) between any two passed destructive test locations.

- The Installer may trace the welding path to an intermediate location a minimum of 10 feet from the point of the failed test in each direction and take a small sample for an additional field testing in accordance with the destructive test procedure at each location. If these additional isolation samples pass the field test, then full laboratory samples are taken at both locations. If these laboratory samples meet the specified strength criteria, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

In all cases, failed seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken or the entire seam is reconstructed and retested. In cases exceeding 150 feet of reconstructed seam, a sample taken from the zone in which the seam has been reconstructed must pass destructive testing. Repairs will be made in accordance with this Section. CQA personnel will document all actions taken in conjunction with destructive test failures.

7.7 Deficiencies, Problems, and Repairs

7.7.1 Inspection for Defects

All seams and non-seam areas of the geomembrane will be examined by CQA personnel for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane should be clean at the time of examination.

7.7.2 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, must be repaired by the Installer in accordance with the specifications. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be agreed upon between the Installer, the CQA Engineer, and the Project Manager and will be documented in the final report.

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

- surfaces of the geomembrane which are to be repaired will be abraded no more than one hour prior to the repair;
- all surfaces must be clean and dry at the time of the repair;
- all seaming equipment used in repairing procedures must be approved;
- the repair procedures, materials, and techniques are those approved by CQA personnel in advance of the specific repair;
- patches or caps should extend at least 6 inches beyond the edge of the defect, and all corners of patches should be rounded with a radius of at least 3 inches; and
- the geomembrane below large caps should be appropriately cut to avoid water or gas collection between the two sheets.

7.7.3 Verification of Repairs

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

7.8 Geomembrane Documentation

The Geosynthetics CQA Consultant will document that the CQA requirements associated with the geomembrane have been addressed and satisfied. This includes the following required types of documentation:

- daily field report;
- photographic log; and
- geomembrane data sheets.

Details of the required contents of each of the above types of documentation are provided in Section 12 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes geomembrane documentation will be prepared by the Geosynthetics CQA Consultant. Contents of the Final CQA Report are presented in Section 12.6 of this Plan.

TABLE 10a
MATERIAL SPECIFICATIONS FOR TEXTURED LLDPE GEOMEMBRANES

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD	MQC TESTING FREQUENCY (Minimum)
Thickness: Nominal	min. avg.	mil	40(1)	ASTM D 5994	per roll
8 out of 10 values must exceed		mil	36		
all 10 values must exceed		mil	34		
Asperity Height(2)	min. avg.	mil	10	ASTM D 7466	every 2nd roll(3)
Density	min. avg.	g/cc	0.939	ASTM D 1505 ASTM D 792	200,000 lb
Tensile Properties (each direction)	min. avg.			ASTM D 6693 Type IV	20,000 lb
Break Strength		lb/in.	60		
Break Elongation		percent	250		
2% Modulus	maximum	lb/in.	2400	ASTM D 5323	per formulation
Tear Resistance	min. avg.	lb	22	ASTM D 1004	45,000 lb
Puncture Resistance	min. avg.	lb	44	ASTM D 4833	45,000 lb
Axi-Symmetric Break Resistance Strain	minimum	percent	30	ASTM D 5617	per formulation
Carbon Black Content	range	percent	2.0 to 3.0	ASTM D 4218(4)	20,000 lb
Carbon Black Dispersion		cat.	note(5)	ASTM D 5596	45,000 lb
Oxidative Induction Time (OIT)	min. avg.				200,000 lb
Standard OIT; or		minutes	100	ASTM D 3895	
High Pressure OIT		minutes	400	ASTM D 5885	
Oven Aging at 85°C and 90 days	min. avg.			ASTM D 5721	per formulation
Standard OIT; or		% ret.	35	ASTM D 3895	
High Pressure OIT		% ret.	60	ASTM D 5885	
UV Resistance at cycle of 20 hr UV at 75°C then 4 hr condensation at 60°C	min. avg.	% ret.	35	ASTM D 5885	per formulation
High Pressure OIT at 1600 hrs					

Notes:

(1) The average of the 10 readings shall meet or exceed the nominal specified thickness of 40 mils.

(2) Of 10 readings, 8 of 10 must be > 7 mils and lowest individual reading must be > 5 mils.

(3) Alternate the measurement side for double-sided textured sheet.

(4) Other methods are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(5) Carbon black dispersion for 10 different views shall have 9 (min) in Categories 1 or 2 and 1 (max) in Category 3.

(6) This specification is based on the Geosynthetic Research Institute (GRI) GM-17 Specification, currently the industry standard. Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for 40 mil textured LLDPE geomembranes.

TABLE 10b
MATERIAL SPECIFICATIONS FOR TEXTURED HDPE GEOMEMBRANES

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD	MQC TESTING FREQUENCY (Minimum)
Thickness: Nominal	min. avg.	mil	60(1)	ASTM D 5994	per roll
8 out of 10 values must exceed		mil	54		
all 10 values must exceed		mil	51		
Asperity Height(2)	min. avg.	mil	10	ASTM D 7466	every 2nd roll(3)
Density	min. avg.	g/cc	0.940	ASTM D 1505 ASTM D 792	200,000 lb
Tensile Properties (each direction)	min. avg.			ASTM D 6693 Type IV	20,000 lb
Yield Strength		lb/in.	126		
Break Strength		lb/in.	90		
Yield Elongation		percent	12		
Break Elongation		percent	100		
Tear Resistance	min. avg.	lb	42	ASTM D 1004	45,000 lb
Puncture Resistance	min. avg.	lb	90	ASTM D 4833	45,000 lb
Stress Crack Resistance(4)	minimum	hours	300	ASTM D 5397 (App.)	per GRI GM-10
Carbon Black Content	range	percent	2.0 to 3.0	ASTM D 4218(5)	20,000 lb
Carbon Black Dispersion		cat.	note(6)	ASTM D 5596	45,000 lb
Oxidative Induction Time (OIT)	min. avg.				200,000 lb
Standard OIT; or		minutes	100	ASTM D 3895	
High Pressure OIT		minutes	400	ASTM D 5885	
Oven Aging at 85°C and 90 days	min. avg.			ASTM D 5721	per formulation
Standard OIT; or		% ret.	55	ASTM D 3895	
High Pressure OIT		% ret.	80	ASTM D 5885	
UV Resistance at cycle of 20 hr UV at 75°C then 4 hr condensation at 60°C	min. avg.	% ret.	50	ASTM D 5885	per formulation
High Pressure OIT at 1600 hrs					

Notes:

(1) The average of the 10 readings must meet or exceed the nominal specified thickness of 60 mils.

(2) Of 10 readings, 8 of 10 must be > 7 mils and lowest individual reading must be > 5 mils.

(3) Alternate the measurement side for double-sided textured sheet.

(4) Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation.

(5) Other methods are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(6) Carbon black dispersion for 10 different views will have 9 (min) in Categories 1 or 2 and 1 (max) in Category 3.

(7) This specification is based on the Geosynthetic Research Institute (GRI) GM-13 Specification, currently the industry standard. Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for 60 mil textured HDPE geomembranes.

TABLE 11
MATERIAL SPECIFICATIONS FOR
GEOMEMBRANE LINER INTERFACE SHEAR STRENGTHS

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD	CQA TESTING FREQUENCY (Minimum)
Interface Shear Strength (geomembrane to geosynthetic clay liner)	Minimum	psf	Failure Envelope(1)	ASTM D 5321(1)	Note 1
Interface Shear Strength (geomembrane to geocomposite)	Minimum	psf	Failure Envelope(1)	ASTM D 5321(1)	Note 1

Notes:

(1) Interface shear strength testing will be performed by a qualified, independent third-party geosynthetics testing laboratory on the geosynthetic materials intended for use as the liner system floor prior to shipping. Interfaces identified above will have effective-stress interface strengths that meet or exceed the following:

Normal Stress (psf)	Large-Displacement Effective-Stress Interface Strength	
	Shear Strength (psf)	Equivalent Secant Friction Angle (°)
8000	1950	13.7

Interface shear tests will be performed at the normal stress indicated above, using fresh specimens for each test configuration. The adjacent interface may be tested in one test configuration (e.g., geocomposite to geomembrane to geosynthetic clay liner). The geosynthetic clay liner will be tested in a hydrated condition.

Passing interface strength results for a particular interface are applicable from project-to-project at the site (e.g., for subsequent cell construction, next liner phases, etc.) and testing need not be repeated, provided that the geosynthetic type and soil source/properties proposed for use remains representative of those tested.

TABLE 12
WELDED SEAM SPECIFICATIONS FOR GEOMEMBRANES

PROPERTY	QUALIFIER	UNITS	VALUES[3, 4]		TEST METHOD[5]	CQA TESTING FREQUENCY
			40 mil LLDPE	60 mil HDPE		
Fusion Seams						
Air Test	-	psi	30 psi pressure, 5 minute hold, pressure must not drop by 3 psi		ASTM D 5820	Observe Installer testing 100% of fusion seams
Shear Strength	Minimum	lb/in.	60	120	GRI GM-19 (using ASTM D 6392)	(1) and (2)
Shear Elongation at Break	Minimum	%	50	50		
Peel Strength	Minimum	lb/in.	50	91		
Peel Separation	Minimum	%	25	25		
Extrusion Seams						
Vacuum Test	-	psi	5 psi vacuum, 10 second hold		ASTM D 5641	Observe Installer testing 100% of extrusion seams
Shear Strength	Minimum	lb/in.	60	120	GRI GM-19 (using ASTM D 6392)	(1) and (2)
Shear Elongation at Break	Minimum	%	50	50		
Peel Strength	Minimum	lb/in.	44	78		
Peel Separation	Minimum	%	25	25		

Notes:

(1) Trial seams will be made at start of each day and at re-start after breaks, shift change, etc. Elongation/separation measurements may be eliminated for field testing.

(2) Destructive tests will be taken at a minimum frequency of one per 500 linear feet of welded production seam.

(3) For all destructive tests, 4 of 5 samples must meet or exceed the above values, and all samples must meet or exceed 80% of the above values for a test to pass.

(4) Locus-of-break patterns will meet the acceptable break codes given in GRI GM-19. The following are patterns are unacceptable break codes: fusion – AD, AD-Brk >25%; extrusion – AD1, AD2, AD-WLD (if strength is not achieved)

(5) This specification is based on the Geosynthetic Research Institute (GRI) GM-19 Specification, currently the industry standard for welded geomembrane seams. Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geomembrane seams.

TABLE 13
CQA CONFORMANCE TESTING REQUIREMENTS FOR GEOMEMBRANES

TEST	METHOD	MINIMUM FREQUENCY OF CQA TESTING[1]
Thickness – Lab Measurement	ASTM D 5994	1 per 100,000 ft^2
Sheet Density	ASTM D 1505/D 792	1 per 100,000 ft^2
Tensile Properties	ASTM D 6693 Type IV	1 per 100,000 ft^2
Carbon Black Content	ASTM D 4218	1 per 100,000 ft^2
Carbon Black Dispersion	ASTM D 5596	1 per 100,000 ft^2
Interface Shear Strength	ASTM D 5321	1 per interface specified in Table 11[2]

Notes:
(1) CQA testing frequency will also be at a minimum of one per resin lot.
(2) See Table 11 for information on testing conditions.
(3) Specified test methods and parameters may be replaced by Design Engineer to be consistent with the industry standard for geomembranes.

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8. GEOTEXTILES

8.1 Introduction

This section addresses the material specifications and CQA requirements for the geotextile component of the leachate collection system. The following topics are discussed in the remainder of this section:

- Geotextile Material Specifications;
- Pre-Installation CQA Evaluation of Material Sources;
- Material CQA Conformance Testing;
- Field CQA Evaluation/Monitoring During Construction; and
- Geotextile Documentation.

8.2 Geotextile Specifications

8.2.1 Geotextile Material Requirements

Material requirements for the geotextile are presented in Table 14.

8.2.2 Geotextile MQC

The Geotextile Manufacturer will implement a MQC program for the geotextile, which will include MQC sampling and testing to demonstrate the geotextile quality and suitability for use. The required MQC tests, methods, and frequencies are presented in Table 14.

8.3 Pre-Installation Evaluation of Material Sources

Prior to installation of the geotextile, the Geotextile Manufacturer will provide CQA personnel with the required MQC information including:

- Written certification, signed by a responsible party employed by the Manufacturer. The Manufacturer will guarantee the specified roll values are met for physical, mechanical, and environmental properties corresponding to the test procedures for the required geotextile properties listed in the specifications.

- MQC certificates with test results signed by a responsible party employed by the Manufacturer. Each quality control certificate will include date, roll identification numbers, testing procedures, and results of quality control tests performed using the methods specified and at the required frequencies given in the specifications.

CQA personnel will examine all Manufacturer's certificates to verify that the property values listed on the certifications meet or exceed the specifications and that proper and complete

documentation has been provided for all geotextile to be used at the site. CQA personnel will report any deviations from the above requirements to the Installer and Project Manager prior to installation of the geotextile. Any sample that does not comply with the requirements will result in rejection of the roll from which the sample was obtained and additional testing of rolls from the same lot or batch until a pattern of acceptable test results is established.

8.4 Material CQA Conformance Testing

Conformance testing requirements for the geotextiles are presented in Table 15. Conformance testing will be performed by an independent, third-party laboratory. Conformance sampling may be performed either at the manufacturing plant or upon delivery of rolls to the site, as requested by the Project Manager. Conformance samples will be taken across the entire roll width. All conformance test results will be reviewed by CQA personnel prior to deployment of the material. Any nonconformance will be immediately reported to the Contractor and Project Manager. When a sample fails a conformance test, the material from the lot represented by the failing test should be considered out-of-specification and rejected.

Additional conformance samples may be taken to isolate the portion of the lot not meeting the specifications. To isolate the out-of-specification material, two additional conformance samples should be taken from the closest numerical roll numbers to the failing sample. If both samples pass, only the initial failed roll will be rejected. If any one of the additional tests fails, then the entire lot will be rejected or the procedure will be repeated with additional tests to further bracket the failing rolls within the lot.

8.5 Field CQA Evaluation/Monitoring During Installation

The geotextile will be shipped in rolls with relatively weather-resistant opaque wrappings, and each roll will be labeled with the Manufacturer's name and product identification. During unloading and storage, geotextile will be handled to minimize damage. The geotextile will also be stored in a manner that minimizes damage, including exposure to ultraviolet light. CQA personnel will inspect the geotextile rolls prior to use. Any damaged rolls will be repaired or replaced by the Installer or Contractor, as appropriate.

During installation of geotextile, CQA personnel will verify compliance with the following:

- geotextiles are not placed during inclement weather such as high winds or rain;
- immediately prior to geotextile placement, the underlying geosynthetics are free of sharp protrusions or other obstructions that could potentially damage the material;
- in the presence of wind, geotextiles are temporarily weighted with sandbags (or equivalent), and the weights remain until the material is secured with an overlying layer;

- geotextiles are kept continually under slight tension to minimize the presence of wrinkles, and if necessary, the material is positioned by hand after being unrolled to minimize wrinkles;

- geotextiles are placed in the locations and to the dimensions shown on the applicable design details and drawings;

- a visual examination of the material is carried out over the entire surface, after installation, to verify that no potentially harmful foreign objects, such as needles or tools, are present;

- proper orientation and joining techniques are used:
  - on slopes shallower than 10H:1V, geotextiles can be overlapped 6 inches and either seamed with polymeric thread with properties equal or exceeding those of the geotextile or thermally bonded;

- holes or tears in the geotextile are repaired by spot-seaming a patch in place with a minimum of 24 inches overlap in all directions; and

- the geotextiles are not left exposed for longer than the maximum allowable period (as recommended by the Manufacturer) after placement unless a longer exposure period is approved by the Design Engineer and the Project Manager.

CQA personnel will also verify that the Contractor places all soil and aggregate materials on top of geotextiles in such a manner that:

- the geosynthetics and underlying materials are not damaged;
- wrinkles are minimized; and
- excess tensile stresses are not produced in the geosynthetics.

Equipment or vehicles will not be operated above the geosynthetics unless the equipment or vehicles meets the following ground pressure requirements and the corresponding minimum thickness of soil is present overlying the geosynthetics.

Allowable Equipment Ground Pressure (psi)	Minimum Thickness of Soil Overlying Geosynthetics (in.)
<5	12
<10	18
<20	24
>20	36

8.6 Geotextile Documentation

The Geosynthetics CQA Consultant will document that the CQA requirements associated with the geotextile have been addressed and satisfied. This includes the following required types of documentation:

- daily field report;
- photographic log; and
- geotextile data sheets.

Details of the required contents of each of the above types of documentation are provided in Section 12 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes geotextile documentation will be prepared by the Geosynthetics CQA Consultant. Contents of the Final CQA Report are presented in Section 12.6 of this Plan.

TABLE 14
MATERIAL SPECIFICATIONS FOR GEOTEXTILES

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD	MINIMUM FREQUENCY OF MQC TESTING(1)
Type			Nonwoven		
Mass Per Unit Area	minimum	oz/yd^2	8	ASTM D 5261	1 per 100,000 ft^2
Grab Tensile Strength	minimum	lbs	160	ASTM D 4632	1 per 100,000 ft^2
Trapezoidal Tear Strength	minimum	lbs	60	ASTM D 4533	1 per 100,000 ft^2
Puncture Strength	minimum	lbs	100	ASTM D 4833	1 per 100,000 ft^2
Apparent Opening Size	minimum	sieve size	70	ASTM D 4751	1 per 500,000 ft^2
Water Permeability	minimum	cm/s	0.1	ASTM D 4491	1 per 500,000 ft^2
UV Resistance	minimum	percent ret. @ 500 hrs	70	ASTM D 4355	per formulation

Notes:
(1) CQA testing frequency will also be at a minimum of one per resin lot.
(2) Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geotextiles.

TABLE 15
CQA CONFORMANCE TESTING REQUIREMENTS FOR GEOTEXTILES

TEST	METHOD	MINIMUM FREQUENCY OF CQA TESTING(1)
Mass Per Unit Area	ASTM D 5261	1 per 250,000 ft^2
Grab Tensile Strength	ASTM D 4632	1 per 250,000 ft^2
Trapezoidal Tear Strength	ASTM D 4533	1 per 250,000 ft^2
Puncture Strength	ASTM D 4833	1 per 250,000 ft^2

Notes:
(1) CQA testing frequency will also be at a minimum of one per resin lot.
(2) Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geotextiles.

9. GEOCOMPOSITES

9.1 Introduction

This section addresses the material specifications and CQA requirements for double-sided geocomposite drainage layer component of the liner system. The following topics are discussed in the remainder of this section:

- Geocomposite Specifications;
- Pre-Installation CQA Evaluation of Material Sources;
- Material CQA Conformance Testing;
- Field CQA Evaluation/Monitoring During Construction; and
- Geocomposite Documentation.

9.2 Geocomposite Specifications

9.2.1 Geocomposite Material Requirements

Material requirements for the geocomposite are presented in Table 16. The geotextile components of the geocomposite will meet the material requirements presented in Table 14.

9.2.2 Geocomposite MQC

The Geocomposite Manufacturer will implement a MQC program for the geocomposite, which will include MQC sampling and testing to demonstrate the product quality and suitability for use. The required MQC tests, methods, and frequencies are presented in Table 16 for the geocomposite and Table 14 for the geotextile component of the geocomposite.

9.3 Pre-Installation Evaluation of Material Sources

Prior to installation of the geotextile, the Geotextile Manufacturer will provide CQA personnel with the required MQC information including:

- Written certification, signed by a responsible party employed by the Manufacturer. The Manufacturer will guarantee the specified roll values are met for physical, mechanical, and environmental properties corresponding to the test procedures for the required geomembrane properties listed in the specifications.

- MQC certificates with test results signed by a responsible party employed by the Manufacturer. Each quality control certificate will include date, roll identification numbers, testing procedures, and results of quality control tests performed using the methods specified and at the required frequencies given in the specifications.

CQA personnel will examine all Manufacturer's certificates and results to verify that the property values listed on the certifications meet or exceed the specifications and that proper and complete documentation has been provided for all geocomposite to be used at the site. CQA personnel will report any deviations from the above requirements to the Installer and Project Manager prior to installation of the geocomposite. Any sample that does not comply with the requirements will result in rejection of the roll from which the sample was obtained and additional testing of rolls from the same lot or batch until a pattern of acceptable test results is established.

9.4 Material CQA Conformance Testing

Conformance testing requirements for the geocomposite are presented in Table 17. Conformance testing will be performed by an independent, third-party laboratory. Conformance sampling may be performed either at the manufacturing plant or upon delivery of rolls to the site, as requested by the Project Manager. Conformance samples will be taken across the entire roll width. All conformance test results will be reviewed by CQA personnel prior to deployment of the material. Any nonconformance will be immediately reported to the Installer and Project Manager. When a sample fails a conformance test, the material from the lot represented by the failing test should be considered out-of-specification and rejected.

Additional conformance samples may be taken to isolate the portion of the lot not meeting the specifications. To isolate the out-of-specification material, two additional conformance samples should be taken from the closest numerical roll numbers to the failing sample. If both samples pass, only the initial failed roll will be rejected. If any one of the additional tests fails, then the entire lot will be rejected or the procedure will be repeated with additional tests to further bracket the failing rolls within the lot.

9.5 Field Evaluation/Monitoring During Installation

The geocomposite will be shipped in rolls with relatively weather-resistant opaque wrappings, and each roll will be labeled with the Manufacturer’s name and product identification. During unloading and storage, geocomposite will be handled in a manner that minimizes damage. The geocomposite will also be stored in a manner that minimizes damage, including exposure to ultraviolet light. CQA personnel will inspect the geocomposite rolls prior to use. Any damaged rolls will be repaired or replaced by the Installer or Contractor, as appropriate.

During installation of geocomposite, CQA personnel will verify compliance with the following:

- geocomposites are not placed during inclement weather such as high winds or rain;
- immediately prior to geocomposite placement, the underlying geomembrane is free of objects that could potentially damage the geosynthetics;

- in the presence of wind, geocomposites are temporarily weighted with sandbags (or equivalent), and the weights remain until the material is secured with an overlying layer;

- geocomposites are kept continually under slight tension to minimize the presence of wrinkles, and if necessary, the material is positioned by hand after being unrolled to minimize wrinkles;

- geocomposites are placed in the locations and to the dimensions shown on the applicable design details and drawings;

- a visual examination of the material is carried out over the entire surface, after installation, to verify that no potentially harmful foreign objects, such as needles or tools, are present;

- proper orientation and joining techniques are used:
  - adjacent rolls will be overlapped by approximately 2 to 4 inches as recommended by the Manufacturer, tying the geonet component with plastic ties or similar and sewing the geotextile component;

- holes or tears in the geocomposite are repaired by typing a patch in place with a minimum of 24 inches overlap in all directions and ties placed every 6 inches; and

- the geocomposites are not left exposed for longer than the maximum allowable period (as recommended by the Manufacturer) after placement unless a longer exposure period is approved by the Design Engineer and the Project Manager.

CQA personnel will also verify that the Contractor places all soil and aggregate materials on top of geocomposites in such a manner that:

- the geosynthetics and underlying materials are not damaged;
- wrinkles are minimized; and
- excess tensile stresses are not produced in the geosynthetics.

Equipment or vehicles will not be operated above the geosynthetics unless the equipment or vehicles meets the following ground pressure requirements and the corresponding minimum thickness of soil is present overlying the geosynthetics.

Allowable Equipment Ground Pressure (psi)	Minimum Thickness of Soil Overlying Geosynthetics (in.)
<5	12
<10	18
<20	24
>20	36

9.6 Geocomposite Documentation

The Geosynthetics CQA Consultant will document that the CQA requirements associated with the geocomposite have been addressed and satisfied. This includes the following required types of documentation:

- daily field report;
- photographic log; and
- geocomposite data sheets.

Details of the required contents of each of the above types of documentation are provided in Section 12 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes geocomposite documentation will be prepared by the Geosynthetics CQA Consultant. Contents of the Final CQA Report are presented in Section 12.6 of this Plan.

TABLE 16
MATERIAL SPECIFICATIONS FOR GEOCOMPOSITES

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD	MINIMUM FREQUENCY OF MQC TESTING(1)
Geotextile Component – Per Table 14					
Geonet Component					
Polymer Composition	minimum	Percent	95% polyethylene	-	-
Thickness	minimum	Inch	0.20	ASTM D 1777	1 per 100,000 ft^2
Tensile Strength	minimum	lb/inch	40	ASTM D 5035	1 per 100,000 ft^2
Carbon Black Content	minimum	%	2.0	ASTM D 4218	1 per 100,000 ft^2
Density	minimum	g/cc	0.935	ASTM D 792 or ASTM D 1505	1 per 100,000 ft^2
Geocomposite					
Transmissivity(2)	minimum	m^2/s	2×10^{-4}	ASTM D 4716	1 per 500,000 ft^2

Notes:
(1) Index transmissivity test for liner system geocomposite on floor will be performed at: Applied stress of 8000 psf (min.), Gradient of 0.02, Load duration of 15 minutes. Test configuration between two steel plates.
(2) Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geotextiles.

TABLE 17
CQA CONFORMANCE TESTING REQUIREMENTS FOR GEOCOMPOSITE

TEST	METHOD(1)	MINIMUM FREQUENCY OF CQA TESTING(1)
Geotextile Component – Per Table 15		
Geonet Component		
Thickness	ASTM D 1777	1 per 250,000 ft^2
Tensile Strength	ASTM D 5035	1 per 250,000 ft^2
Carbon Black Content	ASTM D 4218	1 per 250,000 ft^2
Density	ASTM D 792 or ASTM D 1505	1 per 250,000 ft^2

Notes:
(1) CQA testing frequency will also be at a minimum of one per resin lot.
(2) Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geotextiles.

10. GEOSYNTHETIC CLAY LINERS

10.1 Introduction

This section addresses the material specifications and CQA requirements for the geosynthetic clay liner (GCL) component of the liner system. The following topics are discussed in the remainder of this section:

- GCL Material Specifications;
- Pre-Installation CQA Qualifying of Material Sources;
- Material CQA Conformance Testing;
- Field CQA Evaluation/Monitoring of Construction Techniques; and
- GCL Documentation.

10.2 GCL Specifications

10.2.1 GCL Material Requirements

The GCL will be manufactured with a bentonite core between two geotextile layers. The GCL will be reinforced by needle punching or stitch bonding.

10.2.2 Manufacturing Quality Control (MQC)

The GCL Manufacturer will implement a MQC program for the GCL, which will include MQC sampling and testing to demonstrate the GCL quality and suitability for use. The required MQC tests, methods, and frequencies are presented in Table 18.

10.3 Pre-Installation Evaluation of Material Sources

Prior to installation of the GCL, the GCL Manufacturer will provide CQA personnel with the required MQC information including:

- Written certification, signed by a responsible party employed by the Manufacturer. The Manufacturer will guarantee the specified roll values are met for physical, mechanical, and environmental properties corresponding to the test procedures for the required GCL properties listed in the specifications.

- MQC certificates with test results signed by a responsible party employed by the Manufacturer. Each quality control certificate will include date, roll identification numbers, testing procedures, and results of quality control tests performed using the methods specified and at the required frequencies given in the specifications.

- Certification from the Manufacturer that the GCL has been continuously inspected using metal detectors and found to be needle free (if needle-punched GCL will be used).

- The origin and identification of the bentonite source using for GCL production, and a certification statement from the bentonite supplier stating that the bentonite properties are met for the specified test procedures and properties listed in the specifications.

- Copies of dated quality control certificates issued by the bentonite supplier for the required properties listed in the specifications.

CQA personnel will examine all GCL Manufacturer's certifications to verify that the property values listed on the certifications meet or exceed the specifications and that proper and complete documentation has been provided for all GCL to be used at the site. CQA personnel will report any deviations from the above requirements to the Installer and Project Manager prior to installation of the GCL. Any sample that does not comply with the requirements shall result in rejection of the roll from which the sample was obtained, and additional testing of rolls from the same lot or batch until a pattern of acceptable test results is established.

10.4 Material CQA Conformance Testing

Conformance sampling and testing requirements for the GCL are presented in Table 19. Conformance sampling may be performed either at the manufacturing plant or upon delivery of rolls to the site, as requested by the Project Manager. Conformance samples will be taken across the entire roll width. All conformance test results will be reviewed by CQA personnel prior to deployment of the material. Any nonconformance will be immediately reported to the Installer and Project Manager. When a sample fails a conformance test, the material from the lot represented by the failing test should be considered out-of-specification and rejected.

Additional conformance samples may be taken to isolate the portion of the lot not meeting the specifications. To isolate the out-of-specification material, two additional conformance samples should be taken from the closest numerical roll numbers to the failing sample. If both samples pass, only the initial failed roll shall be rejected. If any one of the additional tests fails, then the entire lot shall be rejected and the procedure may be repeated with additional tests to further bracket the failing rolls within the lot.

10.5 Field Evaluation/Monitoring During Installation

Prior to construction, CQA personnel and the Project Manager will discuss the proposed GCL panel layout plan with the Installer. The purpose of the review is to become familiar with the proposed orientation of the panels, the general installation sequencing, and the quantities of materials needed for the job, and to assess whether the proposed installation layout complies with the specifications.

The GCL shall be shipped in rolls with weather-resistant opaque wrappings, and each roll shall be labeled with the manufacturer's name and product identification (e.g., batch and roll numbers, dimensions, etc.). The GCL rolls will be kept in their water resistant covering to avoid exposure to the elements (precipitation, humidity, UV exposure) and ultimately to prevent premature hydration or damage. CQA personnel will inspect and inventory the GCL rolls in their storage area prior to use. Any prematurely hydrated or otherwise damaged rolls shall be repaired or replaced.

Prior to deployment of GCL, CQA personnel will observe the work area and verify that the top of the subgrade surface has been fully approved. The subgrade will be relatively smooth and uniform and free of irregularities, dimples, loose soil, or abrupt changes in grade. It is the responsibility of CQA personnel to provide subgrade acceptance forms to the Installer and verify that they have been signed by CQA personnel and the Installer prior to deployment.

CQA personnel shall monitor GCL deployment and verify compliance with the following:

- GCL is not placed during inclement weather, such as high winds, rain, or an imminent threat of rain and does not prematurely hydrate;
- immediately prior to GCL placement, the underlying subgrade is free of objects that could potentially damage the overlying geosynthetics;
- GCL is deployed with the proper side facing upward;
- Wrinkles are minimized and removed as much as possible during deployment;
- GCLs are placed in the locations and to the dimensions shown on the applicable design details and drawings;
- GCL edges and roll ends are overlapped and bentonite is added to the overlaps following the Manufacturer's recommendations;
- GCL repairs are constructed by removing the damaged portion of the GCL and placing a patch or new GCL panel over the damaged area with a minimum 12 inches overlap in all directions; and
- the quantity of GCL deployed during one working day does not exceed the amount that can be covered by geomembrane by the end of the day unless specifically allowed by the Project Manager.

Equipment or vehicles will not be operated above the geosynthetics unless the equipment or vehicles meets the following ground pressure requirements and the corresponding minimum thickness of soil is present overlying the geosynthetics.

Allowable Equipment Ground Pressure (psi)	Minimum Thickness of Soil Overlying Geosynthetics (in.)
<5	12
<10	18
<20	24
>20	36

10.6 GCL Documentation

The Geosynthetics CQA Consultant will document that the CQA requirements associated with the GCL have been addressed and satisfied. This includes the following required types of documentation:

- daily field report;
- photographic log; and
- GCL data sheets.

Details of the required contents of each of the above types of documentation are provided in Section 12 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes GCL documentation will be prepared by the Geosynthetics CQA Consultant. Contents of the Final CQA Report are presented in Section 12.6 of this Plan.

TABLE 18
MATERIAL SPECIFICATIONS FOR GEOSYNTHETIC CLAY LINERS

PROPERTY	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD	MQC TESTING FREQUENCY
Bentonite					
Bentonite Swell Index	minimum	ml/2g	24	ASTM D5890	1 per 50 tons (min. 1 per rail car)
Fluid Loss	maximum	ml	18	ASTM D5891	1 per 50 tons (min. 1 per rail car)
GCL					
Bentonite Content (Mass/Area), Oven Dried Basis	Minimum	lbs/ft^2	0.75	ASTM D5993	1 per 50,000 ft^2
Tensile Strength, Machine Direction (MD)	Minimum	lb/in.	23	ASTM D6768	1 per 250,000 ft^2
Hydraulic Conductivity	maximum	cm/sec	5×10^{-9}	D5887	1 per 250,000 ft^2

Notes:

(1) Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for GCLs.

TABLE 19
CQA CONFORMANCE TESTING REQUIREMENTS FOR GCL

TEST	METHOD	MINIMUM FREQUENCY OF CQA TESTING(2)
Bentonite Content (Mass/Area)	ASTM D 5993	1 per 250,000 ft^2

Notes.

(1) Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for GCLs.

11. CQA SURVEYING

11.1 Introduction

CQA surveying of lines and grades will be conducted on an ongoing basis during construction to measure and document construction as verification that the work was constructed in accordance with the design grades, elevations, and configuration. The CQA Surveyor will be responsible for providing data necessary to verify the Contractor's/Installer's work and for preparing Record Drawings for inclusion in the Final CQA Report.

The duties of the CQA Surveyor are for independent verification and do not relieve the Contractor/Installer of their responsibility to provide their own construction/installation surveying to layout, control, and document their work.

11.2 Survey Control

At least one permanent benchmark/monument will be established for the site(s) in a location convenient for daily tie-in. The vertical and horizontal control for this benchmark/monument will be established within normal land surveying standards.

11.3 Precision and Accuracy

A wide variety of survey equipment is available for the surveying requirements for these projects. The survey instruments used for this work should be sufficiently precise and accurate to meet the needs of the projects. Specifically, the survey instruments used by the CQA Surveyor will be capable of reading to a precision of 0.01 feet and with a setting accuracy of 10 seconds. Calibration certificates for survey instruments may be requested by the Project Manager.

11.4 Scope of CQA Surveying

11.4.1 Lines, Grades, and Thicknesses

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

- For the perimeter berm and other landfill-related earthworks:
  - original grade surface (i.e., subgrade);
  - compacted surface of cut slopes; and
  - finished grade surface.
- For the liner system and final cover system:
  - prepared surface; and
  - finished surface of each component.

11.4.2 Geomembrane Panel Layout Drawings

A Panel Layout Drawing of the geomembrane liner will be prepared by either the CQA Surveyor or the Geosynthetics CQA Consultant, as directed by the Project Manager at the outset of the project. The drawings will show the layout and identification of geomembrane panels and their seams. The locations of anchor trenches, tie-ins between phases, terminations, destructive test locations, and repairs will also be shown. The information needed to prepare the Panel Layout Drawings may be obtained either using survey instruments (if responsibility assigned to CQA Surveyor) or by field measurements (if responsibility assigned to the Geosynthetics CQA Consultant).

11.4.3 Frequency and Spacing

All surveying should be carried out immediately upon completion of a given installation to facilitate progress and avoid delaying commencement of the next installation. In addition, spot checks during placement and compaction of earthwork components will be necessary to assist the Earthwork Contractor in complying with required grades. At the least the following minimum spacing and locations should be provided for CQA survey points:

- within the limits of liner system or final cover system as appropriate, the surfaces should be CQA surveyed on a grid spaced no wider than 50 feet × 100 feet for the liner system and 100 feet × 100 feet for the final cover system;
- a line of survey points no further than 100 feet apart and at changes in direction (e.g., corners) must be taken along the limit of liner (anchor trench);
- a line of survey points no further than 100 feet apart must be taken along any slope break (e.g., crests-of-slope, toes-of-slope, drainage divides);
- at the corners of the top and bottom of all sumps.

11.4.4 Record Drawings

The CQA Surveyor will prepare Record Drawings of the liner system or final cover system features identified above in Sections 11.4.1 and 11.4.2, showing survey data at the required minimum frequency and spacing identified above in Section 11.4.3. For a given project, the actual features will vary depending on whether the liner system or final cover system was constructed. The Record Drawings, signed and sealed by the Texas licensed Professional Land Surveyor, will be included in the Final CQA Report.

11.5 CQA Survey Document Retention

Original field CQA survey notes and electronic data files will be retained by the CQA Surveyor. Interim survey information will be provided to CQA personnel in tabular or electronic format at the end of each day of surveying or at the end of a given surveying task, as requested by CQA

personnel. CQA personnel may also request that the CQA Surveyor submit periodic partial/draft Record Drawings for a given project component.

12. CQA DOCUMENTATION

12.1 Introduction

CQA personnel will document that all QA requirements have been addressed and satisfied. Also, during construction, CQA personnel will maintain at the site a complete file of the construction documents (specifications, drawings, etc.), the Plan, test procedures, daily reports, testing logs, and other pertinent forms and documents.

CQA personnel will prepare the following types of documentation:

- Daily Field Report;
- Photographic Log;
- Soils CQA Records (observation logs and testing data sheets);
- Geosynthetics CQA Records (observation logs and testing data sheets); and
- Final CQA Report.

The required contents of the CQA documentation is described in the remainder of this section.

12.2 Daily Field Report

The CQA Consultant(s) will prepare a brief Daily Field Report for each day of liner system or final cover system construction. This report will be prepared by the CQA Site Manager (or their designee). The Daily Field Report may include information such as the following:

- date, project name, location, and other identification;
- a brief narrative of the events and activities, including construction activities, meetings, and observations that occurred during a given day;
- a summary of the locations where construction and installation occurred during the day or reference to other logs showing/describing their location;
- a reduced-scale site map if necessary;
- weather conditions;
- equipment and personnel in each work area, including subcontractors;
- name of parties to any discussions;
- relevant subject matter or issues;
- activities planned and performed;
- constraints or suggestions;
- a description of concerns or potential problems, as follows:
  - a description of the situation or deficiency;
  - the location and probable cause of the situation or deficiency;
  - how and when the situation or deficiency was found or located;

  - documentation of the response to the situation or deficiency;
  - final results of any responses;
  - any measures taken to prevent a similar situation for occurring in the future;
- scheduling information;
- off-site materials received, including quality verification documentation;
- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality; and
- the signature of the CQA personnel who authored the report.

12.3 Photographic Documentation

A Photographic Log will be maintained by the CQA Site Manager(s). These photographs will serve as a chronological pictorial record of work progress, problems, and mitigation activities. These records will be presented to the Project Manager upon completion of the project. Select photographs will be included in the Final CQA Report.

12.4 Soils CQA Records

Soils CQA Records (observation logs and testing data sheets) kept for soils related activities will be completed by CQA personnel. The information will be recorded as testing is done in the field or as results are received from the laboratory. The records will be available for review on site, and copies will be included in the Final CQA Report. The relevant forms that may be needed during the soils portions of the project are listed below:

- field test log(s) for each soils component and category of tests, including:
  - an identifying number for cross referencing and document control;
  - date, project name, location, and other identification;
  - reference to specific locations of areas of work being tested and/or observed and documented (identified by lift and location);
  - locations where tests and samples were taken;
  - the test results, including indication of passing or failing test results (with cross-reference for the failing test to a corresponding repair and passing test);
- laboratory test data sheets and/or results (e.g., particle size, Atterberg limits, compaction, oven moisture content, sand cone density, etc.);
- summary tables of laboratory tests, with comparison to the specifications and indication of passing or failing test results;
- equipment calibration information; and
- the CQA Monitor(s) initials or signature.

12.5 Geosynthetics Field CQA Records

Records kept for geosynthetics-related activities will be completed by CQA personnel. The information will be recorded as shipments are received from the Manufacturer, as testing is done in the field, or as results are received from the laboratory. The records will be available for review on site, and copies will be issued as part of the Final CQA Report. The relevant records and forms that may be needed during the project are listed below:

- Material Inventory Logs;
- Manufacturer Quality Control Certifications and Test Results;
- CQA Conformance Testing Laboratory Results;
- Subgrade Acceptance Certifications;
- Panel Placement Logs;
- Trial Seam Logs;
- Production Seam Logs;
- Nondestructive Test Logs;
- Destructive Test Logs and Laboratory Test Results;
- Repair Summary Logs; and
- Seam and Panel Repair Locations Logs.

12.6 Final CQA Report

Upon completion of all required liner system or final cover system construction and evaluation, and before placing a newly-lined area into service, the CQA Consultant(s) will prepare and submit a Final CQA Report to the Project Manager, for submittal to TCEQ. Each liner system project and final cover system project will have a separate Final CQA Report. Also, the Final CQA Reports may be further subdivided if it would facilitate preparation and review of the project (e.g., separate reports for soils CQA and geosynthetics CQA, especially if prepared by different CQA Consultants).

Each Final CQA Report will be signed and sealed by the CQA Engineer(s) under whose direction the CQA activities were conducted. Each Final CQA Report will contain a narrative describing the conduct of work and testing programs required by the Plan, "as-built" Record Drawings, and appendices of photographs, laboratory tests, and field data. At a minimum, this report will specifically identify, address, and include the necessary supporting information and certifications required, to include:

- a summary narrative of the construction activities, including a discussion of required CQA and CQC testing (procedures, protocols, required and actual testing frequencies, failed tests, procedures to correct failed areas, documentation of re-tests, etc.);

- observation logs and testing data sheets showing all testing results, including documentation of any failed tests and documentation that areas represented by failed tests were corrected and re-tested;

- a discussion of changes from design and material specifications;

- Record Drawings; and

- a certification statement sealed and signed by each licensed Texas P.E. who served as the CQA Engineer(s), indicating that the facility was constructed in accordance with the permitted design as reflected on the construction documents (drawings, specifications, Plan, etc.) and any properly authorized clarifications or changes.