

APPENDIX V  
CONCEPTUAL CQA PLAN

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**CONCEPTUAL CONSTRUCTION QUALITY  
ASSURANCE PLAN**

**MARANA REGIONAL LANDFILL**

**PIMA COUNTY, ARIZONA**

Prepared for  
Marana Regional Landfill

May 2011

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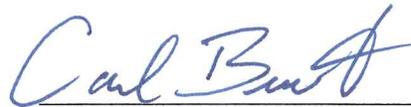
Project 090250

## Conceptual Construction Quality Assurance Manual Marana Regional Landfill

Pima County, Arizona

The material and data in this manual were prepared under the supervision and direction of the undersigned. This manual was prepared consistent with current and generally accepted principles and practices for civil and geotechnical engineering quality assurance for this area and within the limitations provided herein.

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# 1 INTRODUCTION

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## 1.1 Purpose

The purpose of this manual is to describe the quality assurance procedures to be used during construction of the liner and leachate collection system components at Marana Regional Landfill (MRLF), Marana, Arizona. The primary goals of the quality assurance program are to

- Determine if proper construction techniques, materials, and procedures are used.
- Determine if the intent of the construction documents and project design reports are met.
- Identify construction problems and provide a mechanism for resolution.

Upon completion of construction, information generated through the quality assurance program will be used to prepare a project construction report.

## 1.2 Document Format

The Construction Quality Assurance (CQA) Manual is considered a template for individual CQA Plans which will be prepared for each phase of construction at the MRLF. It is anticipated that the CQA Manual will be reviewed and modified as necessary to reflect the current scope of construction. It is presented in five sections. Section 1 is the introduction and presents the document format, definitions, and terms used throughout the document. Section 2 presents general requirements of the quality assurance program and organization. Sections 3 and 4 present special requirements for specific work items of the construction, including procedures such as materials verification, test standards, testing frequencies, conformance and construction testing, sample numbering and processing, and monitoring for each work item. Section 5 presents methods of documentation and record keeping.

All parties involved in the construction should be thoroughly familiar with this document, the construction drawings, and the construction specifications.

## 1.3 Definitions

Whenever the terms listed below are used, the intent and meaning will be interpreted as indicated.

### **ASTM**

American Society for Testing and Materials.

### **Construction Quality Assurance (CQA)**

A planned and systematic series of observations and tests designed to provide adequate confidence that materials and services meet contractual and regulatory requirements.

### **Construction Quality Assurance Consultant (CQA consultant)**

The monitoring firm responsible for implementation of the CQA program.

### **Construction Quality Assurance Monitor (CQA monitor)**

Site representative(s) of the CQA officer responsible for documenting field observations and tests.

### **Construction Quality Assurance Officer (CQA officer)**

The professional representative of the CQA consultant responsible for planning, coordinating, and implementing the CQA plan. The CQA officer shall be an Arizona-registered Professional Engineer.

### **Contract Documents**

The official set of documents issued by the owner, which includes bidding requirements, contract forms, contract conditions, construction specifications or drawings, addenda, and contract modifications.

### **Construction Drawings**

The official plans, profiles, typical cross sections, elevations, and details, as well as their amendments and supplemental drawings, which show the locations, character, dimensions, and details of the work to be performed. Construction drawings are also referred to as the "plans."

### **Construction Specifications**

The qualitative requirements for products, materials, and workmanship upon which the construction is based. Construction specifications are also referred to as "specifications."

### **Contractor**

The person or persons, firm, partnership, corporation, or any combination, private, municipal, or public, who, as an independent contractor, has entered into a contract with the owner.

### **Design Engineer**

The individuals or firms responsible for the design and preparation of the contract documents.

### **Earthwork**

A construction activity involving the use of soil materials as defined in the construction specifications and Section 3 of this manual.

### **Excavation**

Excavation of materials from areas identified on the construction drawings. The process may require exclusion of unsuitable materials.

### **GCL**

Sodium bentonite supported by geotextile or geomembrane used as a solid or liquid barrier.

### **Geomembrane**

An essentially impermeable synthetic membrane, also referred to as flexible membrane liner (FML), used as a solid or liquid barrier.

### **Geotextile**

Woven or nonwoven synthetic fabric used as a filter, separator, or reinforcement in geotechnical applications.

### **Gravel Fill**

Granular material with a maximum size of 1-inch and minimum permeability of 0.1 cm/sec placed as a drainage media.

### **Nonconformance**

A deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of nonconformances include, but are not limited to, physical defects, test failures, and inadequate documentation.

### **Panel**

A unit area of the geomembrane, which will be seamed in the field or in the fabricator's plant.

### **Procedure**

A document that specifies or describes how an activity is to be performed.

### **Project Manager**

Owner's representative with overall project responsibility.

### **Project Documents**

Contractor submittals, construction drawings, record drawings, specifications, shop drawings, construction quality control and quality assurance plans, safety plan, and project schedule.

### **Quality Assurance**

A planned and systematic pattern of procedures and documentation designed to provide adequate confidence that materials or services meet contractual and regulatory requirements, and that these materials will perform satisfactorily in service.

### **Quality Control**

Those actions that provide a means of measuring and regulating the characteristics of a material or service to comply with the requirements of the construction documents. Quality control will be performed by the contractor, manufacturers, suppliers, and subcontractors.

### **Record Drawings**

Drawings recording the constructed dimensions, details, and coordinates of the project.

### **Project Manager**

Owner's representative on site, who is responsible for contract administration.

### **Surveyor**

The individual or firm responsible for grade staking to establish required elevations to construct the project in accordance with the drawings and specifications.

### **Testing**

Verification that materials meet specified requirements by subjecting that material to a set of physical, chemical, environmental, or operating conditions.

### **Testing Laboratory**

A laboratory capable of conducting the tests required by this CQA Manual and the specifications. Testing may be done by the same laboratory or by separate laboratories.

### **USCS**

Unified Soil Classification System (ASTM D2487)

## 2 GENERAL REQUIREMENTS

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This section of the CQA Manual describes general requirements of the CQA consultant as they relate to the overall project. It includes general requirements for meetings, responsibilities of the project team, control of project records, and documentation and control of nonconforming work.

### 2.1 Meetings

To facilitate construction and clearly define construction goals and activities, close coordination between the owner, design engineer, CQA personnel, and contractor is essential. To meet this objective, preconstruction and progress meetings will be held.

#### 2.1.1 Design Review Meeting

After the design has been completed, reviewed, and approved by the owner and applicable state and federal agencies, a design review meeting may be held. The purpose of this meeting, which the design engineer, project manager, CQA officer, and CQA monitor shall attend, is to

- Provide all parties with construction documents
- Review the project documents
- Define the responsibilities for each party
- Define lines of communication
- Establish reporting and documenting procedures
- Identify key personnel

The meeting will be documented by the project manager or designee. Copies of the minutes will be provided to all parties. If required, revised project documents will be distributed.

## **2.1.2 Preconstruction Meeting**

A preconstruction meeting shall be held at the site prior to commencing construction and will be attended by the owner, project manager, contractor, and design engineer. If appropriate, the CQA officer, CQA monitor, and others designated by the owner will attend the preconstruction meeting. However, if they do not attend the preconstruction meeting, the CQA officer and CQA monitor will attend a pre-liner installation meeting for projects involving installation of geosynthetic landfill liner. The purpose of the preconstruction meeting will be to:

- Identify key personnel
- Review the construction drawings, specifications, CQA program, work area security, safety procedures, and related issues
- Define lines of communication and authority
- Establish reporting and documentation procedures
- Review testing equipment and procedures
- Establish testing protocols and procedures for correcting and documenting construction or nonconformances
- Conduct a site inspection to discuss work areas, stockpile areas, laydown areas, access roads, haul roads, and related items
- Review the project schedule

The meeting will be documented by the owner or his representative. Copies of the minutes and relevant documents will be prepared and provided to all parties.

## **2.1.3 Progress Meetings**

Informal progress meetings are recommended periodically throughout the project. At a minimum, this meeting should be attended by the owner and/or representative and contractor. During liner installation, the progress meetings will be attended by the CQA monitor and the contractor. The purpose of these meetings is to:

- Discuss progress, problems and resolutions, and schedule
- Review test data
- Discuss the contractor's personnel and equipment assignments for the day

- Review the previous day's activities and accomplishments
- Resolve any outstanding problems or disputes

### **2.1.4 Other Meetings**

As required, special meetings will be held to discuss problems or nonconformances. Persons attending will be determined on as-needed basis. If the problem requires a design modification and subsequent change order, the design engineer should also be present. These meetings will be documented by the CQA monitor.

## **2.2 Communications Between Construction Personnel**

Figure 1 presents an organization and communication chart depicting the relationships of the owner, contractor, design engineer, and CQA consultant. The purpose of this organization chart is to define their reporting and communication responsibilities as they relate to the project. Responsibilities of each party are described in Section 2.3.

### **2.2.1 Communications with the Contractor**

Only the individuals assigned to this project, as defined in this manual, should communicate with the contractor. When written communications are required, they must be documented on the appropriate forms. Formal letters to the contractor should normally be signed by the CQA officer and reviewed by the owner.

### **2.2.2 Communications with the Owner**

Only those individuals assigned to this project, as defined in this manual, should communicate with the owner. All communications must be through proper channels as defined in the project organization chart. Communications of an official nature must be in writing.

## **2.3 Responsibilities of Construction Personnel**

### **2.3.1 Responsibilities of the Project Manager**

The project manager is the primary owner's representative for the project. The project manager defines the overall project scope and has the authority to make changes to that scope, if needed (with proper regulatory coordination).

### **2.3.2 Responsibilities of the Operations Supervisor**

The operations supervisor will be on-site full time to oversee and monitor construction during the earthwork operations.

### **2.3.3 Responsibilities of the CQA Officer**

The CQA Officer acts as an auditor to verify and document the proper and complete implementation of the quality assurance program. The CQA officer will be responsible for documenting the construction and preparing the final construction report. The final construction report will include a statement by the CQA officer as to whether the construction was performed in substantial conformance with the contract drawings and specifications, and design intent. The CQA officer, in cooperation with the design engineer, must approve all design changes and clarifications to design questions.

### **2.3.4 Responsibilities of the CQA Monitor**

The CQA monitor represents the owner by observing and testing the contractor's work activities. The monitor documents the activities of the contractor in sufficient detail and with continuity to provide a high level of confidence that the work product follows the intent of the construction documents. The monitor also performs tests and/or coordinates the services of third-party testing laboratories, when appropriate, to provide a high level of confidence that the characteristics of the materials and services meet the requirements of the construction documents.

Whenever a monitor performs visual observations or performs tests, he is responsible for timely preparation and processing of all required documentation and reports. Accurate and concise reports must be prepared for all monitoring activities and for each test performed. Section 5 of this document describes documentation requirements.

### **2.3.5 Responsibilities of the Contractor**

The contractor is responsible for coordinating amongst any of its subcontractors. These responsibilities include scheduling, performing the work within the timeframe and budget agreed to in the contract, and performing the work in accordance with the plans and specifications. The contractor is expected to cooperate with the CQA monitor to achieve a quality product.

### **2.3.6 Responsibilities of the Surveyor**

The surveyor will work at the direction of the contractor or the owner, as the case may be, to provide grade staking for establishing required elevations to construct the project in accordance with the design intent.

## **2.4 Control of Documents, Records, and Forms**

### **2.4.1 Project Control of Construction Documents**

Construction documents, including specifications, drawings, and change orders, are controlled by the design engineer. The CQA officer maintains one or more copies of the most current set of construction documents for use by the CQA monitor. Upon issuance of new copies or revisions, it is the responsibility of the owner to notify the contractor and CQA staff of the revisions, provide revised construction documents, and order the recall of all unrevised copies of the construction documents.

### **2.4.2 Project Control of Record Information**

Record information is controlled by the CQA monitor and surveyor. During the progress of the work, the CQA officer and design engineer obtain record information provided by the contractor, CQA monitor, surveyor, or others. All drawings prepared by the registered Professional Land Surveyor or Professional Engineer shall be sealed by that professional and presented in a format to facilitate inclusion in the CQA officer's certification report. At the completion of the project, this information is compiled by the CQA officer for use in preparing a record of the construction. Final record drawings are included with the Construction Certification Report.

### **2.4.3 Project Control of Forms**

Daily report forms, test report forms, and other project forms are controlled by the CQA monitor, who maintains a master of each form. Upon issuance of a new form, the CQA monitor must recall and remove all superseded copies along with the master.

### **2.4.4 Processing Daily Reports**

Each CQA monitor writes a daily record of work progress for each day in which CQA monitoring services are performed. The daily reports are reviewed by the CQA officer, who maintains a complete file of daily reports. A summary monthly report is prepared by the CQA officer, and forwarded to the owner.

### **2.4.5 Processing Test Reports**

A test report must be completed by the CQA monitor whenever testing is performed. The test reports must be peer-reviewed. The review includes a check for mathematical accuracy, conformance to test requirements, conformance to specifications, and a check for clarity, legibility, traceability, and completeness. The review must be evidenced by the signature of

the reviewer. Copies of all test reports are transmitted weekly to the CQA officer, and the original maintained by the CQA monitor.

#### **2.4.6 Processing Project Records**

Project records are completed as needed. Use of the project records is limited to the scope for which they are intended. The record must be completed by filling in all the blanks provided on the form and followed by the signature of the individual completing the form. All project records must be maintained by the CQA monitor.

### **2.5 Documentation and Control of Nonconformance**

#### **2.5.1 Observation of Nonconformance**

Whenever a nonconformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQA monitor must notify the contractor and CQA officer as soon as possible.

#### **2.5.2 Determining Extent of Nonconformance**

Whenever a nonconformance is discovered or observed in the construction process, product, job related materials, documentation, or elsewhere, the CQA monitor will determine the extent of the nonconformance. The extent of the deficiency may be determined by additional sampling, testing, observations, review of records, or any other means deemed appropriate.

#### **2.5.3 Documenting Nonconformance**

All nonconformances must be documented in writing on the daily records, logs, and elsewhere, as appropriate. The documentation must occur immediately upon determining the extent of the nonconformance. For those nonconformances that are considered serious or complex in nature, or that require an engineering evaluation, a nonconformance report will be initiated and issued to the project manager, design engineer, CQA officer, and contractor.

#### **2.5.4 Corrective Measures**

For a simple or routine nonconformance, corrective measures will be determined by specification direction, or if none exists, the CQA monitor, CQA officer, and contractor will discuss standard construction methods to correct the deficiency. For those nonconformances requiring a nonconformance report, the design engineer must determine corrective measures. A copy of the nonconformance report, with the corrective measure determination, is forwarded to the CQA officer and contractor for implementation of the corrective action.

### **2.5.5 Verification of Corrective Measures**

Upon notification by the contractor that corrective measures are complete, the CQA monitor verifies its completion. The verification must be accomplished by observations or retesting and photographs. Written documentation of the corrective measures must be made by the CQA monitor on daily reports, logs and forms, and the nonconformance report. Verification of corrective measures is reviewed by the CQA officer.

## **3 CONSTRUCTION QUALITY ASSURANCE FOR EARTHWORK**

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### **3.1 Introduction**

This section describes the monitoring and testing that will be performed to assure that the earthwork construction meets the specified requirements. The items discussed below are not necessarily ordered in the sequence of actual construction.

The scope of earthwork construction for this project includes the following:

- Excavation to design grade (other than routine excavation by the owner and/or operator as part of routine landfill operations for daily cover acquisition, haul road preparation/maintenance, temporary controls, and the like)
- Fine grading
- Selective soil stockpiling
- Subgrade preparation
- Engineered fill placement
- Gravel fill placement
- Drainage soil layer construction

The overall goal of the earthwork quality assurance program is to assure that proper construction techniques and procedures are used and that the project is built in accord with the project construction drawings and specifications. Another function of the quality assurance program is to identify problems that may occur during construction and to verify that these problems are avoided or corrected before construction is completed.

Construction must be conducted consistent with the project construction drawings and specifications. To monitor conformance, a quality assurance testing program will be implemented that includes (1) a review of the contractor's quality control submittals, (2) material evaluation, (3) construction testing, and (4) construction observation.

Activities will be conducted in accordance with this manual, and the project construction drawings and specifications.

## **3.2 Material Evaluation**

### **3.2.1 Testing**

Material evaluation testing is required for on site borrow sources which have not been previously tested and/or characterized and for any off site borrow sources before construction begins. Definitions and requirements of the materials are provided in the project specifications. Test samples will be obtained in accordance with standard operating procedures and applicable American Society for Testing and Materials (ASTM) standards. Archive samples and test results will be maintained and stored at the project site.

The frequency of material evaluation testing is shown in Table V-1.

### **3.2.2 Materials Submittals**

Material submittals may be used by the CQA monitor to establish the acceptability of materials. When sample submittals are required, they will be made available to the CQA monitor. Acceptance and proper review of submittals are the responsibility of the CQA officer.

### **3.2.3 Certificates of Compliance and Conformance**

Where permissible by the specifications, certificates of compliance and conformance may be used by the CQA monitor to establish the acceptability of materials. Those certificates generally state that the material is in compliance or conformance with a particular code, standard, or specification. The certificate may be used for acceptance of a product before or in lieu of testing, if allowed by the specifications.

## **3.3 Construction Testing**

### **3.3.1 Test Procedures**

The CQA monitor or third-party testing laboratory must perform the various field and laboratory tests in accordance with the applicable standard, as specified in the construction documents or this manual. In most instances, the applicable procedure is an ASTM standard. Construction testing is conducted during construction activities.

During progress of the work, additional procedures may be needed for other testing or sampling. If such procedures do not exist, or if they exist and need to be modified, written procedures must be developed by the CQA officer.

### **3.3.2 Test Frequencies**

Table V-1 establishes the test frequencies for earthwork construction quality assurance. The test frequencies listed establish a minimum number of required tests. Extra testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Extra testing may also be performed to provide additional data for engineering evaluation. Any retests performed as a result of a failing test do not contribute to the total number of tests performed in satisfying the minimum test frequency.

Examples of conditions that may warrant additional tests include the following:

- Compactors slip while compacting
- Excessive pumping or cracking of fill
- Lift thickness greater than specified
- Dirt-clogged rollers used to compact the fill
- Improperly ballasted compactor
- Adverse weather
- Equipment breakdown
- Work conducted in difficult areas
- Appearance of lignite, gypsum, or other deleterious soil materials
- High frequency of failed tests

## **3.4 Monitoring Requirements**

Earthwork components of the construction are summarized in Section 3.1. Each component has specific construction requirements that must be monitored. The following paragraphs list monitoring requirements for each type of earthwork.

### **3.4.1 Excavation to Design Grade/Fine Grading**

- Verify that stripping is complete and strippings are placed in designated stockpiles.
- Verify that construction staking is performed before work.
- Review survey with design engineer

### **3.4.2 Selective Soil Stockpiling**

- Visually monitor excavation to identify soil types.
- Confirm soil types by sampling and visual classification.
- Monitor excavation, visually classify soil, and recommend stockpile location to contractor.

### **3.4.3 Subgrade Preparation**

- Verify excavation and grading is completed.
- Monitor scarification, compaction, and fine grading activities.
- Verify compaction of subgrade by density testing and/or proofrolling as provided for in the specifications.
- Verify surface texture is appropriate for installation of overlying materials as required by the specifications.
- Confirm that construction and/or record surveys are performed prior to deployment of overlying materials.

### **3.4.4 Engineered Fill Placement**

- Verify subgrade is scarified and recompacted to design requirements.
- Verify removal and stockpiling of oversized material.
- Verify that source of material is suitable for engineered fill.
- Verify lift thickness.
- Test compaction and moisture content at required frequencies.
- Sample and perform classification testing at required frequencies.
- Verify that completed grades meet slope requirements.
- Verify that final grading meets tolerance requirements.

### **3.4.5 Operations Soil Layer and Gravel Fill Placement**

- Obtain samples of gravel for testing.
- Review material submittals.
- Perform sampling and gradation and permeability testing of material during installation, at the frequencies established in this manual, to verify material quality.
- Verify that underlying geomembrane installations are complete before material installation.
- Verify thickness of material placed by direct field measurements of in-place material or use of staking rods.
- Monitor placement of material and mark any geomembrane damaged during material installation. Verify that damage is repaired.
- Monitor deployment process and traffic over geosynthetic-lined areas for compliance with specification requirements.
- Monitor placement of material over piping and verify that pipe is not damaged. Verify that damaged pipe is replaced.

### **3.5 Construction Surveys**

Elevations shall be determined by the Surveyor on a minimum 50-foot grid at the following locations:

- Top of subgrade
- Top of operations soil layer
- Any other surface or feature as identified in the specifications

The tolerances applicable in setting survey stakes will be as set forth in the specifications.

## **4 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS**

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### **4.1 Introduction**

This section describes CQA procedures for the installation of the geosynthetic components at the Marana Regional Landfill. Five types of geosynthetics will be used for this project. A GCL and high-density polyethylene (HDPE) geomembrane will be installed as the composite liner. A geocomposite will be installed as a drainage layer. Geotextile will be installed around the gravel fill as a separator. HDPE pipe will be installed as part of the leachate collection and removal system. This manual stresses careful documentation during the quality assurance process, from the verification of materials through the geosynthetic installation.

The overall goal of the geosynthetics quality assurance program is to assure that proper construction techniques and procedures are used and that the project is built in accord with the project construction drawings and specifications. Another function of the quality assurance program is to identify problems that may occur during construction and to verify that these problems are avoided or corrected before construction is complete. The program includes (1) a review of the contractor's quality control submittals, (2) material evaluation (conformance testing), (3) construction testing, and (4) construction observation. Conformance testing refers to material testing that takes place before material installation. Construction testing includes activities that occur during installation. Activities will be conducted in accordance with this manual, and the project construction drawings and specifications.

### **4.2 Geosynthetic Clay Liner**

#### **4.2.1 Delivery**

The CQA monitor or the installer's representative will verify the following:

- Equipment used to unload the rolls will not damage the GCL.
- Care is used in unloading and stacking the rolls.
- All documentation required by the specifications has been received.

At the CQA officer or owner's discretion, damaged rolls may be rejected. Rejected rolls shall be removed from the site or stored at a location designated by the owner, separate from accepted rolls. All rolls that do not have proper manufacturer's documentation shall also be stored at a set location until all documentation has been received and approved.

#### 4.2.2 Conformance Testing

After delivery or at the manufacturer's plant, GCL samples shall be obtained at the frequency specified in Table V-2 for conformance testing.

**Sample Procedures.** Samples shall be taken across the entire roll width and shall not include the first 2 feet. Unless otherwise specified, samples shall be 2 feet long by the roll width. On each sample, the CQA monitor or representative collecting the sample shall mark the machine direction, the manufacturer's roll identification number, and the date the sample was obtained. Any roll that cannot be identified shall be rejected by the CQA monitor.

**Tests** The following laboratory testing shall be conducted:

- Moisture content
- Mass per unit area
- Grab strength<sup>1</sup>
- Permeability<sup>1</sup>
- Shear strength<sup>1</sup> (refer to project specifications)

<sup>1</sup> One per project sent to laboratory

Samples shall be taken at the frequencies and tested for the properties stated in Table V-2 or in the project specifications.

When optional procedures are noted in the tests method, the specification requirements shall prevail. The CQA monitor will review all test results and report any nonconformance to the project manager and to the installer.

#### 4.2.3 Installation

**Surface Preparation.** Before GCL installation, the CQA monitor will ensure that:

- All lines and grades have been verified by a qualified surveyor.
- The GCL subgrade has been prepared consistent with the earthwork specifications.

- The GCL subgrade has been compacted and smoothed to be free of surface irregularities, runs, loose soil, and protrusions, consistent with the specifications.
- There are no excessively soft areas that could result in GCL liner damage (see earthwork specification for remedial measures).
- The GCL subgrade moisture content does not exceed the specified value (see earthwork specifications).
- All voids and cracks in the subgrade have been filled and there are no ruts in the subgrade greater than 1 inch deep.
- Construction stakes and hubs have been removed.
- The installer has certified, in writing, that the surface on which the GCL will be installed is acceptable.

**GCL Panel Placement.** During GCL panel placement, the CQA monitor shall:

- Observe the underlying surface for entrapped particles that may impact the GCL.
- Observe the surface of the GCL for needles, punctures, tearing, thinning, or other evidence that the material may not meet specification requirements.
- Inspect the GCL for evidence of premature hydration, such as wet areas or swelling. Hydrated areas shall be removed and replaced with dry material.
- Verify that equipment used in deployment does not damage the GCL.
- Verify that GCL panels are deployed down, not across, slopes.
- Verify that GCL panels deployed are covered the same day. GCL must be inspected and approved by CQA monitor before covering.
- Verify that the GCL is placed with the correct sides facing up and down.
- Verify that adequate anchor trenches are constructed.

The CQA monitor shall inform the installer and the project manager if the above conditions are not met.

**Field Seaming.** During GCL placement, the CQA monitor shall verify that:

- The panels overlap at least 6 inches on vertical seams, and a minimum of 12” or manufacturer’s recommended overlap, whichever is greater, on horizontal seams.

- Granular bentonite is applied at the specified rate, unless otherwise provided in the specifications.

**Repairs.** Any portion of the GCL with a flaw shall be repaired consistent with the specifications. The CQA monitor shall verify that

- All punctured, torn, or hydrated material is removed.
- The GCL “patch” is placed with the same side up as the originally placed material.
- The patch overlaps the repair area at least 12 inches in all directions.
- The patch is secured in place, if necessary, using procedures identified in the specifications.
- Bentonite is applied.

**Final Moisture Verification.** If required in the specifications, the CQA monitor shall verify that the moisture content of the GCL does not exceed a prescribed maximum allowable value on the day it is covered with a geomembrane.

#### **4.2.4 Deficiencies**

When deficiencies (items that do not meet specified values) are discovered, the CQA monitor shall immediately determine the nature and extent of the problem, notify the CQA officer and installer, and complete required documentation. In all cases, the CQA monitor will notify the installer within 1/2 hour after discovering the deficiency, or on the next working day if discovered at the end of a shift. If the deficiency will cause construction delays of more than 8 hours or will necessitate substantial rework, the CQA monitor shall also notify the owner.

The installer shall correct the deficiency to the satisfaction of the CQA officer. If the installer is unable to correct the problem, the CQA monitor will develop and present to the owner suggested solutions for his approval. If the solution requires a design modification, the design engineer shall also be contacted.

The corrected deficiency shall be retested before additional work is performed. All retests and the steps taken to correct the problem shall be documented by the CQA monitor.

### **4.3 Geomembrane**

#### **4.3.1 Delivery**

Upon delivery of the geomembrane, the CQA monitor will verify that

- The geomembrane is delivered in rolls and not folded. Folded geomembrane is not acceptable because the highly crystalline structure of the geomembrane will be damaged if it is folded. Any evidence of folding or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls does not damage the geomembrane.
- The geomembrane is stored in an acceptable location and in accordance with the specifications. The geomembrane is protected from puncture, dirt, grease, mud, mechanical abrasions, excessive heat, or other damage.
- All manufacturing documentation required by the specifications has been received.
- Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until all documentation has been received, reviewed, and accepted.

#### **4.3.2 Submittal Review**

The CQA consultant or his representative should review contractor submittals required in the specifications. The owner should be notified of submittals that have not been made at the required time. Submittals should be consistent with the specifications requirements and any deficiencies should be reported to the owner.

#### **4.3.3 Conformance Testing**

**Tests.** Geomembrane samples will be obtained for testing at the frequencies stated in Table V-2. The samples will be forwarded to the testing laboratory for the following conformance tests:

- Density
- Carbon black content
- Carbon black dispersion
- Thickness
- Tensile properties
- Shear strength

Where optional procedures are noted in the test method, the specification requirements prevail. The CQA officer may require additional test procedures, and will inform the testing

laboratory in writing. The CQA monitor must review all test results and report any nonconformance to the CQA officer before product installation.

**Sampling Procedure.** Samples will be taken either at the manufacturing plant by the testing laboratory before rolls are shipped, or at the site by the CQA monitor after rolls are shipped. In either case, the sampling procedures are the same.

Specimens should be taken across the entire roll width and should not include the first 1 foot. Five 1-foot by 1-foot specimens should be taken from the roll. Specimen locations should be evenly spaced across the roll width and be limited to the first 5 feet of geomembrane (i.e., taken near the end of the roll). The five specimens constitute one sample. The sampler should mark the roll identification number and machine direction on each specimen. The five specimens from any one sample should be taped together or otherwise packaged so that they do not become separated before arriving at the testing laboratory. A test request sheet should be included with each shipment. Samples should be shipped so that they arrive at the laboratory within 24 hours after sampling. In addition, a minimum 1-foot by 5-foot specimen from each sample should be retained by the testing laboratory at least until the project is completed.

#### 4.3.4 Panel Placement

Before installation of the geomembrane, the contractor must submit drawings showing the panel layout, indicating the panel identification number, both fabricated (if applicable) and field seams, as well as details not conforming to the drawings. This submittal is used to guide the orientation of panel placement during construction.

During placement, the CQA monitor must maintain up-to-date logs documenting panel and roll numbers, seam numbers, test locations and results, repair locations and results, and nondestructive testing information. The CQA monitor will review the contractor-prepared as-built (record) drawings, using the logs as reference.

During panel placement, the CQA monitor should

- Verify that the geomembrane is placed with texturing as directed by the construction drawings.
- Record panel numbers and dimensions on a panel/seam log.
- Observe the geomembrane surface as it is deployed and record all panel defects and repair of the defects. All repairs must be made in accord with the specifications.
- Verify that equipment used does not damage the geomembrane during handling or equipment transit, by contact with hydrocarbons, or by other means.

- Verify that the GCL beneath the geomembrane has not been damaged since previous acceptance.
- Verify there are no stones, construction debris, or other items beneath the geomembrane that could cause damage to the geomembrane.
- Verify that the geomembrane is not dragged across an unprotected surface. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, if necessary.
- Record weather conditions, including temperature, wind, and humidity. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, geomembrane should not be seamed when the air temperature is less than 32°F, or when standing water or frost is on the ground. Seaming below 32°F may be allowed as the discretion of the CQA consultant if means are taken to protect the geomembrane seam area from adverse temperatures and additional trial welds pass. The geomembrane should not be deployed during excessive winds that can lift and move the geomembrane panels.
- Verify that people working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.
- Verify that the method used to deploy the sheet minimizes wrinkles and that the sheets are anchored and ballasted to prevent movement by the wind. (The contractor is responsible for any damage resulting to or from windblown geomembrane.)
- Verify that no more panels are deployed than can be seamed on the same day. This is particularly important if seaming problems are occurring.

The CQA monitor must inform both the contractor and the CQA officer if the above conditions are not met.

#### **4.3.5 Field Seaming**

The contractor must provide the CQA officer and monitor with a seam and panel layout drawing and update this drawing daily as the job proceeds. No panels should be seamed until the panel layout drawing has been accepted by the CQA monitor. A seam numbering system must be agreed to by the CQA monitor and contractor before the start of seaming operations. One procedure is to identify the seam by adjacent panels.

Before geomembrane welding, each welder and welding apparatus (both wedge and extrusion welders) must be tested in accordance with the specifications to determine whether the equipment is functioning properly. One trial weld should be taken before the start of work and one at mid-shift. A third trial seam at the end of the day should be considered if

seam quality is in question or temperatures fall below 32°F. The trial weld sample must be 3 feet long and 12 inches wide, with the seam centered lengthwise. The CQA monitor must observe all welding operations, quantitatively test each trial weld for peel and shear, and record the results. It is very important that the trial weld be completed under conditions similar to those under which the panels will be welded. The trial weld must meet specified requirements for peel and shear and the break must be ductile or a film tearing bond (FTB) for a wedge weld. If at any time the CQA monitor believes that an operator or welding apparatus is not functioning properly, a weld test must be performed. If there are wide changes in temperature (20°F), humidity, or wind speed, the test weld should be repeated. The test weld must be allowed to cool to ambient temperature before testing.

During geomembrane welding operations, the CQA monitor must verify the following:

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Equipment used for welding will not damage the geomembrane.
- The extrusion welder is purged before beginning a weld until all the heat-degraded extrudate is removed (extrusion welding only).
- Seam grinding has been completed less than one hour before seam welding, and the upper sheet is beveled (extrusion welding only).
- Grind marks do not extend more than 1/4 inch from the edge of the weld.
- The geomembrane surface temperature is between 32 and 130° F.
- The ends of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only).
- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture before welding.
- The weld is free of dust, rocks, and other debris.
- For cross seams, the seam is ground to a smooth incline before welding (fusion welding only).
- The seams are overlapped a minimum of 3 inches for extrusion and 4 inches for hot wedge welding, or in accord with manufacturer's recommendations, whichever is more stringent.
- No solvents or adhesives are present in the seam area.

- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- If necessary, a strip of geomembrane, wide enough and long enough to protect the hot wedge welder from running on the subgrade, is placed below the geomembrane. This piece may be as long as the seam itself or shorter and moved along with the seaming equipment. If necessary, a firm substratum such as a flat board or similar hard surface is placed directly under the weld overlap to achieve firm support.
- The panels are welded in accord with the plans and specifications.
- There is no free moisture in the weld area.

### 4.3.6 Construction Testing

Construction testing is performed on seams welded at the construction site. These tests include quality control and quality assurance testing performed by the contractor.

#### 4.3.6.1 Nondestructive Seam Testing

The purpose of nondestructive testing is to detect discontinuities or holes in the seam, and it indicates whether a seam is continuous and nonleaking. Nondestructive tests for geomembrane include vacuum testing and air-pressure testing. Nondestructive testing must be performed over the entire length of the seams constructed on site.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to observe performance of the testing in compliance with the specifications, locate seam defects, and document their repairs. Nondestructive testing procedures are documented in the specifications and are generally described below.

- For welds tested by vacuum method, the weld is placed under suction using a vacuum box made of rigid housing, with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section that has been thoroughly saturated with a soapy water solution (1 ounce of soap to 1 gallon of water). The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner, to ensure a leak-tight seal. The vacuum pump is energized and the vacuum box pressure reduced to approximately 5 pounds per square inch (psi) gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than 10 seconds.
- Pressure testing is used to test double seams that have an enclosed air space between them. Both ends of the air channel should be sealed. The pressure feed device, usually a needle equipped with a pressure gauge, is inserted into the channel. Air is

then pumped into the channel to a minimum pressure of 30 psi. A 2-minute relaxing period is allowed for the pressure to stabilize. The air chamber must sustain the pressure for 5 minutes without losing more than 2 psi. After a passed pressure test, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing, by capping.

During nondestructive testing, the CQA monitor should perform the following:

- Review technical specifications regarding test procedures.
- Verify that equipment operators are fully trained and qualified to perform their work.
- Verify that test equipment meets project specifications.
- Verify that the entire length of each seam is tested in accord with the specifications.
- Observe all continuity testing and record results.
- Verify that all testing is completed in accord with the project specifications.
- Identify the failed areas by marking them with a waterproof marker compatible with the geomembrane and inform the contractor of the areas that require repair.
- Verify that all repairs are completed and tested in accord with the project specifications.
- Record all completed and tested repairs.

#### 4.3.6.2 Destructive Seam Testing

Destructive seam tests will be performed independently by the installer and CQA consultant at intervals stated in the project specifications. However, the CQA monitor must perform additional tests if there is suspicion that a seam does not meet specification requirements. Reasons for performing additional tests may include, but are not limited to:

- Wrinkling in seam area
- Excess crystallinity
- Suspect seaming equipment or techniques

- Weld contamination
- Insufficient overlap
- Adverse weather conditions
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam
- Failing tests

There are two types of destructive testing required for the geomembrane installation: peel adhesion (peel) and bonded seam strength (shear). The purpose of peel and shear tests is to evaluate seam strength and long-term performance. Shear strength measures the continuity of tensile strength through the seam and into the parent material. Peel strength determines weld quality. Test welds must be allowed to cool naturally to ambient temperature before testing. Destructive testing must be performed concurrently with seaming operations, not at the completion of the entire installation.

The CQA monitor selects locations where seam samples will be cut for laboratory testing. Select locations as follows:

- A minimum of one test per 500 feet of welded seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals.
- A maximum frequency must be agreed to by the contractor and CQA monitor at the preconstruction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the CQA monitor. Samples taken as the result of failed tests do not count toward the total number of required tests.
- Test locations are at the discretion of the CQA monitor and may be selected on the basis of liner distortion, weld contamination, or other potential areas of poor seaming.

The CQA monitor will not inform the contractor in advance of selecting the destructive sample locations.

#### 4.3.6.3 Destructive Test Sampling Procedures

The contractor will remove samples at locations identified by the CQA monitor. The CQA monitor must

- Observe sample cutting.
- Mark the top of each sample with an identifying number.

- Log the seam number, destructive test number, welder, date, and time on the appropriate logs.
- Record sample location.
- Record the sample location, weather conditions, and reason sample was taken (random sample, visual appearance, result of a previous failure, etc.).

Two types of samples must be taken at each test location. First, obtain two sets of seam specimens 42 inches apart with the weld centered across the samples' length. Each set consists of two specimens that are 1 inch wide by 12 inches long. The contractor must test each set in the field using a tensiometer capable of quantitatively measuring shear and peel strengths. For double-wedge welding, test both welds. The CQA monitor must observe the tests. A geomembrane seam sample passes when the break is a ductile, FTB. An FTB means the test strip must break at the edge or the outside of the seam, but not in the seam. In addition, the seam strength must meet the specified values.

If one or more of the 1-inch specimens fails in either peel or shear, the contractor can, at his discretion, (1) reconstruct the entire seam between previous passing test locations, or (2) take another test sample 10 feet from the point of the failed test and repeat this procedure. If the second test passes, the contractor can either reconstruct or cap-strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated, until the length of the poor-quality seam is established. Repeated failures indicate that either the seaming equipment or the operator is not performing properly, and appropriate corrective action must be taken immediately.

Once the field test specimens have passed, a sample must be recovered between the passing field specimen locations for laboratory testing. The sample must be 42 inches long by 12 inches wide, with the weld centered along the length. Divide the recovered sample into three parts: one 12-inch by 12-inch section for the contractor, one 12-inch by 18-inch section for the testing laboratory to test, and one 12-inch by 12-inch section for the owner to archive. Record the results of laboratory testing.

If the laboratory test fails in either peel or shear, the contractor must either reconstruct the entire seam, or recover additional samples at least 10 feet on either side of the failed sample for retesting. Sample size and disposition must be as described in the preceding paragraph. This process is repeated until passed tests bracket the failed seam section. All seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

#### 4.3.6.4 Testing Laboratory Destructive Testing

All CQA destructive samples must be shipped to the Geosynthetic Testing Laboratory to verify seam quality. Testing includes bonded seam strength and peel adhesion. Test at least five specimens from each sample in each method used. Minimum test values are presented

in the specifications. The testing laboratory must provide test results within 24 hours, in writing or via telephone, to the CQA monitor. Certified test results are to be provided within five days. The CQA monitor must immediately notify the contractor in the event of a failed test result. The geomembrane may not be covered, except as necessary to provide wind protection, until passing results are received from the testing laboratory.

### 4.3.7 Repairs

Any portion of the geomembrane that is flawed or fails a nondestructive or destructive test, or portions where destructive tests were cut or nondestructive tests left cuts or holes, must be repaired in accord with the specifications. The CQA monitor must locate and record all repairs. Repair techniques include the following:

- Patching—used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- Extrusion—used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 1/2-inch in the largest dimension.
- Capping—used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested (also used to cap tee-seams where wedge-welding is used).
- Removal—used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal must be patched or capped.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than 1 hour before the repair.
- Clean and dry all surfaces at the time of repair.
- Verify acceptance of the repair procedures, materials, and techniques by the CQA monitor in advance of the specific repair.
- Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches before extrusion welding.

### **4.3.8 Wrinkles**

During placement of operations layer over the geomembrane, temperature changes or creep may cause wrinkles to develop in the geomembrane. Any wrinkles that can fold over must be repaired either by cutting out excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane, which could result in the geomembrane folding. Panels that are being seamed together should be at approximately the same temperature and have approximately the same amount of wrinkling. The CQA monitor must monitor geomembrane for wrinkles and notify the contractor if wrinkles are being covered with soil. The CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

### **4.3.9 Geomembrane Anchor Trench**

The geomembrane should be placed in the anchor trench to the dimensions shown on the construction drawings. Excess material must be removed before the anchor trench is backfilled. The geomembrane anchor trench is left open until panels are seamed together. Expansion and contraction of the geomembrane should be accounted for in the liner placement. The anchor trench should be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

### **4.3.10 Geomembrane Acceptance**

The contractor retains all ownership and responsibility for the geomembrane until acceptance by the owner. In the event the contractor is responsible for placing materials over the geomembrane, the contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete and the cover material is placed. After panels are placed, seamed, tested successfully, and repairs made, the completed installation is walked by the owner's and contractor's representatives. Any damage or defect found during this inspection is repaired properly by the installer. The installation is not accepted until it meets the requirements of both representatives. In addition, the geomembrane is accepted by the CQA officer only when the following has been completed:

- The installation is finished.
- All seams have been inspected and verified to be acceptable.
- All required laboratory and field tests have been completed and reviewed.
- All required contractor-supplied documentation has been received and reviewed.
- All record drawings have been received and reviewed by the CQA monitor. The record drawings show the true panel dimensions, and the locations of seams, trenches, pipes, appurtenances, and repairs.

## 4.4 Geocomposite

Nonwoven geocomposite is utilized on this project as a drainage medium conveying leachate migrating toward the landfill liner into the LCRS. Proper installation of geocomposite is essential to ensure that the system operates as intended.

### 4.4.1 Delivery

During delivery, the CQA monitor must verify the following:

- Equipment used to unload the rolls will not damage the geocomposite.
- Rolls are wrapped in impermeable, opaque protection covers.
- Care is used to unload the rolls.
- All documentation required by the specifications has been received.
- Each roll is marked or tagged with the following information: manufacturer's name, project identification, lot number, roll number, and roll dimensions. Log this information on the geosynthetics received log.
- The geosynthetics received log is completed
- Materials are stored in a location that will protect the rolls from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls must be rejected and removed from the site or stored at a location, separate from accepted rolls, designated by the owner. All rolls that do not have proper manufacturer's documentation must also be stored at a separate location, until all documentation has been received and approved.

### 4.4.2 Conformance Testing

**Tests.** After delivery, the CQA monitor must obtain geocomposite conformance test samples from the material delivered to the site at the frequency listed in Table V-2. Forward samples to the testing laboratory for the following tests:

- Thickness
- Grab tensile strength and density
- Peel strength
- Transmissivity

Where optional procedures are noted in the test method, the specification requirements prevail. The CQA monitor reviews all test results and reports any nonconformance to the CQA officer and contractor.

**Sampling Procedure.** Obtain samples across the entire roll width and do not include the first 2 feet. Unless otherwise specified, samples must be 3 feet long by the roll width. Mark the manufacturer's roll identification number, as well as the machine direction, on the sample. Fill out a test request sheet and include with the shipment. Samples should be shipped so that they arrive at the laboratory with 24 hours after sampling.

#### 4.4.3 Geocomposite Installation

**Surface Preparation.** Before geocomposite installation, the CQA monitor must verify the following:

- All lines and grades have been verified by the contractor.
- The subgrade has been prepared in accord with the earthwork specification, and the geomembrane installation, including all required documentation, has been completed.

**Geocomposite Placement.** During geocomposite placement, the CQA monitor must

- Observe the geocomposite as it is deployed and record all defects and disposition of the defects (panel rejected, patch installed, etc.). All repairs are to be made in accord with the specifications.
- Verify that equipment used does not damage the geocomposite by handling, equipment transit, leakage of hydrocarbons, or other means.
- Verify that people working on the geocomposite do not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite.
- Verify that the geocomposites are anchored to prevent movement by the wind.
- Verify that the panels overlap as specified.
- Verify that the geocomposite was not exposed to direct sunlight for more than five days except for the geocomposite over the sideslope geomembrane.
- Verify that the geonet component is joined to adjacent panels using nylon zip-ties at the spacing specified prior to seaming or geotextile component. Use of zip-ties of a contrasting color to the geonet material aids in visual identification of zip-tie installation and spacing.

- Verify that the geotextile component is seamed to adjacent panels by stitching or heat bonding prior to installation of operations soil layer.
- Examine the geocomposite after installation to ensure that no potentially harmful foreign objects are present.

The CQA monitor must inform both the contractor and the CQA officer if the above conditions are not met.

## **4.5 Geotextiles**

Nonwoven geotextile is utilized on this project as a separator around the gravel fill. Proper installation of geotextile is essential to ensure that the system operates as intended.

### **4.5.1 Delivery**

During delivery, the CQA monitor must verify the following:

- Equipment used to unload the rolls will not damage the geotextile.
- Rolls are wrapped in impermeable, opaque protection covers.
- Care is used to unload the rolls.
- All documentation required by the specifications has been received.
- Each roll is marked or tagged with the following information: manufacturer's name, project identification, lot number, roll number, and roll dimensions. Log this information on the geosynthetics received log.
- The geosynthetics received log is completed
- Materials are stored in a location that will protect the rolls from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls must be rejected and removed from the site or stored at a location, separate from accepted rolls, designated by the owner. All rolls that do not have proper manufacturer's documentation must also be stored at a separate location, until all documentation has been received and approved.

## 4.5.2 Conformance Testing

**Tests.** After delivery, the CQA monitor must obtain geotextile conformance test samples from the material delivered to the site at the frequency listed in Table V-2. Forward samples to the testing laboratory for the following tests:

- Tensile strength and elongation
- Puncture resistance
- Permittivity
- Trapezoidal tear strength
- Apparent opening size (AOS)
- Mass per unit area

Where optional procedures are noted in the test method, the specification requirements prevail. The CQA monitor reviews all test results and reports any nonconformance to the CQA officer and contractor.

**Sampling Procedure.** Obtain samples across the entire roll width and do not include the first 2 feet. Unless otherwise specified, samples must be 3 feet long by the roll width. Mark the manufacturer's roll identification number, as well as the machine direction, on the sample. The geotextile may be folded for shipping. Fill out a test request sheet and include with the shipment. Samples should be shipped so that they arrive at the laboratory with 24 hours after sampling.

## 4.5.3 Geotextile Installation

**Surface Preparation.** Before geotextile installation, the CQA monitor must verify the following:

- All lines and grades have been verified by the contractor.
- The subgrade has been prepared in accord with the earthwork specification, and, if placed over a geomembrane, the geomembrane installation, including all required documentation, has been completed.
- The supporting surface does not contain stones larger than 1-inch size that could damage the geotextile.
- There are no excessively soft areas that could result in damage to the geotextile.

- All construction stakes and hubs have been removed.

**Geotextile Placement.** During geotextile placement, the CQA monitor must

- Observe the geotextile as it is deployed and record all defects and disposition of the defects (panel rejected, patch installed, etc.). All repairs are to be made in accord with the specifications.
- Verify that equipment used does not damage the geotextile by handling, equipment transit, leakage of hydrocarbons, or other means.
- Verify that people working on the geotextile do not smoke, wear shoes that could damage the geotextile, or engage in activities that could damage the geotextile.
- Verify that the geotextiles are anchored to prevent movement by the wind.
- Verify that the panels overlap a minimum of 24 inches.
- Verify that the geotextile was not exposed to direct sunlight for more than five days except for the geotextile over the sideslope geomembrane.
- Examine the geotextile after installation to ensure that no potentially harmful foreign objects are present.

The CQA monitor must inform both the contractor and the CQA officer if the above conditions are not met.

#### **4.5.4 Repairs**

Repair procedures include:

- Patching—used to repair large holes, tears, large defects, and destructive sample locations.
- Removal—used to replace areas with large defects where the preceding method is not appropriate.

Holes, tears, and defects must be repaired in the following manner. Soil or other material that may have penetrated the defect must be removed completely before repair. Should any tear, hole, or defect exceed 20 percent of the width of the roll, the roll must be removed and replaced. If the defect is not located on a slope, the patch must be made using the same type of material placed with a minimum 24-inch overlap in all directions.

## 4.6 HDPE or PVC Pipe

HDPE pipe is used on this project as part of the leachate collection and removal and drainage systems. Proper installation of pipe is essential to ensure that the systems operate as intended.

### 4.6.1 Delivery

During delivery, the CQA monitor must verify the following:

- Equipment used to unload the pipe does not damage the pipe.
- The pipe is stacked consistent with the manufacturer's recommendations.
- Pipe is proper size and dimension.
- Perforated pipe has holes in locations and dimensions specified in the contract documents.
- All documentation required by the specifications has been received.
- Each section is marked according to specification requirements, including pipe manufacturer, SDR size, ASTM designation, and date of manufacturer.
- The geosynthetics received log is completed.

Any damaged pipe must be rejected and removed from the site or stored at a location, separate from the accepted pipe designated by the owner. All pipe that does not have proper manufacturer's documentation must also be stored at a separate location, until all documentation has been received and approved.

### 4.6.2 Installation

The CQA monitor should verify:

- Pipe is installed to the lines and grades shown on the drawings.
- Pipe segments are joined consistent with the manufacturer's recommended procedure.
- Pipe installation is performed with minimum amount of lifting and moving.
- Fittings are not used as the point of attachment for lifting.

- Loose material (shavings, soil, stones, etc.) are removed from the pipe prior to assembly or welding.

## 5 DOCUMENTATION

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The quality assurance program depends on thorough monitoring and documentation of all construction activities during liner installation, pipe and gravel installation, operations/drainage layer placement, stormwater diversion, etc. Therefore, the CQA officer and monitors will document that all quality assurance requirements are addressed and satisfied. Documentation consists of daily record-keeping, testing and installation reports, nonconformance reports (if necessary), progress reports, design and specification revisions, and a construction report.

### 5.1 Daily Record Keeping

At a minimum, daily records consist of construction progress, daily construction report, observation and test data sheets, and, as needed, nonconformance/corrective measure reports. All forms are copied to the CQA officer for review.

#### 5.1.1 Daily Record of Construction Progress

The daily field report will summarize ongoing construction and discussions with the contractor, and will be prepared by the CQA monitors. At a minimum, the report will include the following:

- Date, project name, project number, and location
- Weather data
- A description of all ongoing construction for the day in the area of the monitor's responsibility
- An inventory of equipment used by the contractor
- Items of discussion and names of parties involved in discussions
- A brief description of tests and observations, identified as passing or failing, or, in the event of failure, a retest
- Areas of nonconformance/corrective actions, if any, (nonconformance/corrective action form to be attached)

- Summary of materials received and quality documentation
- Follow-up information on previously reported problems or deficiencies
- Record of any site visitors
- Signature of CQA monitor

### **5.1.2 Observation and Test Data Sheets**

Observation and test data sheets should include the following information as appropriate for the form being used:

- Date, project name, and location
- Weather data, as applicable
- A reduced-scale site plan showing sample and test locations
- Test equipment calibrations, if applicable
- A summary of test results identified as passing, failing, or, in the event of a failed test, retest
- Completed calculations
- Signature of the CQA monitor
- Signature of the CQA officer

Sample test report forms and installation documentation forms will be submitted to the design engineer and owner for approval.

### **5.1.3 Nonconformance Reports**

In the event of a nonconformance event, a nonconformance verification report form is included with the daily report. Procedures for implementing and resolving any nonconformances to the specification are outlined in Section 2.5 of this CQA manual.

## **5.2 Photographs**

Construction activities will be photographed. Photographs include any significant problems encountered and corrective actions, and document construction progress. The photographs

are identified by location, time, and date. Photographs will be included in the Construction Certification Report to document key events/features of construction.

### **5.3 Design and Specification Changes**

Design and specification changes may be required during construction and are only made with written agreement of the design engineer, owner, and contractor. The regulatory agencies are notified by the CQA officer of any significant changes. When change orders are issued, they are prepared by the owner with technical input from the design engineer and CQA officer. The owner distributes change orders to the required parties for signature and execution.

### **5.4 Construction Report**

At the completion of the project, the CQA officer submits a final Construction Certification Report. This report documents that the liner and leachate collection system have been constructed in substantial compliance with the construction drawings and specifications.

At a minimum, the report contains

- A summary of major construction activities
- A summary of laboratory and field test results
- Sampling and testing location drawings
- A description of significant construction problems and the resolution of these problems
- A list of changes from the construction drawings and specifications and the justification for these changes
- Record drawings
- A statement of compliance with the construction documents and design intent

All surveying and base maps required for the development of the record drawings are prepared by the project surveyor. The final Construction Certification Report will be signed and sealed by the CQA officer.

## TABLES

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**Table V-1**  
**Soil and Rock Construction Testing Frequencies**  
**Construction**  
**Marana Regional Landfill**  
**Marana, Arizona**

Tests <sup>1</sup>	Test Method <sup>2</sup>	Earthfill (cy) <sup>3</sup>	Gravel Fill (cy)
<u>Laboratory Testing</u>			
Compaction Characteristics	D 698	5,000	--
Particle Size	D 422	5,000	
	C 136	--	500
Liquid and Plastic Limits (Atterberg)	D 2487	--	--
Permeability	D 5084	--	--
	D 2434	--	500
<u>Field Testing<sup>4</sup></u>			
In-Place Density	D 2922	500	--
	D 1556	10,000 <sup>5</sup>	--
Moisture Content	D 3017	500	--
	D 2216	10,000 <sup>6</sup>	--
<sup>1</sup> Minimum one test for every material type or quantity shown, whichever results in a greater number of tests. CQA officer may require more tests based on test results and/or field conditions. <sup>2</sup> Test methods are ASTM unless otherwise indicated. Alternative test methods and frequencies may be utilized as appropriate to industry standards and approved by the design engineer, CQA officer and owner. <sup>3</sup> cy - cubic yards. <sup>4</sup> "Field Testing" includes testing performed in the laboratory. <sup>5</sup> Perform one field density test at the frequency indicated by either the sand cone or drive cylinder method. <sup>6</sup> Perform one laboratory moisture content test at the frequency indicated by either the (forced-draft) oven or microwave oven method.			

**Table V-2**

**Geosynthetics Testing Frequencies  
Construction  
Marana Regional Landfill  
Marana, Arizona**

Test <sup>1</sup>	Test Method <sup>2</sup>	GCL (ft <sup>2</sup> )	Geomembrane (ft <sup>2</sup> )	Geotextile (ft <sup>2</sup> )	Geocomposite (ft <sup>2</sup> )
<b>Laboratory Testing</b>					
Moisture Content	D 2216	100,000			
Flow Rate	D 1238				
Grab Tensile Strength and Elongation	D 4632	1 Test		100,000	
Tear Strength	D 4533			100,000	
Puncture Resistance	D 4833			100,000	
Permittivity	D 4491			100,000	
Apparent Opening Size	D 4751			100,000	
Mass per Unit Area	D 5261 or D 5993	100,000		100,000	
Thickness	Micrometer		100,000		100,000
Density	D 792, Method A, or D1505		100,000		100,000
Carbon Black Content	D 1603		100,000		100,000
Carbon Black Dispersion	D 5596		100,000		100,000
Tensile Properties	D 638		100,000		100,000
Permeability	D 5887	1 Test			1 Test
Shear Strength	D5321	1 Test per liner system configuration <sup>3</sup>			
<p>1. Minimum one test for every material batch or quantity shown, whichever results in a greater number of tests. CQA officer may require more tests based on test results and/or field conditions.</p> <p>2. Test methods are ASTM designations unless otherwise indicated. Alternative test methods and frequencies may be utilized as appropriate to industry standards and approved by the design engineer, CQA officer and owner.</p> <p>3. Shear test liner system configuration as installed with failure possible via soil/GCL, internal GCL, GCL/Geomembrane, or Geomembrane/drainage layer interface. Note at which interface failure occurs.</p>					



# FIGURES

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Organizational Chart to be developed on a per project basis and inserted here.