

CONSTRUCTION QUALITY ASSURANCE PLAN
FOR THE INSTALLATION
OF CHLOROSULFONATED POLYETHYLENE
GEOMEMBRANE LINERS

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SOUTHWEST DISTRICT TAMPA

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1. INTRODUCTION

1.1 Terms of Reference

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This plan addresses the Construction Quality Assurance (CQA) of the installation of chlorosulfonated polyethylene (CSPE) geomembranes used by Waste Management of Florida (WMF) in construction of the Southeast Hillsborough County Landfill Expansion, Cells 5 and 6.

The CSPE geomembrane component of lining systems used in Cells 5 and 6 Expansion project. It should be emphasized that extreme care and careful documentation are required in the production and installation of all CSPE geomembrane. This plan therefore delineates the CQA procedures and standards for the production and installation of the CSPE geomembrane.

This plan reflects the requirements of the Hazardous and Solid Waste Amendments of 1984 to the Resource Conservation and Recovery Act (RCRA), and "Construction Quality Assurance for Hazardous Waste Land Disposal Facilities", Technical Guidance Document, Document EPA/530-SW-86-031, October 1986.

1.1.2 Construction Quality Assurance and Construction Quality Control

This plan is devoted to CQA, not to Construction Quality Control (CQC). In the context of this plan, CQA and quality control are defined as follows:

Construction Quality Assurance - A planned and systematic pattern of all means and actions designed to provide adequate confidence that items or services meet contractual and regulatory requirements, and will perform satisfactorily in service.

Construction Quality Control - Those actions which provide a means to measure and regulate the characteristics of an item or service to contractual and regulatory requirements.

In the context of liner production and installation:

- CQA refers to means and actions employed by the Geosynthetic CQA Consultant to assure conformity of the lining system production and installation with the CQA Plan, drawings and specifications.

CQA is provided by a party independent from production and installation.

- CQC refers to those actions taken by the Manufacturer, Fabricator, and Installer to ensure that the materials and the workmanship meet the requirements of the plans and specifications. Quality Control is provided by the manufacturers of the various components of the lining system (the "geosynthetics") and their Installer(s).

1.1.3 Lining Materials

The material comprising this lining system is a geomembrane. For the purpose of this document, the term "geomembrane" refers to CSPE geomembranes. The CSPE geomembrane is the key components of the lining system, and, therefore, none of the geomembrane requirements contained herein should be compromised in any way.

The CQA of geosynthetics is addressed herein in its entirety, including all stages from manufacture to installation. The CQA of soils is only discussed relative to their interaction with the geomembrane.

1.1.4 Terms of Reference

The scope of this plan includes the CQA applicable to manufacturing, fabrication (if applicable), shipment, handling, and installation of the CSPE geomembrane. In particular, full time CQA of the fabrication and installation of the geomembrane. The degree of periodic CQA of the other operations such as manufacturing should be determined in accordance with the requirements of project specifications submitted by the Design Engineer.

This plan does not address design guidelines, installation specifications, or selection of geomembranes and other geosynthetics (which includes compatibility between geosynthetic and contained material).

This plan does not address the CQA of soils, except in cases where soil placement may have an influence on the geosynthetics.

A CQA review of the design, including calculations, plans, drawings, and specifications, should also be carried out for each project, in addition to, and independent of, the programs outlined herein. Such

quality assurance of the design (peer review) is therefore beyond the scope of this plan.

1.1.5 Units

In this plan, all properties and dimensions are expressed in U.S. units, with "equivalent" SI units in parentheses. It should be noted that the conversion is typically only accurate within ten per cent. In cases of conflict or clarification, the U.S. units shall be deemed to govern.

1.1.6 References

The plan includes references to test procedures of the American Society for Testing and Materials (ASTM), the Federal Test Method Standards (FTMS) and the "Standards for Flexible Membrane Liners" of the National Sanitation Foundation (NSF). Recognizing the changing nature of the above standards and the geosynthetic industry at large, this plan is subject to periodic revision.

1.2 Parties

The completion of municipal solid waste disposal facilities is dependent on the interaction of many parties. The parties discussed below are those associated with the ownership, design, specification, manufacture, fabrication (if applicable), transportation, installation, and CQA of the liner system. The qualifications of the Installer and Geosynthetic CQA Consultant are particularly critical to the successful completion of the lining systems, and must be emphasized in the CQA Plans.

1.2.1 Designer

The Designer is responsible for the design, drawings, plans and specifications of the lining system.

1.2.2 Earthwork Contractor

The Earthwork Contractor is responsible for the preparation of the supporting soil on which the lining system is to be installed, and may also be the party responsible for placing earth and granular materials (if any) over the installed lining system.

1.2.3 Resin Supplier

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

1.2.4 Geomembrane Manufacturer

The Geomembrane Manufacturer is responsible for the production of geomembrane rolls from resin.

1.2.5 Fabricator

The Fabricator (if applicable) is responsible for the fabrication of factory panels of geomembranes constructed from rolls received from the Manufacturer. He may also be responsible for delivery of the factory panels to the site.

1.2.6 Installer

The Installer is responsible for field handling, storing, placing, seaming, loading (against wind), and other aspects of the geomembrane installation. The Installer may also be responsible for transportation of the geomembranes to the site.

1.2.7 Transporter

The Transporter transports the factory panels of geomembrane between: the Manufacturer and the site; and/or between the Manufacturer and the Fabricator (if applicable), and/or between the Fabricator and the site.

1.2.8 Geosynthetic Quality Assurance Consultant

The Geosynthetic CQA Consultant is a party, independent from the Owner, Manufacturer, Fabricator, and Installer, that is responsible for observing and documenting activities related to the CQA of the production and installation of the geosynthetic components of the lining system, i.e., the geomembrane. He is also responsible for issuing a certification report, sealed by a Registered Professional Engineer in the State of Florida. The Geosynthetic CQA Consultant is often the party who provides

CQA of the geosynthetic aspects of the design. He is also responsible for supervising the laboratory testing of the geomembrane.

1.2.9 Soils Quality Assurance Consultant

The Soils CQA Consultant is a party, independent from the Owner, Manufacturer, Fabricator and Installer that is responsible for observing, testing and documenting activities related to the CQA of the earthworks at the site. He is also responsible for issuing a certification report, sealed by a Registered Professional Engineer in the State of Florida. The Soils CQA Consultant may also be the Geosynthetics CQA Consultant, provided that he has demonstrated expertise in both areas.

1.2.10 Geosynthetic Quality Assurance Laboratory

The Geosynthetic CQA Laboratory is a party, independent from Owner, Manufacturer, Fabricator, and Installer, responsible for conducting tests on samples of geosynthetics taken from the site. The Geosynthetic CQA Laboratory service cannot be provided by any party involved with the manufacture, fabrication, or installation of any of the geosynthetic components.

1.2.11 Owner

The Owner owns, and/or is responsible for, the lined facility; in this plan, the term "Owner" shall apply equally to "Operator", i.e., the party responsible for operating the lined facility.

1.2.12 Project Manager

The Project Manager is the official representative of the owner; in this plan, the term "Project Manager" shall apply equally to "Construction Coordinator", i.e., the individual in charge of coordinating field activities.

1.2.13 Duties of Geosynthetic Quality Assurance Personnel

The personnel of the Geosynthetic CQA Consultant include:

- The Geosynthetic CQA Managing Engineer, who operates from the offices of the Geosynthetic CQA Consultant's firm and visits the site periodically.
- The Geosynthetic Site CQA Manager who is located at the site (and, if appropriate, at the fabrication plant).
- The Geosynthetic CQA Monitors who are located at the site (and, if appropriate, at the fabrication plant).

The duties of Geosynthetic CQA Personnel are as follows:

1.3 Geosynthetic CQA Consultant

1.3.1 Geosynthetic Quality Assurance Managing Engineer

The Geosynthetic CQA Managing Engineer:

- reviews all designs, plans, and specifications;
- reviews all other site-specific documentation, including bid documents, proposed layouts, and manufacturer's and installer's literature;
- develops a CQA plan specific to geosynthetics;
- attends the resolution meeting;
- administers the geosynthetic CQA program, i.e., assigns and manages all CQA personnel, reviews all field reports, and provides engineering review of all CQA related issues;
- provides CQA of the geosynthetic quality assurance personnel, including site visits;
- reviews all changes to design, plans and specifications; and
- with the Geosynthetic CQA Manager, prepares the final report, including a review of the Record Drawing(s).

In addition, the Geosynthetic CQA Managing Engineer may act as a third party peer reviewer for the design calculations.

1.3.2 Geosynthetic CQA Manager

The Geosynthetic Site CQA Manager:

- acts as the on-site (resident) representative of the Geosynthetic CQA Consultant;
- attends all CQA related meetings, i.e., resolution, pre-construction, daily, weekly, etc.;
- 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;
- prepares, or oversees the ongoing preparation of, the Record Drawing(s)
- assigns locations for destructive test sampling;
- notes any on site activities that could result in damage to the geosynthetics;
- reports to the Project Manager, and logs in his daily report, any relevant observations;
- prepares the weekly, or as agreed upon by the Project Manager, summary of Geosynthetic CQA activities;
- oversees the marketing, packaging and shipping of all laboratory test samples;
- reviews results of laboratory testing and makes appropriate recommendations;

- reports any unresolved deviations from the Geosynthetic CQA Plan to the Project Manager; and
- prepares the final report with the Geosynthetic CQA Managing Engineer.

1.4 Meetings and Visits

To guarantee a high degree of quality during installation, clear, open channels of communication are essential. To that end, meetings are critical.

1.4.1 Resolution Meeting

Following the completion of the design, plans, and specifications for the project, a Resolution Meeting shall be held. This meeting shall include all parties then involved, including the Geosynthetic CQA Managing Engineer, the Geosynthetic Site CQA Manager, the Soil CQA Consultant, the Design Engineer, and the Project Manager.

The purpose of this meeting is to be planning for coordination of tasks, anticipate any problems which might cause difficulties and delays in construction, and, above all, present the Geosynthetic CQA Plan to all the parties involved. It is very important that the rules regarding testing, repair, etc., be known and accepted by all.

The first part of the Resolution Meeting may be devoted to a review of the design drawings and specifications for completeness and clarity. This is different from the peer review of the design, including design calculations, which shall have been carried out previously.

This meeting should include all of the following activities:

- communicate to all parties any relevant documents;
- review critical design details of the project;
- review the seam layout drawing provided by the Designer, the Fabricator (if applicable), or the Installer;
- review the project specific Geosynthetic CQA Plan or take steps to develop it, whichever is appropriate;

- make any appropriate modification to the Geosynthetic CQA Plan, i.e., ensure that site-specific considerations are added to the plan;
- make any appropriate modifications to the Geosynthetic CQA Plan to ensure that it specifies all CQA activities that are necessary;
- make any appropriate modifications to the design criteria, plans, and specifications so that the fulfillment of all design specifications or performance standards can be determined through the implementation of the site-specific Geosynthetic CQA Plan;
- reach a consensus on the Geosynthetic CQA Plan and quality control procedures, especially on methods of determining acceptability of the lining system;
- assign responsibilities of each party;
- decide the number of spare seaming units to be maintained on site by the Installer (this number depends on the number of seaming crews and on the type of seaming equipment);
- establish methods for documenting and reporting, and for distributing documents and reports;
- establish lines of authority and communication; and
- prepare a time schedule for all operations.

The meeting shall be documented by a person designated at the beginning of the meeting, and minutes shall be transmitted to all parties.

1.4.2 Pre-Construction Meeting

A Pre-Construction Meeting shall be held at the site. As a minimum, the meeting shall be attended by the Installer, the Geosynthetic Site CQA Manager, the Earthwork Contractor, the Soils CQA Manager, and the Project Manager.

Specific topics considered for this meeting include:

- make any appropriate modifications to the project specific Geosynthetic CQA Plan;

- review the responsibilities of each party;
- review lines of authority and communication;
- review methods for documenting and reporting, and for distributing documents and reports;
- 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 the time schedule for all operations;
- conduct a site walk-around to verify that earthwork construction is proceeding on schedule, and to review material storage locations;
- review panel layout and numbering systems for panels and seams;
- finalize field cutout sample sizes;
- review seam testing procedures;
- review repair procedures; and
- review precautions to be taken to prevent damage to the subgrade surface.

The meeting shall be documented by a person designated at the beginning of the meeting, and minutes shall be transmitted to all parties. In certain instances, the Resolution Meeting and Pre-Construction Meeting may be combined, provided that all provisions of 1.4.1 and 1.4.2 are addressed.

1.4.3 Progress Meetings

A daily progress meeting shall be held between the Earthwork and Geosynthetic Site CQA Managers, the Installer's superintendent, the Project Manager, and any other concerned parties. This meeting shall discuss current progress, planned activities for the next shift, and any business or revisions to the work. The Geosynthetic Site CQA Manager shall log any problems, decisions, or questions arising at this meeting in

his daily report. Any matter requiring action which is raised in this meeting shall be reported to the appropriate parties.

1.4.4 Periodic Visits

Periodically, the construction site will be visited by a the Managing Engineer of the Geosynthetic CQA Consultant. This visit should be coordinated with a similar visit by the Designer and the Soils CQA Consultant. State regulatory officials may be informed of the dates of the visits.

2. CHLOROSULFONATED POLYETHYLENE GEOMEMBRANE MANUFACTURE, FABRICATION, AND DELIVERY

2.1 Chlorosulfonated Polyethylene Geomembrane Manufacture

The Manufacturer of the Chlorosulfonated Polyethylene (CSPE) reinforced geomembrane shall have previously demonstrated the ability to produce Industrial Grade Reinforced CSPE Geomembrane, hereafter referred to as CSPE geomembrane, CSPE, geomembrane or liner. The Manufacturer must also demonstrate the successful manufacture of at least 10 million ft² (929,000 m²) of similar liner material for hydraulic lining installations.

2.2 Manufacturing

2.2.1 Raw Material

The raw materials used in the manufacture of the CSPE geomembrane shall be first quality products designed and manufactured specifically for the purposes of this work, and which have been satisfactorily demonstrated by prior use to be suitable and durable for such purposes. The contractor shall at the time of the bidding, supply the Geosynthetic CQA Consultant with the name of the lining manufacturers, followed by conformance test results demonstrating that the products manufactured for this project meet design specifications.

2.2.2 CSPE Geomembrane Composition

The CSPE geomembrane is a thermoplastic elastomeric lining material consisting of one ply of fabric reinforcement encapsulated by two plies of CSPE sheeting. The CSPE geomembrane shall be made by encapsulating reinforcing polyester fabric between two sheets of CSPE sheeting, each sheet having a minimum thickness of 15 mils (.4 mm). The CSPE sheeting shall be composed of CSPE which is a minimum of 45 percent by weight of the finished sheeting.

Conformance testing will be carried out by the Manufacturer to demonstrate that the product meets the project specifications. At the Owner's discretion, additional testing may be implemented. This testing shall be conducted by a Qualified Geosynthetics CQA Laboratory with the Owner incurring this additional expense. If the results of the Manufacturer's Laboratory and the Geosynthetics CQA Laboratory differ, the testing will be repeated by the Geosynthetics CQA Laboratory, and the

Manufacturer will be allowed to monitor this testing. The results of this latter series of tests will prevail, provided that the applicable test methods have been followed. Prior to the installation of any CSPE geomembrane, the Manufacturer will provide the Owner's Project Manager and the Geosynthetics CQA Consultant with "Certificates of Compliance" with the requirements set forth in the project specifications for the installation of the CSPE geomembrane.

2.2.3 CSPE Geomembrane Properties

Prior to the installation, the CSPE Geomembrane Manufacturer will provide the Owner's Project Manager and the Geosynthetics CQA Consultant with the following:

- a material properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the project specifications;
- a list of quantities and descriptions of materials other than the base polymer which comprise the CSPE geomembrane;
- the sampling procedure and results of testing; and
- a certification that property values given in the properties sheet are minimum values and are guaranteed by the CSPE Geomembrane Manufacturer.

The Geosynthetics CQA Consultant will verify that:

- the property values certified by the CSPE Geomembrane Manufacturer meet all of the specifications; and
- the measurements of properties by the CSPE Geomembrane Manufacturer are properly documented and that the test methods used are acceptable.

2.2.4 CSPE Geomembrane Panels

Prior to shipment, the CSPE Geomembrane Manufacturer shall provide the Project Manager and the Geosynthetics CQA Consultant with a quality control certificate for each panel of CSPE geomembrane provided. The quality control certificate will be signed by a responsible party employed

by the CSPE Geomembrane Manufacturer, such as the production manager. The quality control certificate will include:

- panel numbers and identification; and
- sampling procedures and results of quality control tests; as a minimum, results shall be given for thickness, tensile strength, and tear resistance, evaluated in accordance with the methods indicated in the specifications or equivalent methods approved by the Designer.

The Geosynthetics CQA Consultant will:

- verify that the quality control certificates have been provided at the specified frequency for all panels, and that each certificate identifies the panels related to it; and
- review the quality control certificates and verify that the certified roll properties meet the specifications.

2.2.5 Factory Fabrication

The CSPE geomembrane roll goods shall be fabricated into large panels seamed with CSPE Bodied Solvent-Adhesive. The edges of the CSPE geomembrane referred to as scrim shall be encapsulated a minimum of 3/8 in. (1.0 mm). Factory seams shall be a minimum width of 1.5 in. (30 mm) scrim-to-scrim with encapsulated edges bonded on both top and bottom edges. Seam strength for these areas shall be at least 200 lb (91 kg) per ASTM D751. The fabricated geomembrane panels shall be designed to minimize the amount of field seaming at the job site. The fabricator shall certify that all factory seams are of sufficient strength, that the parent material will break before seam separation occurs. After fabrication, the geomembrane shall be accordion folded and packed for minimum handling in the field.

2.2.6 Conformance Testing

2.2.6.1 Tests

Upon delivery of the CSPE geomembrane panels, the Geosynthetics CQA Consultant will ensure that samples are removed at the specified frequency and forwarded to the Geosynthetics CQA Laboratory for testing to ensure

conformance to both the design specifications and the list of guaranteed properties.

As a minimum, tests to determine the following characteristics will be performed on CSPE liners:

- thickness;
- tensile characteristics; and
- hydrostatic resistance.

2.2.6.2 Test Procedures

The following test procedures will be complied with:

- thickness (overall-ASTM D-751);
- thickness (overscrim-optical method as modified in NSR54);
- breaking strength - fabric minimum (ASTM D-751, Method A); and
- Mullen Burst (ASTM D751A, Procedure 1).

Optional test methods are not permitted.

2.2.6.3 Sampling Procedures

Samples will be taken from panels selected by the Geosynthetics CQA Consultant. Unless otherwise specified, samples will be 3 ft (1 m) by 3 ft (1 m). Unless otherwise specified, samples will be taken at a rate of one per 100,000 ft² (10 000 m²) or one per resin batch, whichever provides the greater number of samples.

2.2.6.4 Test Results

The Geosynthetics CQA Consultant will examine all results from laboratory conformance testing and will report any non-conformance to the Project Manager.

2.2.6.5 Procedures in the Case of a Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the Geosynthetics CQA Laboratory:

- The Manufacturer will replace the panel of CSPE geomembrane that is in non-conformance with the specifications with a panel that meets specifications.
- The Installer will remove conformance samples for testing by the Geosynthetics CQA Laboratory from the closest numerical panel on sides of the failed panel. These two samples must both conform to specifications. If either of these samples fail, every panel of CSPE geomembrane on site and every panel delivered subsequently must be tested by the Geosynthetics CQA Laboratory for conformance to the specifications. This additional conformance testing will be at the expense of the Manufacturer.

The Geosynthetics CQA Consultant will document actions taken in conjunction with conformance test failures.

2.3 Delivery

2.3.1 Transportation and Handling

Transportation of the CSPE geomembrane is the responsibility of the Manufacturer, Installer, or other party as agreed upon. All handling on site is the responsibility of the Installer.

2.3.2 Receiving

Proper receiving and storage practices are essential to prevent damage to the geomembrane prior to installation. All geomembrane panels must be neatly accordion-folded, packed separately, in sealed cardboard containers, and banded to hardwood pallets in preparation for shipment to the project site.

Each palletized container shall weigh a maximum of 6,000 lbs (2720 kg). The Installer shall provide a forklift or other handling equipment of sufficient capacity to unload the containers from the carrier vehicle without damage.

The Geosynthetics CQA Consultant will verify that:

- handling equipment used on the site is adequate and does not pose any risk of damage to the CSPE geomembrane;
- the Installer's personnel handle the CSPE geomembranes with care;
- the Manufacturers panel identification number or letter corresponding to the project geomembrane panel layout plan is clearly marked on the outside of the box; and
- the size of each panel and the proper unfolding direction are also indicated.

Upon delivery at the site, the Installer and the Geosynthetics CQA Consultant will conduct a surface observation of all palletized containers for damage. This examination will be conducted without unfolding the factory panels unless defects or damages are found or suspected during visual observation of the shipping containers. The Geosynthetics CQA Consultant will indicate to the Project Manager:

- any factory panels, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and
- any factory panels which include minor repairable flaws.

2.3.3 Storage

The Installer will be responsible for the storage of the CSPE geomembrane on site. The Project Manager will provide storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible. Storage space should be protected from theft, vandalism, passage of vehicles, etc.

The CSPE geomembrane should be installed as soon as possible upon arrival to the project site. ~~The CSPE geomembrane shall not be left outside for more than two weeks before it is installed.~~ However, if short-term storage of the sealed palletized containers is necessary, a warehouse or other covered structure out of direct exposure to the elements will be required.

When the sealed palletized containers are stored outside on the installation site, the containers must be covered with reflectorized,

waterproof materials to protect the contents from damaging ultra-violet light and to keep the geomembrane panels dry for installation. Geomembrane solvent adhesives should also be protected from wind, rain, or excessive cold or heat. Store adhesive containers and other geomembrane installation accessories in covered shelters.

The Geosynthetics CQA Consultant will verify that storage of the CSPE geomembrane ensures adequate protection against dirt, shock, and other sources of damage.

3. CSPE GEOMEMBRANE INSTALLATION

3.1 Earthwork

3.1.1 Surface Preparation

The Earthwork Contractor will be responsible for preparing the supporting soil according to the Designer's specifications:

The Geosynthetics CQA Consultant will verify that:

- a qualified land surveyor has verified all lines and grades;
- a qualified geotechnical engineer, normally the Soils CQA Consultant, has verified that the supporting soil meets the density specification;
- the surface to be lined has been rolled and compacted so as to be smooth, uniform, free of irregularities, protrusions, loose soil, and abrupt changes in grade;
- the surface of the supporting soil does not contain stones, sticks or other debris, which may puncture or tear the CSPE geomembrane;
- there is no area excessively softened by high water content; and
- when seaming to existing CSPE geomembrane, all excavation to expose previously installed geomembrane shall be performed by hand to prevent damage.

The Installer will certify in writing that the surface on which the CSPE geomembrane will be installed is acceptable. The certificate of acceptance will be given by the Installer to the Project Manager prior to commencement of CSPE geomembrane installation in the area under consideration. The Geosynthetics CQA Consultant will be given a copy of this certificate by the Project Manager.

After the supporting soil has been accepted by the Installer, it will be the Installer's responsibility to indicate to the Project Manager any change in the supporting soil condition that may require repair work. If the Geosynthetics CQA Consultant concurs with the Installer, then the Project Manager will ensure that the supporting soil is repaired.

3.1.2 Anchorage System

Anchor trenches will be excavated by the Earthwork Contractor (unless otherwise specified) to the lines and widths shown on the design drawings, prior to CSPE geomembrane placement. The Geosynthetics CQA Consultant will verify that anchor trenches have been constructed according to the design drawings.

Slightly rounded corners will be provided in trenches where the geomembrane adjoins the trench so as to avoid sharp bends in the geomembrane. No loose soil will be allowed to underlie the CSPE geomembrane in the trenches.

Backfilling of anchor trenches will be conducted in accordance with Section 3.5.

3.2 Geomembrane Placement

3.2.1 Field Panel Identification

A field panel is the unit area of CSPE geomembrane which is to be seamed in the field, i.e., an unfolded panel or a portion thereof cut in the field.

It will be the responsibility of the Geosynthetics CQA Consultant to ensure that each field panel is given an "identification code" (number or letter-number) consistent with the Manufacturer's layout plan. This identification code will be agreed upon by the Owner's Project Manager, Installer, and Geosynthetics CQA Consultant. This field panel identification code should be as simple and logical as possible. (Note: roll numbers established in the manufacturing plant are usually cumbersome and are not related to location in the field.) It will be the responsibility of the Installer to ensure that each field panel placed is marked with the Manufacturer's original panel identification code. The panel number will be marked at a location agreed upon by the Owner's Project Manager, Installer, and Geosynthetics CQA Consultant.

The Geosynthetics CQA Consultant will establish a table or chart showing correspondence between Manufacturer's panel numbers and field panel identification codes. The field panel identification code will be used for all CQA records.

3.2.2 Field Panel Placement

3.2.2.1 Location and Deployment

The Geosynthetics CQA Consultant will verify that field panels are installed at the location indicated in the Engineer's layout plan, as approved or modified.

Referring to the size, location and pull direction markings on each palletized container, the installer shall utilize lift equipment to place the pallets in the proper orientation for deployment. Banding straps and cardboard containers should be removed from each pallet only when the installation crew is ready to deploy a particular panel. Care should be exercised to avoid worker injury when cutting and removing tensioned steel banding straps, if utilized during shipping.

3.2.2.2 Compensation for Material Expansion and Contraction

The Installer will be responsible for calculation of the required amount of compensation which must be installed. The Installer will be responsible for ensuring that sufficient CSPE liner is installed to compensate for contraction of the material during anticipated lower temperatures.

3.2.2.3 Installation Schedule

Field panels will be placed one at a time, and each field panel will be seamed immediately after its placement (in order to minimize the number of unseamed field panels exposed to wind).

It is usually beneficial to "shingle" overlaps in the downward direction to facilitate drainage in the event of precipitation. It is also beneficial to proceed in the direction of prevailing winds. Scheduling decisions must be made during installation, in accordance with varying conditions. In any event, the Installer will be fully responsible for the decision made regarding placement procedures.

The Geosynthetics CQA Consultant will evaluate every change in the schedule proposed by the Installer and advise the Project Manager on the acceptability of that change. The Geosynthetics CQA Consultant will verify that the condition of the supporting soil has not changed detrimentally during installation. The Geosynthetics CQA Consultant will

record the identification code, location, and date of installation of each field panel.

3.2.2.4 Weather Conditions

CSPE liner placement will not proceed at an ambient temperature below 40°F (5°C) unless otherwise authorized. CSPE liner placement will not be done during any precipitation, in an area of ponded water.

The Geosynthetics CQA Consultant will verify that the above conditions are fulfilled. Additionally, the Geosynthetics CQA Consultant will verify that the supporting soil has not been damaged by weather conditions. The Geosynthetics Site CQA Manager will inform the Project Manager if the above conditions are not fulfilled.

3.2.2.5 Method of Placement

The Geosynthetics CQA Consultant will verify that:

- any equipment used does not damage the CSPE geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means;
- the prepared surface underlying the CSPE geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;
- any geosynthetic materials immediately underlying the CSPE geomembrane are clean and free of debris;
- all personnel working on the CSPE geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;
- the method used to unfold the panels does not cause scratches or crimps in the CSPE 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, tires), not likely to damage the CSPE geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along the edges of panels to minimize the risk of wind flow under the panels); and
- direct contact with the CSPE geomembrane is minimized; i.e., the CSPE geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected.

The Geosynthetics Site CQA Manager will inform the Owner's Project Manager if the above conditions are not fulfilled.

3.2.2.6 Damage

The Geosynthetics CQA Consultant will visually observe each panel, after placement and prior to seaming, for damage. The Geosynthetics Site CQA Manager will advise the Project Manager 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 recorded by the Geosynthetics CQA Consultant. Repairs will be made according to procedures described in Section 3.4.

As a minimum, the Geosynthetics CQA Consultant will ensure:

- the panel is placed in such a manner that it is unlikely to be damaged; and
- any tears, punctures, holes, thin spots, etc. are either marked for repair or the panel is rejected.

3.3 Field Seaming

3.3.1 Seam Layout

The Installer will provide the Owner's Project Manager and the Geosynthetics CQA Consultant with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The Geosynthetics CQA Consultant will review the seam layout drawing and verify that it is consistent with the accepted state of practice and this CQA Plan. No panels may be seamed in the field without the Project Manager's approval. In addition, no panels not specifically shown on the seam layout drawing may be used without the Project Manager's prior approval.

In general, 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 ft (1.5 m) from the toe of slopes, or areas of potential stress concentrations, unless otherwise authorized by the Project Manager.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Resolution and/or Pre-Construction Meeting.

3.3.2 Requirements of Personnel

All personnel performing seaming operations will be qualified by experience. Seaming personnel shall have installed a minimum of 9 million ft² (836,100 m²) of CSPE geomembrane and demonstrated through documentation the successful installation of quantity of geomembranes.

The Installer will provide the Owner's Project Manager and the Geosynthetics CQA Consultant with a list of proposed seaming personnel and their experience records. This document will be reviewed by the Owner's Project Manager and the Geosynthetics CQA Consultant.

3.3.3 Seaming Equipment and Products

Approved processes for field seaming will be accomplished with CSPE Bodied Solvent-Adhesives. Proposed alternate processes will be documented and submitted to the Engineer or his representative for approval. All sealing materials shall be of a type recommended and supplied by the

manufacturer and shall be delivered to the site in the original sealed containers with indelible labels intact bearing the brand name, manufacturer's mark number, and complete directions as to proper storage.

3.3.4 Seam Preparation

The Geosynthetic CQA Consultant will verify that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
- if any area of the seam requires cleaning, only solvents approved by the CSPE manufacturer may be used;
- only cloth rags are to be used for general cleaning or solvent application; and
- seams are aligned with the fewest possible number of wrinkles and "fishmouths".

The Geosynthetic Quality Assurance Consultant shall verify that seam preparation is completed in accordance with the Manufacturers instructions.

3.3.5 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows:

- unless authorized in writing by the Project Manager, no seaming will be attempted at an ambient temperature below 40°F (5°C).
- below an ambient temperature of 90°F (32°C), preheating may be required.
- in all cases, the geomembrane will be dry and protected from wind.
- the ambient temperatures will be measured approximately 6 in. (150 mm) above the CSPE geomembrane surface.

If the Installer wishes to use methods which may allow seaming at ambient temperatures below 90°F (32°C), the Installer will demonstrate and certify that such methods produce seams which are entirely equivalent to

seams produced at ambient temperatures above 90°F (32°C), and that the overall quality of the CSPE geomembrane is not adversely affected.

The Geosynthetics CQA Consultant will verify that these weather conditions are fulfilled and will advise the Project Manager if they are not. The Project Manager will then decide if the installation will be stopped or postponed.

3.3.6 Field Seams

The Geosynthetics CQA Consultant will verify that:

- only Manufacturer's approved bodied solvent-adhesives are to be utilized during seaming operations;
- the bodied solvent-adhesive containers should be shaken vigorously prior to use;
- container lids are to be replaced to ensure the containers are kept sealed;
- seams are not constructed in the rain or when the CSPE panels are exposed to mud, standing water, or extreme cold; and
- the panels of CSPE geomembrane have a finished overlap of a minimum of 3 in. (76 mm) scrim to scrim.

The Geosynthetics CQA Consultant will log all appropriate temperatures and conditions, and will log and report to the Owner's Project Manager any non-compliance.

3.3.7 General Seaming Procedure

Unless otherwise specified by the Manufacturer, the general seaming procedure used by the Fabricator will be as follows:

- Only manufacturer's approved adhesives and solvents are to be utilized during seaming operations.
- Seams will be bonded 18 in. (450 mm) at a time.

- (• Apply minimum 1 in. (25 mm) wide adhesive bead to both bonding surfaces using 2 in. (50 mm) paint brushes and clean, one-gallon containers filled one-quarter full of solvent.
- Once solvent is applied, mate and seal overlapped panel edges with a 2 in. (50 mm) nylon or steel roller.
- If required, a firm smooth substrate will be provided by using a flat wooden board, metal platen, or other similar hard surface directly under the seam overlap to achieve proper support. The underlying support will be approved by the Project Engineer prior to use. The bonding procedure should stop approximately 2 ft (.6 m) from the end of the underlying support.
- (• The underlying support should be pulled ahead and seam bonding continued until the seam is sealed from the center to one end. Then, return to the center of the seam and work toward the opposite end.
- Proper alignment and overlap of the geomembrane panels must be maintained during bonding to avoid fishmouth gaps or wrinkles. If seam gaps are encountered during the seaming process, tension should be applied to the geomembrane panels in the direction in which seaming had begun to remove these wrinkles.
- If required heat guns may be utilized to maintain an approximate material temperature of 100°F (38°C) during seaming operations.
- If seaming operations are carried out at night, adequate illumination will be provided.
- (• Seaming will extend to the outside edge of panels to be placed in the anchor trench.
- (• The bonded seams will be flood coated by applying bodied solvent-adhesive along the top edge of the seam.

The Geosynthetics CQA Consultant will verify that the above seaming procedures are followed, and will inform the Project Manager if they are not.

3.3.8 Nondestructive Seam Continuity Testing

3.3.8.1 Concept

The Installer will nondestructively test all field seams over their full length using an air lance. Air lance testing is described in Sections 3.3.8.2. The purpose of nondestructive tests is to check the continuity of seams. It does not provide any information on seam strength. Continuity testing will be carried out as the seaming work progresses, not at the completion of all field seaming. Nondestructive testing will not be permitted before sunrise or after sunset unless the Installer demonstrates capabilities to do so.

The Geosynthetics CQA Consultant will:

- observe all continuity testing;
- record location, date, test unit number, name of tester, and outcome of all testing; and
- inform the Installer and Project Manager of any required repairs.

The Installer will complete any required repairs in accordance with Section 3.4.

The Geosynthetics CQA Consultant will:

- observe the repair and re-testing of the repair;
- mark on the CSPE geomembrane that the repair has been made; and
- document the results.

The following procedures will apply to locations where seams cannot be nondestructively tested:

- If the seam is accessible to testing equipment prior to final installation, the seam will be nondestructively tested prior to final installation.
- If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations will be observed by the Geosynthetics CQA Consultant and Installer for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation will be recorded by the Geosynthetics CQA Consultant.

3.3.8.2 Air Lance Testing

The air lance testing equipment will be comprised of the following:

- an air compressor capable of exerting a minimum air pressure of 50 psi;
- a pressure hose with fittings and connections; and
- a 3/16 in. (.47 mm) diameter nozzle.

The air lance testing procedure will be performed as follows:

- energize the air compressor until a minimum pressure of 50 psi is maintained;
- identify the area of field seam to be tested;
- direct the pressurized air lance nozzle perpendicular to the edge of the field seam;
- maintain the pressurized nozzle a maximum distance of 6 in. (150 mm) from the edge of the field seam;
- any loose edges in the field seam are to be marked for repair; and
- repair locations are to be retested.

3.3.9 Destructive Testing

3.3.9.1 Concept

Destructive seam tests will be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing will be done as the seaming work progresses, not at the completion of fabrication seaming. Destructive testing will be conducted in accordance with the Designer's specifications and the CQA Plan.

3.3.9.2 Location and Frequency

The Geosynthetics Site CQA Manager will select locations where seam samples will be cut out for laboratory testing. Those locations will be established as follows:

- A minimum frequency of one test per 500 ft (150 m) of seam length, or one sample per each seam length, whichever provides for the greater number of samples. This minimum frequency is to be determined as an average taken throughout the entire facility.
- A maximum frequency will be agreed upon by the Installer, Project Manager and Geosynthetics Site CQA Manager at the Resolution and/or Pre-Construction Meeting.
- Test locations will be determined during seaming at the Geosynthetics Site CQA Manager's discretion. Selection of such locations may be prompted by suspicion of inadequate bonding, contamination, offset seams, or any other potential cause of imperfect seaming.

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

3.3.9.3 Sampling Procedure

Samples will be cut by the Installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The Geosynthetics CQA Consultant will:

- observe sample cutting;
- assign a number to each sample, and mark it accordingly;
- record the sample location on the layout drawing; and
- record the reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the CSPE geomembrane).

All holes in the CSPE geomembrane resulting from destructive seam sampling will be immediately repaired in accordance with repair procedures

described in Section 3.4.3. The continuity of the new seams in the repaired area will be tested according to Section 3.3.8.2.

3.3.9.4 Size of Samples

The destructive sample will be 12 in. (0.3 m) wide by 42 in. (1.1 m) long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:

- one portion, measuring 12 in. x 12 in. (0.3 m x 0.3 m), to the Installer for laboratory testing;
- one portion, measuring 12 in. x 12 in. (0.3 m x 0.3 m), to the Owner for archive storage; and
- one portion, measuring 12 in. x 18 in. (0.3 m x 0.45 m), for Geosynthetic CQA Laboratory testing.

Final determination of the sample sizes will be made at the Pre-Construction Meeting.

3.3.9.5 Geosynthetics Construction Quality Assurance Laboratory Testing

Destructive test samples will be packaged and shipped, if necessary, by the Geosynthetics CQA Consultant in a manner which will not damage the test sample. The Project Manager will verify that packaging and shipping conditions are acceptable. The Project Manager will be responsible for storing the archive samples. This procedure will be fully outlined at the Resolution Meeting. Test samples will be tested by the Geosynthetics CQA Laboratory. The Geosynthetics CQA Laboratory will be selected by the Geosynthetics CQA Consultant with the concurrence of the Project Manager.

Testing will include "Seam Strength" (ASTM D3083 as modified in NSF Appendix A and with requirement for sample conditioning time). The minimum acceptable values to be obtained in these tests are those indicated in the project specifications. At least five specimens will be tested for each test method. Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear...).

The Geosynthetics Site CQA Manager will review laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

3.3.9.6 Installer's Laboratory Testing

The Installer's laboratory test results (if any) will be presented to the Project Manager and the Geosynthetics CQA Consultant for comments.

3.3.9.7 Destructive Sample Pass/Fail Criteria

All seam sample specimens must meet or exceed minimum acceptable values as indicated in the specifications. However, the following Pass/Fail criteria must also be observed in governing the acceptance of a specimen.

<u>Peel Test</u>	<u>Criteria</u>
Seam Separation	in plane of scrim or ≥ 10 p.p.i.
<u>Shear Test</u>	<u>Criteria</u>
Seam Separation	0%
Bonded Seam Strength	200 p.p.i.
Location of Failure	outside the weld area (Film Tearing Bond)

All specimens from a destructive seam sample must meet the above requirements as well as obtain the required strengths as indicated in the specifications.

3.3.9.8 Procedures for Destructive Test Failure

The following procedures will apply whenever a sample fails a destructive test, whether that test conducted by the Geosynthetics CQA Laboratory or the Installer's laboratory. The Installer has two options:

- The Installer can reconstruct the seam between any two passed destructive seam test locations.
- The Installer can trace the seaming path to an intermediate location (10 ft (3 m) minimum from the point of the failed test in each direction) and remove a sample for an additional laboratory test at each location. If these destructive laboratory samples pass the testing criteria, then the seam is reconstructed between these locations by capping. If a sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

All acceptable seams must be bounded by two locations from which destructive samples passing laboratory tests have been taken. In cases exceeding 150 ft (50 m) of reconstructed seam, a sample will be taken from the zone in which the seam has been reconstructed. This sample must pass destructive testing or the procedure outlined in this section must be repeated. The Geosynthetics CQA Consultant will document all actions taken in conjunction with destructive test failures.

3.4 Defects and Repairs

3.4.1 Identification

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

3.4.2 Evaluation

Each suspect location both in seam and non-seam areas will be nondestructively tested using the methods described in Section 3.3.8.2. Each location which fails the nondestructive testing will be marked by the Geosynthetics CQA Consultant and repaired by the Installer. Work will not proceed with any materials which will cover locations which have been repaired until laboratory results with passing values are available.

3.4.3 Repair Procedures

Any portion of the CSPE geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, will be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be agreed upon between the Project Manager, Installer, and Geosynthetics CQA Consultant. The procedures available include:

- patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter; and
- capping, used to repair large lengths of failed seams.

In addition, the following provisions will be satisfied:

- 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 will be approved in advance of the specific repair by the Project Manager, Geosynthetic CQA Consultant, and Installer; and
- patches or caps will extend at least 3 in. to 6 in. (75 mm to 150 mm) beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 in. (75 mm).

3.4.4 Verification of Repairs

Each repair will be logged. Each repair will be nondestructively tested using the methods described in Section 3.3.8.2. Repairs which pass the nondestructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive testing, at the discretion of the Geosynthetics CQA Consultant. Failed tests will require the repair to be redone and retested until a passing test results. The Geosynthetics CQA Consultant should observe all nondestructive testing of repairs and will record the date of the repair and test outcome.

3.4.5 Large Wrinkles

When seaming of the CSPE geomembrane is completed (or when seaming of a large area of the geomembrane is completed) and prior to placing overlying materials, the Geosynthetics CQA Consultant will observe the CSPE geomembrane wrinkles. The Geosynthetics CQA Consultant will indicate to the Project Manager which wrinkles should be cut and resealed by the Installer. The seam thus produced will be tested like any other seam.

3.5 Backfilling of Anchor Trench

Anchor trenches will be adequately drained, to prevent ponding or otherwise softening of the adjacent soils while the trench is open. Anchor trenches will be backfilled and compacted by the Earthwork Contractor or the Installer, as outlined in the specifications or bid documents. Care will be taken when backfilling the trenches to prevent any damage to the CSPE liner. The Geosynthetics CQA Consultant will observe the backfilling operation and advise the Project Manager of any problems.

3.6 CSPE Geomembrane Lining System

The Installer will retain all responsibility for the CSPE liner in the landfill cell until acceptance by the Owner.

The geosynthetic cover system will be accepted by the Owner when:

- the installation is finished;
- verification of the adequacy of all seams and repairs, including associated testing, is complete;
- Installer's representative furnishes the Project Manager with certification that the CSPE liner was installed in accordance with the Manufacturer's recommendations as well as the plans and specifications;
- all documentation of installation is completed including the Geosynthetics CQA Consultant's final report; and

- certification, including record drawing(s), sealed by a registered Professional Engineer registered in the state of Florida has been received by the Project Manager.

The Geosynthetics CQA Consultant will certify that installation has proceeded in accordance with the Geosynthetics CQA Plan for the project except as noted to the Project Manager.

3.7 Materials in Contact with the CSPE Geomembrane

The CQA procedures indicated in this section are only intended to ensure that the installation of these materials does not damage the CSPE geomembrane. Additional CQA procedures may be necessary to ensure that systems built with these materials will be constructed in such a way as to enable proper performance.

3.7.1 Soils

A copy of the specifications prepared by the Engineer for placement of soils will be given to the Geosynthetics CQA Consultant by the Project Manager. The Geosynthetics CQA Consultant will verify that these specifications are consistent with the state of practice, such as:

- placement of soils on the CSPE geomembrane will not proceed at an ambient temperature below 40°F (5°C) nor above 100°F (38°C) unless otherwise specified;
- placement of soils on the CSPE geomembranes will be done in such a manner as to not create waves in the geomembrane of a size that could fold over;
- soils must be free of objects that could cause damage to the CSPE liner;
- a geotextile or other cushion approved by the Engineer may be installed between angular aggregate and the CSPE geomembrane;
- equipment used for placing soil will not be driven directly on the CSPE geomembrane;

- (• a minimum thickness of 1 ft (0.3 m) of soil is specified between a light dozer (such as a wide pad Caterpillar D-4 or similar) and the CSPE geomembrane;
- (• a minimum thickness of 2 ft (0.6 m) of soil is specified between rubber-tired vehicles and the CSPE geomembrane; and
- (• in heavily trafficked areas such as access ramps, the soil thickness should be at least 3 ft (0.9 m).

The Geosynthetics CQA Consultant will:

- measure soil thickness and verify that the required thicknesses are present (or, if applicable, verify that required measurements have been completed by the Soils CQA Consultant, if any);
- verify that final thicknesses are consistent with design; and
- verify that placement of soil is done in such a manner that CSPE geomembrane damage is unlikely.

The Geosynthetics CQA Consultant will inform the Project Manager if the above conditions are not fulfilled.

3.7.2 Appurtenances

A copy of the specifications prepared by the Engineer for appurtenances will be given by the Project Manager to the Geosynthetics CQA Consultant for review.

The Geosynthetics CQA Consultant will verify that:

- installation of the CSPE geomembrane in appurtenance areas, and connection of CSPE geomembrane to appurtenances have been made according to specifications;
- extreme care is taken while seaming around appurtenances since neither nondestructive nor destructive testing may be feasible in these areas; and
- the CSPE geomembrane has not been visibly damaged while making connections to appurtenances.

The Geosynthetics CQA Consultant will inform the Project Manager if the above conditions are not fulfilled.

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