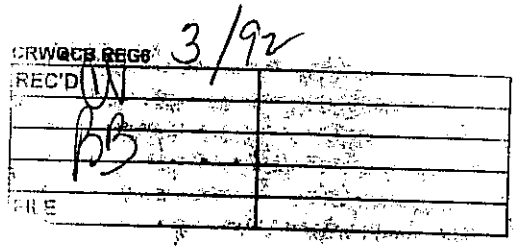
Nursery Products
Planting a Better Tomorrow

VIA ELECTRONIC MAIL AND HAND DELIVERY

March 17, 2011



RECEIVED MAR 17 2011

Harold Singer
Executive Officer
California Regional Water Quality Control Board
14440 Civic Drive, Suite 200
Victorville, CA 92392

Subject: Response to Comments - Design Plan
Nursery Products Hawes Composting Facility

Dear Mr. Singer:

Enclosed with the hard copy of this letter please find the revised Design Plan, including hard copies of oversize attachments. On December 24, 2010 Nursery Products received a letter from the California Regional Water Quality Control Board, Lahontan Region (Water Board) requesting clarification in regard to the previously submitted Design Plan and addenda for the Nursery Products Hawes Composting Facility (HCF).

Prior versions of the Design Plan were previously prepared and submitted to the RWQCB on 5 May 2010. The RWQCB provided comments on the 5 May 2010 Design Plan on 2 July 2010. Nursery Products subsequently submitted addenda to the Design Plan between May and November 2010. The RWQCB provided comments on the submittals for the Design Plan between 7 July and 24 December 2010. The enclosed Design Plan compiles, revises, and updates the information in the Design Plan information into one document and addresses all of the RWQCB comments.

The Water Board's December 24, 2010 letter included four comments regarding the Design Plan. These comments are summarized below with the corresponding response.

1. COMMENT: The RWQCB expressed concern in regard to the design of the surface impoundment diversion berm that will be constructed at the HCF. Specifically, the RWQCB stated that the Design Plan didn't include specifications for compaction of the surface impoundment diversion berm and that the operation of the berm may not be possible as stated in the Design Plan.

RESPONSE: The surface impoundment diversion berm presented in the enclosed Design Plan has been redesigned. Instead of eight openings, three openings are incorporated into the surface impoundment diversion berm to allow the peak discharge from the 100-year, 24-hour storm event from the remainder of the Site into the surface impoundments. A 20-foot opening is incorporated in the diversion berm south of Surface Impoundment A and two 10-foot openings are incorporated in the diversion berm to the east and south of Surface Impoundment B. The openings were redesigned and now include concrete abutment walls on each side of the inlet, intermediate bollards set at 10-foot increments, and concrete aprons upstream and downstream of the inlet to control erosion. The redesign responds specifically to RWQCB comments. Once the water in the surface impoundments approaches the minimum required two feet of freeboard, the openings will be closed by manually inserting 10-foot long stop logs into guide frames attached to the concrete abutments and intermediate bollards. When the stop logs are in place, the stormwater from storm events in excess of the 100-year, 24-hour, storm event will back up onto the northern end of the Site (1,000 year storm event containment area).

2. COMMENT: Provide cross sections that are readable and to scale.

   RESPONSE: Revised cross sections are included in the enclosed Design Plan and are located in Appendix A of the enclosed Design Plan. Two hard copies of the Design Plan including large drawings are being hand delivered to the Water Board.

3. COMMENT: The site plan must include cross sections for any area where a driveway or other access crosses a berm or where a berm is interrupted by an opening that reduces the berm height.

   RESPONSE: The revised Design Plan includes cross sections for all areas where a driveway or other access crosses a berm or where a berm is interrupted by an opening that reduces the berm height. The Plans are in Appendix A.

4. COMMENT: Based on the cross sections submitted it is unclear how the liner will be secured and how the storm flows will be directed into the surface impoundments without eroding the soils at the edge of the surface impoundments and possible destabilizing the liner.

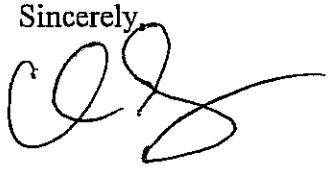
   RESPONSE: The surface impoundment liner system will be ballasted on the bottom of the impoundment and anchored around the perimeter of the impoundment by a 2-foot minimum horizontal run and an additional 9-foot minimum length of liner buried at a downward sloping inclination of 2:1 (horizontal:vertical) such that

the edge of the liner is a minimum of 4 feet below the ground surface. This significant depth of the edge of liner is designed to prevent erosion-caused liner instability. Stormwater is designed to sheet flow into the surface impoundments through openings in the surface impoundment diversion berm. Section 3.2 of the enclosed Design Plan describes the impoundments more fully.

By this letter, Nursery Products has fully responded to the comments of the Water Board regarding the Design Plan. Nursery Products respectfully requests a prompt response from the Water Board as construction is likely to begin in the very near future. Nursery Products would appreciate your response by April 1, 2011.

If you have any questions, or if we can be of help in any way, please feel free to call me at 760-272-1224.

Sincerely,



Chris Seney, P.E.

Enclosures: Design Plan

3/92
RECEIVED MAR 17 2011
REC'D
BB
FILE

Nursery Products
Planting a Better Tomorrow

Prepared for

Nursery Products, LLC
12277 Apple Valley Road, Suite 131
Apple Valley, California 92308

DESIGN PLAN, CONSTRUCTION QUALITY ASSURANCE PLAN & TECHNICAL SPECIFICATIONS

HAWES COMPOSTING FACILITY

Prepared by

Geosyntec consultants

engineers | scientists | innovators

10875 Rancho Bernardo Road, Suite 200
San Diego, California 92127

Project Number SC0554

March 2011

Geosyntec consultants

10875 Rancho Bernardo Road, Suite 200
San Diego, CA 92127
PH 858.674.6559
FAX 858.674.6586
www.geosyntec.com

16 March 2011

Mr. Chris Seney
Nursery Products, LLC
12277 Apple Valley Road, Suite 131
Apple Valley, California 92308

Subject: **Design Plan, Construction Quality Assurance Plan & Technical Specifications**
Nursery Products Hawes Composting Facility
San Bernardino County, California

Dear Mr. Seney:

Geosyntec Consultants Inc., (Geosyntec) has reviewed and revised the attached Design Plan, Construction Quality Assurance Plan & Technical Specifications (Design Plan) originally prepared by Nursery Products, LLC (Nursery Products). This document was prepared in response to comments made by the Lahontan Regional Water Quality Control Board on the prior submittals for this Design Plan.

The design engineer for the overall grading design and the perimeter stormwater controls is Mr. Ceazar Aguilar, P.E. of AEI CASC Consulting. The design engineer for the facility liner systems, environmental monitoring systems, and the surface impoundment stormwater diversion berm is Ms. Jennifer Nevius, P.E. of Geosyntec Consultants.

I certify under penalty of perjury that I have personally examined and am familiar with the information submitted in this Design Plan for the Nursery Products Hawes Composting Facility and all attachments and, based on my inquiry of those individuals immediately responsible for obtaining the information; I believe the information is true, accurate, and complete. My seal as a registered professional engineer licensed in the State of California is affixed below.

Please contact me at (858) 705-5273 if you have any questions.

Sincerely,

Jennifer L. Nevius

Jennifer L. Nevius, R.C.E.64932
Project Engineer

TABLE OF CONTENTS

LIST OF APPENDICES

1. INTRODUCTION

This Design Plan, Construction Quality Assurance (CQA) Plan & Technical Specifications document (Design Plan) has been prepared for the Nursery Products Hawes Composting Facility (HCF) in San Bernardino County, California (Site). This Design Plan has been prepared in accordance with California Code of Regulations, Title 27 (27 CCR) to support the Report of Waste Discharge (ROWD) for the HCF. This plan was prepared to address the requirements of the Lahontan Regional Water Quality Control Board (RWQCB) Order No. R6V-2010-0010 (Board Order) (RWQCB, 2010a).

The Design Plan was previously submitted by Nursery Products to the RWQCB on 5 May 2010. The RWQCB provided comments on the Design Plan on 2 July 2010. Nursery Products subsequently submitted addenda to the Design Plan between July and November 2010. The RWQCB provided comments on the addenda to the Design Plan between 2 July and 24 December 2010 (RWQCB 2010b through 2010e). This Design Plan compiles, revises, and updates the Design Plan, including addenda previously submitted by Nursery Products into one document and addresses the RWQCB comments. Additionally, this Design Plan provides more detailed design information than the conceptual design presented in the ROWD (URS, 2009).

This Design Plan was revised by Geosyntec Consultants, Inc. (Geosyntec) for the use of Nursery Products. This plan was revised by Ms. Jennifer Nevius, P.E., and reviewed by Ms. Jane Soule, P.E., of Geosyntec in accordance with the peer review policy of the firm.

1.1 Purpose

The purpose of this Design Plan is to provide information regarding design and construction of the waste pile, surface impoundments, and appurtenant structures at the HCF. This document satisfies the requirement for a Design Plan and CQA Plan in the Board Order.

1.2 Report Organization

This Design Plan is organized as follows:

- Section 2 presents a description of the HCF features;
- Section 3 presents the HCF design;

- Section 4 presents the CQA Plan;
- Section 5 presents the technical specifications; and
- Section 6 presents the references used to prepare this Design Plan.

1.3 Reference Documents

The following reference documents provide background information and support the CQA Plan for construction:

- American Society for Testing and Materials (ASTM) Annual Book of ASTM Standards. Section 4 Construction, Volume 04.02 Concrete and Aggregates.
- Annual Book of ASTM Standards. Section 4 Construction, Volume 04.08 Soil and Rock(I), and Volume 04.09 Soil and Rock (II); Geosynthetics.
- Annual Book of ASTM Standards. Section 8 Plastics, Volumes 08.01 Plastics (I), 08.02 Plastics (II), and 08.03 Plastics (III).
- Geosynthetics Research Institute (GRI) Specifications. http://www.geosynthetic-institute.org/
- Standard Specifications for Public Works Construction "Greenbook".

2. FACILITY OVERVIEW

2.1 Project Description

The HCF is a biosolids and green material composting facility located on 80 acres of a 160-acre parcel located within an unincorporated area of San Bernardino County. The facility will compost biosolids and green material to produce agricultural grade compost in compliance with U.S. Environmental Protection Agency (EPA) Code of Federal Regulations (CFR), Title 40, Chapter 1, Part 503 and the California Code of Regulations, Title 14 (14 CCR).

The composting process will occur in windrows on approximately 72-acres that the RWQCB has designated as a "waste pile". The waste pile is an engineered pad consisting of prepared, compacted subgrade. The engineered pad will be sloped such that stormwater will flow to two geosynthetics-lined surface impoundments located on the northern end of the facility. The HCF will include stormwater control berms around the perimeter of the facility to control run-off and run-on and an additional berm to separate the waste pile from the surface impoundments. Leak detection monitoring sumps and vadose zone monitoring lysimeters will be located beneath the surface impoundments. Additional stormwater control features are incorporated at the southern end of the facility as described in Section 3 of this Design Plan. Design drawings illustrating the project components are presented in Appendix A.

3. FACILITY DESIGN

The stormwater berms, waste pile pad, surface impoundments, perimeter drainage structures and environmental monitoring features are the primary engineered structures at the facility. These structures were designed to have foundations capable of providing support for the structures, and capable of withstanding hydraulic pressure gradients to prevent failure due to settlement, compression, uplift, and effects of earthquake-induced ground motions.

The primary grading design and the 100-year, 24-hour and 1,000-year, 24-hour hydrology studies were prepared by AEI CASC Consulting of Colton, California. The Site grading was designed to minimize the amount of earthwork required to construct the Site while meeting the engineering objectives of stormwater run-on and runoff control, erosion protection, and minimizing stormwater infiltration. Two hydrology studies were performed for: 1) the 100-year, 24-hour storm event; and 2) the 1,000-year, 24-hour storm event. The hydrology study for the 100-year, 24-hour event was presented in Appendix C of the ROWD (URS, 2009), and the revised 1,000-year, 24-hour hydrology study is presented in Appendix B of this Design Plan.

The Design Drawings for the HCF were originally prepared by URS as part of the ROWD (URS, 2009). These drawings were subsequently revised by Nursery Products and most recently by Geosyntec. The updated design drawings are presented in Appendix A of this Design Plan.

In accordance with the Board Order, all stormwater resulting from the 1,000-year, 24-hour storm event must be contained within the HCF, and the perimeter berm must prevent run-on from the off-site 100-year, 24-hour storm event. The surface impoundments are designed to contain the stormwater runoff from the 100-year, 24-hour storm event falling over the entire HCF plus the stormwater from the 1,000-year, 24-hour storm event falling directly on the surface impoundments, while maintaining a minimum of two feet of freeboard. In storm events in excess of the 100-year, 24-hour storm event, if the water level in the surface impoundment approaches the minimum freeboard requirement, the stormwater will be stopped from flowing to the surface impoundments (by closing the openings with stop logs, see section 3.3). At that point, the stormwaterwill be contained on the northern end of the Site south of the surface impoundment diversion berm.

3.1 Waste Pile Design

The waste pile liner consists of a minimum of 12 inches of engineered fill consisting of native subgrade compacted to 90 percent relative compaction using ASTM D 1557 as the compaction standard. The perimeter berm around the facility will also consist of engineered fill consisting of on-site soil compacted to 90 percent relative compaction using ASTM D 1557 as the compaction standard.

The ROWD demonstrated, through extensive unsaturated flow modeling and laboratory testing, that the Site has characteristics which inhibit the downward migration of water to regional groundwater level, and that the Site, as designed and monitored, will not pose a threat to groundwater quality (URS, 2009).

3.2 Surface Impoundment Design

The two surface impoundments are designed to contain stormwater from the 100-year, 24-hour storm event over the entire facility drainage area and the 1,000-year, 24-hour storm event that falls directly on the surface impoundments. The minimum required volumetric capacity of the ponds is 10.5 acre feet for Surface Impoundment A located in the northwest corner of the facility, and 6.5 acre feet for Surface Impoundment B located in the northeastern portion of the facility. In addition to the required volumetric capacity, the surface impoundments are designed to provide a minimum of 2 feet of freeboard. The impoundments as designed and shown on the design drawings in Appendix A meet the minimum capacity requirements. Details and calculations regarding the sizing of the impoundments are presented in the hydrology studies performed for the HCF (ROWD and Appendix B of this Design Plan). Static and seismic slope stability analyses of the surface impoundment side slopes were presented in Appendix G of the ROWD (URS, 2009).

As presented in the ROWD, the engineered alternative approved by the RWQCB for the surface impoundments is a single composite liner. This liner system includes (from bottom to top, in order of construction):

- 6 inches of prepared compacted native subgrade which is moisture conditioned and compacted to 90 percent of the maximum dry density per ASTM Standard D 1557;

- Leak detection monitoring sump under the lowest part of each surface impoundment that consists of a composite liner of a geosynthetic clay liner

(GCL) and a 60-mil High Density Polyethylene (HDPE) Flexible Membrane Liner (FML), and a cushion geotextile surrounding a gravel drainage layer; and

- A GCL and 60-mil HDPE FML liner.

The geosynthetic FML is the primary liner for the surface impoundments. To provide additional resistance to downward migration of water, and to provide a smooth surface on which to install the FML, a GCL is included in the liner system beneath the FML. A GCL consists of powdered, bentonite clay sewn in between two layers of synthetic fabric. Consequently, this engineered alternative composite liner provides a hydraulic conductivity two orders of magnitude lower than the prescriptive liner requirements outlined in 27 CCR. This design helps protect the vadose zone if a leak were to occur in the FML because the GCL would hydrate to "self-repair" a leak in the FML, mitigating the downward migration of water from the impoundments.

The surface impoundment liner system will be ballasted on the bottom of the impoundment and anchored around the perimeter of the impoundment by a 2-foot minimum horizontal run and an additional 9-foot minimum length of liner buried at a downward sloping inclination of 2:1 (horizontal:vertical) such that the edge of the liner is a minimum of 4 feet below the ground surface. This significant depth of the edge of liner is designed to prevent erosion-caused liner instability. Stormwater is designed to sheet flow into the surface impoundments.

3.3 Stormwater Diversion Design

As presented in the hydrology study in Appendix B of this Design Plan, the HCF surface impoundments and perimeter berms are designed to contain the on-site stormwater from the 1,000-year, 24-hour storm event within the HCF and prevent runon from the 100-year, 24-hour storm event. The primary stormwater diversion features include a partially lined drainage channel at the southern end of the facility, a perimeter berm, a berm separating the drainage areas to each of the surface impoundments, and a berm separating the surface impoundments from the remainder of the Site. These features are described in detail in the following sections, and presented on the design drawings in Appendix A.

3.3.1 Upstream Stormwater Controls

As designed by AEI CASC, the upstream stormwater controls consist of a drainage channel approximately 1,000 feet long at the southern end of the facility, designed to

capture offsite stormwater run-on and redirect offsite flows around the HCF to the west and northwest. The drainage channel has design slopes of 3:1 (horizontal:vertical) and a 25-foot wide channel bottom. Three segments of the drainage channel totaling a length of approximately 610 feet includes Pyramat^{R} lining channel bank erosion protection (or engineer-approved equivalent). Approximately 490 feet of the western end of the drainage channel includes a 3-foot thick, ¼ ton rip-rap lined channel bottom for erosion protection.

3.3.2 Facility Perimeter Berm

A variable height berm with side slopes of 2:1 (horizontal:vertical) is located around the perimeter of the HCF to control stormwater run-on and runoff, to and from the facility, respectively. All stormwater falling within the HCF for the 100-year, 24-hour storm event plus the 1,000-year, 24-hour event over the impoundment area will be contained in the surface impoundments. All stormwater from the 1,000 year, 24 hour storm falling on the Site will also be contained on Site. The minimum perimeter berm height is 1 foot around the entire facility; however, in some areas such as the northern end of the facility, including the northern end of the perimeter berm on the east and west sides of the HCF, the berm will be higher to contain the stormwater from the 1,000 year, 24-hour storm event. The minimum elevation of the top of the berm on the west side of the waste pile is 2317.6 feet Mean Sea Level (MSL) and the minimum elevation of the top of the berm on the eastern side of the waste pile is 2318.7 feet MSL. The minimum elevation at the crest of the facility entrance ramp is 2319.0 feet MSL. The top of the perimeter berm will be smoothly graded and continuous from these elevations to the minimum 1-foot high perimeter berm. The perimeter berm will consist of engineered fill consisting of native subgrade compacted to 90 percent relative compaction using ASTM D 1557 as the compaction standard.

3.3.3 Surface Impoundment Diversion Berm

The surface impoundment diversion berm is designed to allow the 100-year, 24-hour stormwater to flow through three designed diversion berm openings, and then, when the openings are closed, to contain the 1,000-year, 24-hour storm event. The surface impoundment diversion berm is located upstream (i.e. to the south and east) of the surface impoundments, as shown on the design drawings in Appendix A. The diversion berm is of variable height with side slopes of 2:1 (horizontal:vertical). The minimum top of berm elevation of the surface impoundment diversion berm is 2317.6 feet MSL for Surface Impoundment A and 2318.7 feet MSL for Surface Impoundment B, corresponding to berm heights of approximately 2.6 feet and 1.7 feet, respectively. The

northern end of waste pile will be fine graded (within the lowest 1-foot contour) to drain to the diversion berm openings. The diversion berm openings are located at the lowest elevation points and/or the point where the majority of stormwater is directed by the Site grades. The surface impoundment diversion berm will consist of engineered fill consisting of native subgrade compacted to 90 percent relative compaction using ASTM D 1557 as the compaction standard.

Three openings are incorporated into the surface impoundment diversion berm to direct the peak discharge from the 100-year, 24-hour storm event from the remainder of the Site into the surface impoundments. Calculations to size the openings length for flow through during the 100-year, 24-hour storm event are presented in Appendix C. A 20-foot opening is incorporated in the diversion berm south of Surface Impoundment A and two 10-foot openings are incorporated in the diversion berm to the east and south of Surface Impoundment B. The openings are designed with concrete abutment walls on each side of the inlet, intermediate bollards set at 10-foot increments, and concrete aprons upstream and downstream of the inlet to control erosion. The upstream portion of the apron has a thickened edge extending 12 inches below grade to control erosion.

During typical operating conditions, the openings will remain open for water to sheet flow into the impoundments. Anytime the water in the surface impoundments approaches the minimum required two feet of freeboard, the openings will be closed by manually inserting 10-foot long stop logs made of metal (i.e. aluminum or stainless steel), or engineer-approved alternative material into guide frames attached to the concrete abutments and intermediate bollards. The stop logs will be stored in a designated, fully marked location onsite at the office. When the stoplogs are in place, the stormwater from events in excess of the 100-year, 24-hour, storm event will back up onto the northern end of the Site ("1,000 year storm event containment area").

The 1,000-year, 24-hour hydrology study prepared by AEI CASC is presented in Appendix B of this Deisgn Plan (AEI CASC, 2011). The Site design grades and consideration of other site features in the area (office trailer, vehicle parking, tanks, and compost) were used to determine the 1,000 year storm event containment area while the stoplogs are in place. The office trailer is elevated and will not impact the 1,000 year storm event containment area. Vehicles and onsite equipment displace a minimal stormwater volume and would be relocated out of the 1,000 year storm event containment area during such events. Tanks will be located outside of the 1,000 year storm event containment area. When the facility is operating at full capacity, there will be an estimated 3,000 cubic yards of compost within the 1,000 year storm event containment area which is equivalent to approximately 1.8 acre-feet. Approximately 0.9

acre-foot of compost volume (volume that would be within the depth of stormwater) was included for the east and the west sides of the Site in the net stormwater volume in the AEI CASC study to determine the limits of the 1,000 year storm event containment area.

The net volume difference between the 100-year, 24-hour and the 1,000-year, 24-hour storm events plus the contributing volume from the other site features is 5.3 acre-feet (AF) for the On-Site Area A (14.9 AF + 0.9 AF – 10.5 AF) and 3.6 AF (9.2 AF + 0.9 AF – 6.5 AF) for On-Site Area B. These On-Site Areas are the drainage areas to the Surface Impoundments A and B, respectively. To contain the net stormwater volume from a 1,000-year 24-hour precipitation event on the Site, the minimum elevation of the perimeter berm and the surface impoundment diversion berm is 2,317.6 feet for the western portion of the facility draining to Surface Impoundment A, and 2,318.7 feet for the eastern portion of the facility draining to Surface Impoundment B.

3.4 Leak Detection Monitoring Sumps

The HCF design includes a leak detection monitoring sump (LDMS) below the lowest portion of each surface impoundment as presented in Section 3.2 above. The LDMS allows for detection of the potential vertical migration of water and removal of a water sample for testing. The LDMS is composed of, from bottom to top, a GCL, a FML, cushion geotextile, 2 feet of gravel, and nonwoven filter geotextile. A 6-inch diameter PVC pipe is installed within the gravel to allow access for moisture detecting equipment and to allow for sampling and/or pumping of liquid from the LDMS. Details illustrating these sumps are presented in the design drawings in Appendix A of this Design Plan.

3.5 Lysimeters

The liner design includes a lysimeter five feet below each surface impoundment. Lysimeters allow for detection of the potential vertical migration of water and removal of a water sample for testing. The lysimeter is composed of, from bottom to top, a GCL, FML, cushion geotextile, 2 feet of gravel, and nonwoven filter geotextile. A 6-inch diameter PVC pipe is installed within the gravel to allow access for moisture detecting equipment and allow for sampling and/or pumping of liquid from the lysimeter. Details illustrating these unsaturated zone monitoring lysimeters are presented in the design drawings in Appendix A of this Design Plan.

3.6 Groundwater Wells

One operations supply groundwater well and three groundwater monitoring wells are proposed at the HCF. The operations supply well will be located along the northern perimeter of the facility, near the office. Two downstream and one upstream groundwater monitoring wells are proposed. The downstream groundwater monitoring wells are located along the northern perimeter of the facility near the surface impoundments. The upstream groundwater monitoring well is located along the southern perimeter of the facility near the drainage channel. The operations supply groundwater well and the three proposed groundwater monitoring wells are located outside facility operations areas and drainage features.

Details regarding the groundwater monitoring well construction and monitoring requirements are presented in the Monitoring and Reporting Plan and Sampling and Analysis Plan for the HCF. A schematic well construction diagram is presented on the design drawings in Appendix A.

4. CONSTRUCTION QUALITY ASSURANCE PLAN

The construction of the surface impoundments and waste pile will be carried out in accordance with this CQA Plan, prepared to meet the requirements of 27 CCR, Section 20324.

4.1 Purpose

The purpose of the CQA Plan is to address the quality assurance procedures and monitoring requirements for construction of the project. The CQA Plan is intended to: (i) define the responsibilities of parties involved with the construction; (ii) provide guidance for the proper construction of the major components of the project; (iii) establish testing protocols; (iv) establish guidelines for construction documentation; and (v) provide the means for assuring that the project is constructed in conformance with technical specifications, applicable regulatory requirements, and the design drawings.

This CQA Plan addresses the soil, geosynthetic, and appurtenant components of the project. Care and documentation are required in the placement and compaction of soils and in the production and installation of liner materials placed during construction. This CQA Plan delineates the procedures to be followed for monitoring the construction of these materials. This CQA Plan details the CQA consultant activities during the evaluation, moisture treatment, placement, and compaction of soils for earthwork and the CQA protocols applicable to manufacturing, shipping, handling, and installing geosynthetic liner materials.

4.2 Parties Involved with Construction Quality Assurance

4.2.1 Owner and Construction Manager

During the construction the Owner, Nursery Products, will serve as the construction manager and will serve as a single point of contact for the Contractor and CQA consultant during construction.

4.2.2 Design Engineers

The design engineer for the overall grading design and the perimeter stormwater controls is Mr. Ceazar Aguilar, P.E. of AEI CASC Consulting. The design engineer for the facility liner systems, environmental monitoring systems, and the surface impoundment stormwater diversion berm is Ms. Jennifer Nevius, P.E. of Geosyntec.

The applicable design engineer reviews and approves any proposed changes in design during construction.

4.2.3 CQA Consultant

The CQA consultant is an independent party not affiliated with the contractor, geosynthetics installer, subcontractors, suppliers, or manufacturers. The CQA consultant may be the design engineer. The CQA consultant has the overall responsibility for managing, coordinating, and implementing the CQA activities and confirming that the contractor's construction quality control (CQC) activities are performed in accordance with the CQA Plan, design drawings and technical specifications. Critical activities related to the construction, manufacture, and installation of the earthwork, geosynthetics, civil improvements, and other project components will be monitored and documented by the CQA consultant. The CQA consultant will be responsible for issuing a Final Certification Report containing CQA documentation sufficient to satisfy regulatory requirements and the requirements of this CQA Plan.

4.2.4 Contractor

The contractor is responsible for the timely construction of the project, as delineated in the design drawings and technical specifications and in accordance with this CQA Plan. The contractor is also responsible for CQC. In particular, the contractor shall ensure that: (i) only materials meeting the requirements set forth in the design drawings and technical specifications are used; and (ii) the materials are installed in full conformance with the design drawings and technical specifications.

4.2.5 Resin Supplier

The resin supplier produces and delivers the resin to the geosynthetics manufacturer. Qualifications of the resin supplier are specific to the manufacturer's requirements.

4.2.6 Geosynthetics Manufacturer

The geosynthetics manufacturer is responsible for the production of finished material from appropriate raw materials. The geomembrane manufacturer reports to the geosynthetics installer.

4.2.7 Geosynthetics Installer

The geosynthetic installer is the contractor responsible for field handling, storage, placement, seaming, loading, or anchoring against wind uplift, and other aspects of the geosynthetic material installation. The geosynthetic installer will be trained and qualified to install the geosynthetic materials of the type specified for this project.

4.2.8 Soils Testing Laboratory

In the performance of CQA activities, the CQA consultant may engage a soils testing laboratory independent from the contractor, subcontractors, or any material supplier or manufacturer. The testing laboratory will conduct tests on representative soil samples to evaluate their properties and compliance with the design drawings and technical specifications.

4.3 CQA Consultant

Prior to construction, the CQA consultant:

- Reviews the final design drawings;
- Administers the CQA program; and
- Reviews the geosynthetic installers personnel qualifications.

During construction, the CQA consultant will supervise monitoring of activities, including:

- Site grading;
- Excavation, processing, placement, and compaction of native soils as engineered fill;
- Installation of LDMS and lysimeters;
- Installation of GCL & FML, and other liner components;
- Site visits;
- Preparation of daily field reports;

- Verification of the calibration and condition of on-site CQA equipment;
- Overseeing the collection and shipping of laboratory test samples;
- Reviewing results of laboratory testing;
- Reviewing installation and monitoring activities of the geosynthetics; and
- Preparing the Final Certification Report.

4.4 Project Control Meetings

To ensure a high degree of quality during construction, clear, open channels of communication are essential. To this end, meetings of key project personnel are necessary.

4.4.1 Preconstruction Meeting

The preconstruction meeting will include the CQA consultant, construction manager, geosynthetics installer, and the contractor. The purpose of this meeting is to review the design drawings, coordinate construction tasks, anticipate any installation problems which might cause difficulties or delays in construction, and review the CQA Plan with all of the parties involved. It is very important that the criteria regarding testing, repair, etc., be known and accepted by all parties prior to construction.

The CQA consultant will record the discussions and decisions of the meeting. The record of the meeting will be documented in the form of meeting minutes which will be subsequently distributed to all attendees.

4.4.2 Progress Meetings

Progress meetings will be held between the CQA consultant, the construction manager, geosynthetics installer, and the contractor. The progress meeting will be used to discuss current progress, planned activities, or revisions to the work. Minutes of the progress meeting will be documented by the CQA consultant and distributed to all appropriate parties.

4.4.3 Problem or Work Deficiency Meeting

A special meeting will be held, as needed, when and if a problem or deficiency is present or likely to occur. The meeting will be attended by the construction manager,

CQA consultant, and other parties, as appropriate. If the problem requires a design modification, the design engineer should either be present at, or consulted prior to this meeting. The purpose of the work deficiency meeting is to define and resolve the problem or work deficiency as follows:

- Define and discuss the problem or deficiency;
- Review alternative solutions;
- Select a suitable solution agreeable to all parties; and
- Implement an action plan to resolve the problem or deficiency.

Minutes of the work deficiency meeting shall be documented by the CQA consultant and distributed to all appropriate parties, including the RWQCB.

4.5 Documentation

4.5.1 General

An effective CQA plan recognizes construction activities that should be monitored and assigns responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA consultant will document that quality assurance requirements have been satisfied. The CQA consultant will also maintain at the job site a complete file of design drawings, technical specifications, CQA Plan, test procedures, daily logs, and other pertinent documents.

4.5.2 Daily Recordkeeping

Standard reporting procedures will include preparation of daily CQA documentation which, at a minimum, will consist of: (i) field notes, including memoranda of meetings and/or discussions with the design engineer or construction manager; (ii) CQA consulting logs and testing data sheets; and (iii) construction problems and solution summary sheets. This information will be reviewed by the CQA consultant, signed, and transmitted to the construction manager.

Monitoring logs and testing data sheets will be prepared daily. At a minimum, these logs and data sheets will include the following information:

- An identifying sheet number for cross referencing and document control;

- Date, project name, location, and other identification;
- Data on weather conditions;
- A site plan showing work areas and locations selected for random CQA testing;
- Descriptions and locations of ongoing construction;
- Equipment and personnel in each work area;
- Location where in-situ CQA tests and samples were taken;
- A summary of test results;
- Calibration of test equipment;
- Decisions made regarding acceptance of units of work and/or corrective actions to be taken; and
- Signature of CQA consultant representative.

4.5.3 Construction Problems

The construction manager will be informed by the CQA consultant about any significant recurring nonconformance with the design drawings, technical specifications, or CQA Plan. The cause of the nonconformance will be determined and appropriate changes in procedures or specifications may be recommended. These changes will be submitted to the design engineer for approval. When changes are made, they will become part of the construction documents.

4.5.4 Photographic Documentation

Photographs will be taken by the CQA consultant and documented in order to serve as a pictorial record of work progress, problems, and mitigation activities. The files will contain color prints identified with the date, time, and location of the photograph.

4.5.5 Design and/or Specification Changes

Design and/or specification changes may be required during construction. In such cases, the CQA consultant will notify the design engineer and construction manager.

4.5.6 Final Certification Report

At the completion of the work, the CQA consultant will submit to the construction manager a signed and sealed final certification report. This report will document that: (i) work has been performed in compliance with the construction documents; (ii) physical sampling and testing has been conducted at the appropriate frequencies specified in the CQA Plan; and (iii) the required CQA documentation has been completed. At a minimum, this report will include:

- GCL & FML manufacturers quality control documentation;
- A summary describing the CQA activities and indicating compliance with the drawings and technical specifications;
- A summary of CQA/CQC testing, including failures, corrective measures, and retest results;
- Documentation that the geomembrane trial seams were performed according to the CQA Plan and technical specifications;
- Documentation that field seams were non-destructively tested using a method in general accordance with the applicable test standards;
- Geosynthetic panel layout record drawing with destructive test locations;
- Documentation that nondestructive testing was monitored by the CQA consultant, that the CQA consultant informed the geosynthetics installer of any required repairs, and that the CQA consultant inspected the seaming and patching operations for uniformity and completeness;
- Records of sample and resample locations, the name of the individual conducting the tests, and the results of the tests;
- Photo logs; and
- Soil laboratory and field compaction test results.

4.6 Earthwork

This section describes CQA procedures for earthwork operations. The scope of earthwork and related construction quality assurance includes the following elements:

- Clearing, grubbing, and stripping;
- Stockpiling and soil management;
- Excavation; and
- Engineered fill and prepared subgrade.

The contractor and geosynthetics installer shall provide adequate notice to the CQA consultant for inspections and testing. Observation and testing will be periodic to full time, to monitor per the requirements of this CQA Plan.

4.6.1 Earthwork Construction Test Standards

The following test standards apply as called out in this manual and/or the technical specifications:

- ASTM D 422 Standard Test Method for Particle Size Analysis of Soils
- ASTM D 1140 Standard Test Method for Amount of Material in Soils Finer Than the No. 200 Sieve
- ASTM D 1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort
- ASTM D 2216 Standard Test Method of Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D 2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
- ASTM D 4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D 6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

4.6.2 Earthwork Test Frequencies

The CQA consultant conducts earthwork testing necessary to verify that the waste pile is an area of prepared subgrade of no less than 12 inches of engineered native material and the surface impoundments in an area of prepared subgrade of no less than 6 inches of prepared subgrade. The CQA consultant will also verify that the fills, waste pile liner, and berms are moisture conditioned and compacted to a minimum relative compaction of 90 percent per ASTM D 1557 with a minimum field density test frequency of one test per 1,000 cubic yards. 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 re-tests performed as a result of a failing test do not contribute to the total number of tests performed in satisfying the minimum test frequency.

4.6.3 Earthwork Soil Sample Numbering

The CQA consultant maintains soil sample numbers in a master log maintained at the site. Sample numbers begin with (01) and proceed upward. Information contained in the master log of test samples includes:

- Sample number;
- Date sampled;
- Location sampled;
- Location of laboratory testing;
- Date sample sent off site;
- Date test results received; and
- Test results and remarks.

4.6.4 Field Density Tests

4.6.4.1 Test Numbering

The CQA consultant is responsible for maintaining test numbers and results for field density tests performed by the nuclear moisture density gauge. The CQA consultant will maintain field books that identify soil types, date tested, personnel performing the test,

and sequential test number. No test number can be repeated, and re-tests of failing tests must be given a new number and a retest notation. Test data and results must be filled out on the field density test form.

4.6.4.2 Test Locations

The intention of the CQA program is to provide confidence that the earthwork materials and work conform to the technical specifications. To meet this intent, the CQA consultant will perform density tests of soil fills during construction. Density tests must be located at various elevations and uniformly dispersed throughout the entire area. Density test locations must be chosen without bias; however, additional testing can be performed in any areas that are suspect, marginal, or appear to be of poor quality. During the progress of the work, density test locations will be plotted on a drawing by the CQA consultant to document that no significant areas are untested. This drawing becomes part of the Final Certification Report.

4.6.5 Monitoring and Testing Requirements

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

4.6.5.1 Clearing, Grubbing, and Stripping

- Document that erosion and sediment control measures are securely in place prior to initiating clearing, grubbing, and stripping operations in any area.
- Document that clearing and stripping in areas required for site access and execution of the work is complete.
- Document that vegetation, roots, and highly organic soil are removed in areas to receive fill or liner materials.

4.6.5.2 Excavations

- Document that construction staking is performed before work and that survey bench marks with elevations are secured outside the work area.
- Document that the contractor has notified the Underground Service Alert to identify and locate underground utilities.

- Coordinate with the contractor to perform excavation verification surveys upon completion of excavating operations.

4.6.5.3 Engineered Fill and Subgrade Preparation

- Monitor that construction staking is performed before work and that survey bench marks with elevations are secured outside the work area.

- Perform visual and manual soil classifications to verify that material source is suitable for earth fills.

- Verify that the material is free of organic and oversized materials and perform visual classifications during excavation of borrow materials.

- Perform moisture-density relationship testing to determine the maximum dry density and optimum moisture content for earth fill materials.

- Perform nuclear density-moisture tests to document that each lift is compacted in accordance with project requirements.

- Monitor that soil materials are within 3 percent of the optimum moisture content.

- Monitor that desiccated earth fills are properly repaired or removed before placing subsequent lifts.

- Monitor that final earth fill surfaces are free of ruts, gouges, and other features that might contribute to erosion and sediment run-off.

- Monitor that the subgrade below the geosynthetic liner areas is proof-rolled and free of protrusions or depressions greater than ½ inch.

- Coordinate with the contractor and surveyor to perform verification surveys at the completion of earth fill operations. Verify corrective action measures (i.e., for over- or under-builds) as determined by verification surveys.

4.6.6 Drainage Material

- Review the geosynthetics installer's proposed methods to place the gravel over geosynthetics in the LDMS and vadose zone lysimeters for compliance with the drawings and specifications.

- Review provided gradation test result to verify that gravel materials comply with material gradation requirements of the project requirements.

- Monitor placement operations to verify that underlying geosynthetics installations are not damaged and wrinkles are minimized during placement operations.

4.6.7 Non-Conforming Work

If a defect is identified in any soil layer, the CQA consultant shall determine the extent and the nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA consultant shall determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the CQA consultant deems appropriate. If the soil layer has been subject to adverse weather conditions during construction, the CQA consultant shall re-examine the layer for possible damage in overly wet, desiccated or windblown areas.

4.6.7.1 Notification

After determining the extent and nature of the defect, the CQA consultant shall promptly notify the contractor or geosynthetics installer and the construction manager. If necessary, a work deficiency meeting may be held as needed between the necessary parties to assess the problem, review alternative solutions, and implement an action plan.

4.6.7.2 Repairs and Retesting

The contractor ahd geosynthetics installer shall correct all deficiencies to meet the project specifications. If project specification criteria cannot be met, or unusual weather conditions hinder work, the CQA consultant shall develop and present to the construction manager suggested solutions for his approval. The CQA consultant shall schedule appropriate re-tests when the work defect has been corrected. All re-tests by the CQA consultant must verify that the defect has been corrected before additional work is performed by the Contractor in the area of the deficiency. The CQA consultant

shall observe any repair and report any noncompliance with the above requirements in writing to the construction manager.

4.7 LDMS and Lysimeter Construction

The LDMS are designed below the lowest point of each surface impoundment. Lysimeters are designed 5 feet below the surface impoundment bottom. The CQA consultant will monitor that the sumps and lysimeters are constructed in accordance with design drawings presented in Appendix A and the technical specifications.

4.8 GCL & FML Liner Construction

This section discusses and outlines the CQA activities to be performed for the GCL and FML installation. The CQA consultant will review the drawings and the technical specifications regarding the installation.

4.8.1 Material Conformance

The CQA consultant will document that the GCL and FML delivered to the site meets the requirements of the technical specifications prior to installation. The CQA consultant will:

- Review the manufacturer's submittals for compliance with technical specifications; and
- Document the delivery and proper storage of GCL & FML.

4.8.2 Review of Construction Quality Control

The geosynthetics installer will provide the construction manager and the CQA consultant with the following:

- A properties sheet including all specified properties;
- The sampling procedure and results of testing; and
- A certification that property values given in the properties sheet are guaranteed by the manufacturer.

The CQA consultant will document that:

- The property values certified by the manufacturer meet all of the technical specifications; and
- The measurements of properties by the manufacturer are properly documented and that the test methods used are acceptable.

The geosynthetics installer will provide the construction manager and the CQA consultant with a product certification and quality control certificate for every roll of GCL and FML provided. The quality control certificate will be signed by a responsible party employed at the GCL & FML manufacturer. The quality control certificate will include roll numbers and identification and results of quality control tests.

The CQA consultant will evaluate that the quality control certificates have been provided at the specified frequency, and that the certificate identifies the rolls related to the roll represented by the test results. The CQA consultant will also review the quality control certificates and evaluate that the certified roll properties meet the specifications.

4.8.3 Delivery

The CQA consultant will visually inspect and document that the transportation and handling did not damage the FML & GCL. Upon delivery at the site, the Contractor and the CQA consultant will conduct a surface observation of the rolls for defects and damage. This inspection will be conducted without unrolling unless defects or damages are found or suspected. The CQA consultant will notify the construction manager should any rolls be rejected.

4.8.4 Storage

The geosynthetics installer will be responsible for the storage of the GCL and FML on site. The geosynthetics installer will provide storage space in a location (or several locations) such that on-site transportation and handling are optimized. The CQA consultant will document that storage of the GCL & FML provides adequate protection against sources of damage in accordance with ASTM D 4873.

4.9 GCL & FML Installation

The CQA consultant will document that the GCL & FML are installed in accordance with drawings, technical specifications, and manufacturer's recommendations.

4.9.1 Subgrade Preparation

The CQA consultant will document that the prepared subgrade meets the technical specifications, and that placement of the overlying materials does not damage, create large wrinkles, or induce excessive tensile stress in the underlying materials. The prepared subgrade below geosynthetics shall not contain protrusions or depressions greater than ½ inch.

The geosynthetics installer will certify in writing that the surface on which the GCL will be installed is acceptable. The certificate of acceptance will be given by the geosynthetics installer to the construction manager and CQA consultant prior to commencement of GCL & FML installation in the area under consideration.

After the supporting subgrade has been accepted by the construction manager, it will be the geosynthetic installer's responsibility to indicate to the construction manager any change in the supporting soil condition that may require repair work. If the CQA consultant concurs with the geosynthetics installer, then the construction manager will document that the supporting soil is repaired. At any time before and during the installation, the CQA consultant will indicate to the construction manager locations that may not provide adequate support to the liner.

The CQA consultant will document that the geosynthetic terminations have been constructed in general accordance with the drawings. Backfilling above the terminations will be conducted in general accordance with the technical specifications.

4.9.2 GCL & FML Placement

A field panel is the unit area of GCL or FML. It will be the responsibility of the geosynthetics installer to document that each field panel is given an "identification code". This field panel identification code will be as simple and logical as possible. Roll numbers established in the manufacturing plant must be traceable to the field panel identification code.

The CQA consultant will establish documentation showing correspondence between roll numbers and field panel identification codes. The field panel identification code will be used for all quality assurance records.

4.9.3 Field Panel Placement & Installation

A drawing illustrating the field panel layout will be submitted by the geosynthetics installer to the construction manager and CQA consultant for approval prior to construction. The CQA consultant will document that field panels are installed at the location indicated in the panel layout.

Field panels will be placed one at a time. Each FML field panel will be seamed after its placement. The GCL is not seamed, it is overlapped. During field panel placement, it is usually beneficial to begin at the high point area and proceed toward the low point with the "shingle" overlaps to facilitate drainage in the event of precipitation. It is also usually beneficial to proceed in the direction of prevailing winds. Accordingly, an early decision regarding installation scheduling should be made if and only if weather conditions can be predicted with reasonable certainty. Otherwise, scheduling decisions must be made during installation, in general accordance with varying conditions. In any event, the geosynthetics installer is fully responsible for the decision made regarding placement procedures. The CQA consultant will record the identification code, location, and date of installation of each field panel.

FML placement will not proceed when the ambient temperature or geomembrane sheet temperature is below 40 degrees F or above 105 degrees F, unless otherwise authorized by the CQA consultant. GCL & FML placement will not be performed during any precipitation, in the presence of excessive moisture, in an area of ponded water, or in the presence of excessive winds.

The CQA consultant will document that the above conditions are fulfilled. Additionally, the CQA consultant will document that the supporting soil has not been damaged by weather conditions. The CQA consultant will inform the construction manager if the above conditions are not fulfilled.

The CQA consultant will document the following:

- Equipment used does not damage the GCL & FML by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;
- The surface underlying the GCL & FML has not deteriorated since previous acceptance, and is still acceptable immediately prior to GCL & FML placement;
- Elements underlying the GCL & FML are clean and free of debris;

- Personnel working on the GCL & FML do not smoke, wear damaging shoes, or engage in other activities which could damage the liner;

- The method used to unroll the panels does not cause scratches or crimps in the GCL & FML and does not damage the supporting soil;

- The method used to place the panels minimizes wrinkles; and

- Adequate temporary loading and/or anchoring is not likely to damage the liner and has been placed to prevent uplift by wind.

The CQA consultant will inform the construction manager if the above conditions are not fulfilled. Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the CQA consultant.

The geosynthetics installer will provide the construction manager and the CQA consultant with an as-built FML seam layout drawing. The CQA consultant will review the FML seam layout drawing and evaluate that it is consistent with the preliminary panel layout. No FML panels may be seamed in the field with the CQA consultant's approval. In addition, panels not specifically shown on the FML seam layout drawing may not be used without the CQA consultant's prior approval.

Seams and overlaps should be oriented parallel to the line of maximum slope. In corners and odd-shaped locations, the number of seams should be minimized. No FML horizontal seams or GCL horizontal overlaps should be less than 5 feet from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized.

A seam numbering system compatible with the panel numbering system will be agreed upon at the pre-construction meeting. The geosynthetics installer will provide the construction manager and the CQA consultant with a list of proposed FML seaming personnel and their experience records.

The CQA consultant will log ambient temperature, FML seaming apparatus number, and geomembrane surface temperatures as well as seaming apparatus pressures.

The CQA consultant will also document that:

- The geosynthetics installer maintains the appropriate on-site the number of spare operable seaming apparatus';

- Equipment used for seaming the FML is not likely to damage the liner;
- For cross-seams, the edge of the cross-seam is ground to a smooth incline (top and bottom) prior to welding;
- The electric generator is placed on a smooth base such that no damage occurs to the FML;
- A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage;
- The liner is protected from damage in heavily trafficked areas;
- A movable protective layer may be used directly below each overlap of liner that is to be seamed to mitigate build up of moisture between sheets;
- Prior to FML seaming, the seam area is clean and free of moisture, dust, dirt, debris, and foreign material; and
- FML seams are aligned with the fewest possible number of wrinkles and "fishmouths."

If the geosynthetics installer wishes to use methods that may allow FML seaming at ambient temperatures below 40 degrees F or above 104 degrees F, the geosynthetics installer will demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced within acceptable temperature and wind requirements, and that the overall quality of the liner is not adversely affected.

The CQA consultant will document that these FML seaming conditions are fulfilled and will advise the construction manager if they are not. The construction manager will then decide if the installation will be stopped or postponed.

The CQA consultant will document that:

- The panels of FML have finished overlap of a minimum of 3 inches for fusion welding; and
- The procedure used to temporarily bond adjacent panels together does not damage the liner.

Trial seams will be made on fragment pieces of FML to verify that seaming conditions are adequate. The CQA consultant will observe trial seam procedures. Trial seam samples will be assigned a number. The CQA consultant will log the date, time, machine temperature, number of the seaming unit, name of the seamer, and pass or fail description for each trial seam sample tested.

Unless otherwise specified, the general FML seaming procedure used by the geosynthetics installer will be as follows:

- Fishmouths or wrinkles at the seam overlaps will be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles will be seamed and any portion where the overlap is inadequate will then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions.

- If seaming operations are carried out at night, adequate illumination will be provided at the geosynthetics installer's expense.

- Seaming will extend to the outside edge of panels to be placed in the liner anchorage.

The CQA consultant will document that the above FML seaming procedures are followed, and will inform the construction manager if they are not.

The geosynthetics installer will non-destructively test field seams over their length using an air pressure test (for double fusion seams only) or other approved method. The purpose of nondestructive tests is to check the continuity of seams. It does not provide information on seam strength. Air pressure testing should be performed in accordance with GRI Test Method GM6. Continuity testing will be carried out as the seaming work progresses, not at the completion of field seaming.

The CQA consultant will:

- Observe continuity testing;

- Record location, date, test unit number, name of person conducting the test, and the results of tests; and

- Inform the geosynthetics installer and construction manager of required repairs. The geosynthetics installer will complete any required repairs.

The CQA consultant will:

- Observe the repair and re-testing of the repair;
- Mark on the liner that the repair has been made; and
- Document the results.

The following procedures will apply to locations where FML seams cannot be non-destructively tested:

- All such seams will be cap-stripped with the same geomembrane.
- If the seam is accessible to testing equipment prior to final installation, the seam will be non-destructively 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 CQA consultant and geosynthetics installer for uniformity and completeness.

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

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

- The frequency of FML seam testing is a minimum of one destructive sample per 1,000 feet of weld. The minimum frequency is to be evaluated as an average taken throughout each surface impoundment.
- Test locations will be evaluated during seaming at CQA consultant's direction.

The geosynthetics installer will not be informed in advance of the locations where the seam samples will be taken. Samples will be cut by the geosynthetics installer as the seaming progresses in order to have test results before the liner is covered by another material.

The CQA consultant will:

- Observe sample cutting;

- Assign a number to each sample, and mark it accordingly;
- Record sample location on layout drawing; and
- Record reason for taking the sample at this location.

Holes in the liner resulting from destructive seam sampling will be immediately repaired, and the continuity of the new seams in the repaired area will be tested.

Field testing will be performed by the geosynthetics installer using a gauged tensiometer. Prior to field testing, the geosynthetics installer shall submit a calibration certificate for the gauge tensiometer to the CQA consultant. Calibration must have been performed within one year of use on the current project. Two 1-inch wide strips will be taken for peel and shear. The specimens shall not fail in the seam and shall meet the specified strength requirements. If any field test specimen fails, then the appropriate procedures will be followed.

The CQA consultant will witness field tests and mark samples and portions with their number. The CQA consultant will also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description.

At the option of the construction manager, destructive test samples may be packaged, under the responsibility of the geosynthetics installer in a manner that will not damage the test sample. The construction manager will document that packaging and shipping conditions are acceptable. The construction manager will be responsible for storing archive samples. Samples will be tested by the CQA laboratory. The CQA laboratory will be selected by the geosynthetics installer with the concurrence of the construction manager and CQA consultant.

Testing will include "bonded seam strength" and "peel adhesion." At least five specimens will be tested for each test method. Specimens will be selected alternatively by test from the samples. A passing test will meet the minimum required values in at least four out of five specimens.

The CQA laboratory should provide test results no more than 24 hours after they receive the samples. The CQA consultant will review laboratory test results as soon as they become available, and make recommendations to the construction manager.

The following procedures will apply whenever a sample fails a destructive test, whether that test was conducted by the CQA laboratory, the geosynthetics installer laboratory, or by the gauged tensiometer in the field. The geosynthetics installer has two options;

- The geosynthetics installer can reconstruct the seam between two passed test locations.

- The geosynthetics installer can trace the welding path to an intermediate location at 10 feet minimum from the point of the failed test in each direction and take a small sample for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

Acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been taken.

The CQA consultant will monitor the following for GCL placement:

- GCL placement includes the specified minimum overlap.
- Powdered bentonite is placed between all seams.
- No hydrated GCL is placed.

4.9.4 Defects and Repairs

This section prescribes CQA activities to document that defects, tears, rips, punctures, damage, or failing seams shall be repaired.

Seams and non-seam areas of the liner will be examined by the CQA consultant for identification of defects, holes, blisters, undispersed raw materials and signs of contamination by foreign matter. Because light reflected by the liner helps to detect defects, the surface of the liner will be clean at the time of examination.

Portions of the geomembrane exhibiting a flaw, or failing a test, will be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be at the discretion of the CQA consultant. The procedures available include:

- Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;

- Spot welding or seaming, used to repair small tears, pinholes, or other minor localized flaws;

- Capping, used to repair large lengths of failed seams;

- Removing a bad seam and replacing with a strip of new material welded into place.

In addition, the following provisions will be satisfied:

- Surfaces of the geomembrane which are to be repaired will be abraded no more than 20 minutes prior to the repair;

- 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 by the CQA consultant;

- Patches or caps will extend at least 6 inches beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 inches; and

- The geomembrane below large caps should be appropriately cut to avoid water collection between the layers.

Each repair will be numbered and logged, and be tested as appropriate. Repairs that pass the test will be taken as an indication of an adequate repair. Failed tests indicate that the repair will be redone and re-tested until a passing test results. The CQA consultant will observe all testing of repairs and will record the number of each repair, date, and test outcome.

4.9.5 Lining System Acceptance

The geosynthetics installer and the manufacturer will retain all responsibility for the liner materials in the liner system until acceptance by the construction manager. The liner system will be accepted by the construction manager when:

- The installation is finished;
- Verification of the adequacy of all seams and repairs, including associated testing, is complete; and
- The Final Certification Report sealed by a California-registered professional engineer has been received by the construction manager, documenting installation has been completed in accordance with this CQA Plan, the design drawings, and the technical specifications.

4.10 PVC Piping

This section describes CQA procedures for PVC pipe installations. Perforated and solid Schedule 40 PVC pipe will be used to construct the LDMS and lysimeter risers. CQA for the PVC pipe installations will be performed to verify that pipe systems are installed in accordance with the design and specifications.

Upon delivery of the PVC pipe, the CQA consultant will observe pipe for damage during shipping and handling, identify damaged materials, and document that damaged materials are not used. Damaged pipe will be rejected. If rejected, the CQA consultant will document that pipe is removed from the site or stored at a location separate from accepted pipe. No conformance testing is required for PVC pipe.

During pipe installation and welding, the CQA Monitor will:

- Monitor that chains, end hooks, cable slings, or any other devices that may scar the pipe are not used to handle pipe;
- Monitor that the pipe is not damaged during handling operations;
- Monitor that inside and outside of pipe ends are cleaned to remove dirt, water, grease, and other foreign material; and
- Monitor that perforations are made and oriented per the design drawings.

5. TECHNICAL SPECIFICATIONS

5.1 GCL – Geotextile Component

The geotextile component of the GCL shall be manufactured of non-woven/woven, continuous or staple filament, needle-punched, polypropylene or polyester, UV-stabilized yarn oriented into a stable network that maintains its structure during handling, placement, and long-term service.

The geotextile shall be chemical resistant and cannot be heat burnished or contain recycled materials. The geotextile shall have minimum average roll values (MARV) shown in the table below.

5.2 GCL

5.2.1 Submittals

Construction Submittals:

Submit the following to the Owner or Owner's Representative for review no later than 2 days following placement.

- Daily subgrade acceptance by Geosynthetics Installer.
- An area as-built drawing showing the area covered each day on the liner plan. List the GCL roll numbers installed each day. It is not necessary to locate the position of each GCL roll.

Post-Construction Submittals:

- GCL Installation Certification.
- GCL Warranty.

5.2.2 Delivery, Storage, and Handling

Packing and Shipping:

- GCL shall be supplied in rolls wrapped individually in relatively impermeable and opaque protective covers.

- GCL rolls shall be marked or tagged with the following information:
    - Product identification information (manufacturer's name and address, brand product code).
    - Lot number and roll number.
    - Roll length, width, and weight.
    - Geosynthetics Installer shall prepare a full inventory of materials delivered to the site and submit the inventory to the Owner or Owner's Representative.

Storage and Protection:

- Unloading of material that is not already on-site, on-site handling, and storage of the GCL are the responsibility of the Geosynthetics Installer.
- The Owner shall provide on-site storage area(s) for GCL rolls from time of delivery until installation.
- Store and protect GCL from dirt, water, ultraviolet light exposure, and other sources of damage.
    - Place GCL rolls on wooden pallets for above ground storage.
    - Cover GCL rolls with heavy, waterproof tarpaulin.
- Preserve integrity and readability of GCL roll labels.
- Performed in accordance with ASTM D 4873.

5.2.3 Products

The GCL shall consist of a layer of granular sodium bentonite clay needle punched between two nonwoven (see Section 5.1), and shall comply with the criteria listed in this section.

Table 5-1
Required GCL Properties

Material Property	Test Method	Test Frequency	Required Values
Bentonite Swell Index	ASTM D 5890	1 per 50 tonnes	24 mL/2g (min.)
Bentonite Fluid Loss	ASTM D 5891	1 per 50 tonnes	18 mL (max.)
Bentonite Mass/Area	ASTM D 5993	1 per 40,000 ft^2	0.50 lb/ft^2 min.
GCL Tensile Strength	ASTM D 6768	1 per 200,000 ft^2	30 lbs/in MARV
GCL Peel Strength	ASTM D 6496	1 per 40,000 ft^2	3.5 lbs/in min.
GCL Index Flux	ASTM D 5887	Weekly	1×10^{-8} $m^3/m^2/sec$ max
GCL Hydraulic Conductivity	ASTM D 5887	Weekly	5×10^{-9} cm/sec max

Note: Material parameters shall be in accordance with the requirements of the most recent edition of GRI GCL3.

The GCL manufacturer shall provide the Contractor with manufacturing QA/QC certifications for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer and shall include:

- Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the swell index and fluid loss values shown in Table 5-1 above.

- Manufacturer's test data for the finished GCL product demonstrating compliance with the values shown in the table above.

The bentonite sealing compound applied to overlaps shall be made of the same natural sodium bentonite as the GCL and shall be as recommended by the GCL manufacturer. This compound is not required for longitudinal GCL seams that have SuperGroove™.

5.2.4 Execution

5.2.4.1 Surface Acceptance

Subgrade should be proof rolled prior to GCL placement and shall be free of protrusions or depressions greater than ½ inch. GCL should not be placed on saturated soil or ponded water.

The Owner or Owner's Representative's inspection and approval of geomembrane condition each day shall be required prior to GCL installation. Remove any existing debris from the subgrade prior to installation of the GCL.

5.2.4.2 Equipment

Protect subgrade and allow minimal travel limited to low ground pressure equipment on the GCL. Methods used to unroll panels shall not damage the subgrade or GCL. Equipment used shall not damage GCL or geomembrane by handling, trafficking, leakage of hydrocarbons (such as gasoline or oil) or other means. Defects in material installation arising from the use of equipment shall be repaired at the sole cost of the Geosynthetics Installer.

5.2.4.3 Placement

GCL Deployment: Handle GCL in a manner to ensure it is not damaged. At a minimum, comply with the following:

- On slopes 10H:1V and steeper, deploy the GCL down-slope, in a controlled manner, with panels parallel to the slope. The GCL should extend continuously from the crest to the toe of the slope with no horizontal seams.
- Methods used to unroll and place panels shall not damage the GCL surface or edges.
- Method used to place panels shall maintain overlap and minimize wrinkles (especially differential wrinkles between adjacent panels).
- Adjust GCL placement, as necessary, using tools that do not damage the GCL.
- Cut the GCL with a utility knife or other approved device. Do not damage adjacent materials while cutting the GCL.

- During deployment, do not entrap foreign objects that could damage the GCL.

- Do not install GCL during periods of rain, in areas of standing water, over areas which have softened by precipitation (unconfined compressive strength less than 1 ton per square foot), or over areas of ice or frozen subgrade.

- Replace GCL that is prematurely hydrated before placement of the overlying geomembrane. The GCL shall be considered prematurely hydrated if the moisture content of the bentonite exceeds 50%, according to ASTM D 4643 modified to include wet weight in the denominator.

- Only deploy the amount of GCL that can be covered by geomembrane during that day.

- Cover all exposed edges of the GCL with protective tarps and sandbags in place at the end of each day.

Overlaps:

- GCLs shall be overlapped along the sides of each panel a minimum of 6 inches.

- GCLs shall be overlapped, along the end seams, a minimum of 12 inches or per manufacturer's specification. Overlaps shall be oriented in the downslope direction.

Defects and Repairs:

- Repair all flaws or damaged areas by placing a patch of the same material extending at least 1 foot beyond the flaw or damaged area.

- Repair ruts or depressions in the GCL by:

    - Lifting the GCL and filling the rut with subgrade fill soils or other Engineer-approved fill material.

- Leaving the GCL in-place, backfilling the rut with sand or other approved materials, and placing a GCL patch over the backfill (extending at least 1 foot beyond the limits of the backfill).

5.3 HDPE – Smooth Geomembrane

5.3.1 Submittals

Certification Submittals: Prior to delivery of materials to the site, submit the following to the Owner or Owner's Representative for approval:

- Manufacturer's certification for representative geomembrane material.
- Statement that no reclaimed polymer is added to resin during manufacture of actual geomembrane to be used in this project.
- Proposed Panel Layout Drawings for construction shall be submitted prior to installation. The Drawings shall be in sufficient detail to provide an accurate representation of the field seaming and anchor trench details that will be performed. The diagram shall be shown on a drawing with a one-inch equal to 60-feet scale (or larger), shall include the approved construction reference grid, bottom of slopes, anchor trench areas, North arrow, title of drawing, labeling of all features and any other information to define the work. It shall identify each sheet and panel by number. The layout shall conform to the following:
    a) Proposed field seams shall be shown;
    b) No horizontal seams shall be allowed on slopes;
    c) On sideslopes, panels shall be aligned with long axis parallel to the line of maximum slope.
    d) All overlaps shall be in the downslope direction.
    e) Panel layout shall be established such that the total length of seam shall be minimized.
    f) The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc.
- Proposed installation sequence and schedule.

- Manufacturer's and Installer's Qualifications
- List of personnel performing field geomembrane seaming operation, along with pertinent experience information.
- Description of the actual seaming apparatus proposed to be used and extrudate properties.
- Detailed description of proposed field seaming and installation procedures and detailed description of proposed field seam testing methods.

Pre-Construction Submittals: Submit the following to the Owner or Owner's Representative.

- Written list of the lot numbers and specific rolls shipped to the project site.
- Manufacturer's Quality Control data for rolls shipped to the project site indicating compliance with project requirements.
- Manufacturer's data for raw materials:
    a) Copy of quality control certificates issued by resin suppliers.
    b) HDPE resin production date(s).
    c) Results of manufacturer's quality control tests indicating the quality of resin used to manufacture geomembrane rolls assigned to the site conforms with the project requirements.

Construction Submittals: Submit the following to the Owner or Owner's Representative for review on a weekly basis following placement of each panel.

- Quality Control documentation by Geosynthetics Installer.
- Revised Panel Layout Drawings (field sketches)
- Updated Installation Schedules as construction progresses.

Post-Construction Submittals:

- Geomembrane Warranty.

- Record Documentation as detailed in this Section.

5.3.2 Construction Quality Control

Geomembrane Quality Control by the Geosynthetics Installer shall include:

- Visual inspection for installation damage and conformance with the Specifications.

- Non-destructive/destructive seam testing in accordance with this Section.

- It is the responsibility of the Geosynthetics Installer to notify the Owner or Owner's Representative at the start of each workday of his intent to perform activities requiring observation by the Owner or Owner's Representative. The Owner or Owner's Representative will provide one construction observer for observation of membrane placement activity (i.e. one observer for each testing and placement operation). If the Geosynthetics Installer intends to perform multiple activities, then the Geosynthetics Installer shall request in writing with a minimum of five days notice additional inspectors and not commence multiple activities until inspectors are present. The Owner or Owner's Representative will observe all non-destructive testing of all seams.

5.3.3 Qualifications

Manufacturer:

- Manufacturer shall have at least 5 years continuous experience in the manufacture of HDPE geomembrane rolls or similar products. The Manufacturer must demonstrate, by submitting a list of previous projects, a minimum of 15 million sq. ft. of manufacture of HDPE geomembrane or similar products.

Geosynthetics Installer:

- Geosynthetics Installer shall have at least 5 years continuous experience in installation of polyethylene geomembrane or similar products. The Geosynthetics Installer must demonstrate a minimum of 5 million sq. ft. of HDPE geomembrane installed for at least 10 completed facilities.

- Personnel performing seaming operations shall have demonstrated expertise on previous geomembrane installations. Each welder shall have experience seaming a minimum of 1 million sq. ft. of polyethylene geomembrane within the last three years.

5.3.4 Delivery, Storage, and Handling

5.3.4.1 Packing and Shipping:

- Geomembrane shall be packaged and shipped by appropriate means to mitigate damage to the material and to facilitate off-loading.
- Geomembrane rolls shall be marked or tagged with the following information:
    a) Product identification information (Manufacturer's name and address, brand product code).
    b) Lot, number, and roll number.
    c) Roll thickness, length, and width.
    d) Geosynthetics Installer shall prepare a full inventory of materials delivered to the site and submit the inventory to the Owner or Owner's Representative within 2 days of receipt.
- Performed in accordance with ASTM D 4873.

5.3.4.2 Storage and Protection:

The Geosynthetics Installer shall provide on-site storage area(s) for geomembrane rolls from time of delivery, or start of project (for material already on-site) until installation.

- Store and protect geomembrane rolls from puncture, dirt, grease, vandalism, excessive moisture, ultraviolet light exposure, and other sources of damage.
    a) Place geomembrane rolls on smooth, level, elevated surfaces.
    b) Cover geomembrane rolls with heavy, waterproof tarpaulin.
- Installer shall preserve integrity and readability of geomembrane roll labels.

- Geomembrane that is received that does not have proper manufacturer's documentation shall be stored at a separate location until all documentation has been received, reviewed, and accepted.

5.3.4.3 On-site Handling:

- Unloading of material that is not already on-site, on-site handling, and storage of the geomembrane is the responsibility of the Geosynthetics Installer.

- Use appropriate handling equipment when unloading or moving geomembrane rolls from one place to another. Follow the Manufacturer's recommendations for handling geomembrane rolls so as not to cause damage.

- Report any observed damage to the Owner or Owner's Representative.

5.3.5 Products

- The geomembrane shall be produced in sufficient quantities to complete the work for their respective independent use (per these specifications and the Construction Drawings). They will also be produced in rolls free of holes, blisters, striations, undispersed raw materials, or any sign of contamination by foreign matter.

- Resin used in the manufacturing of the geomembrane shall be new, first-quality, virgin polyethylene resin. The addition of reworked polymer (from the manufacturing process) to resin shall be permitted if it does not exceed 2% by weight, contains no encapsulated scrim, and is performed with appropriate cleanliness. The addition of post consumer resin shall not be permitted.

- Geomembrane shall be manufactured from a pure polyethylene resin having a minimum density in accordance with Table 5-2. The resin shall be mixed with the specified amount of carbon black. The carbon black shall be pre-blended with the resin prior to melting.

- The geomembrane shall exhibit the minimum physical properties listed in Table 5-2.

- Geomembrane seams shall meet the minimum requirements listed in GRI Test Method GM-19, shown in Table 5-3. Frequency of destructive seam testing shall be at least 1 per 1000 linear feet of seam length.

- Resin used for extrusion welding shall be produced from same resin type as the geomembrane. Physical properties of the welding resin shall be the same as those of the resin used in the geomembrane.

Table 5-2
Required HDPE Geomembrane Properties

Property	Test Method	Minimum Specification
Thickness, mil	ASTM D 5994	
Minimum Average		60
Lowest Individual Reading		54
Density	ASTM D 1505	0.94
Carbon Black Content, %	ASTM 1603, mod.	2.0
Tensile Properties: (ea. direction)	ASTM D 6693	
Strength at Yield, lb/in		126
Strength at Break, lb/in		228
Elongation at Yield	(1.3" gauge length)	12
Elongation at Break	(2.0" gauge length)	700
Tear Resistance, lb	ASTM D 1004	42
Puncture Resistance, lb	ASTM D 4833	108
Resin Density, g/cm^3	ASTM D 1505	0.932
OIT, minutes	ASTM D 3895 (1 atm, 200" C)	100
Melt Flow Index, g/10 min	ASTM D 1238 (190/2.16)	Less than or equal to 1

Note: HDPE geomembrane shall meet the requirements of the most recent edition of GRI GM 13.

Table 5-3
Required 60-mil HDPE Geomembrane Seam Properties

Property	Test Method	Minimum Specification
Shear Strength		
Fusion	ASTM D 6392	120
Extrusion	ASTM D 6392	120
Shear Strength		
Fusion	ASTM D 6392	91
Extrusion	ASTM D 6392	78

5.3.6 Execution

5.3.6.1 Equipment

- Front-end loaders, cranes, or other approved heavy equipment used for geomembrane deployment shall not be operated over the GCL.

- Panel deployment shall utilize a spreader-bar or similar equipment to mitigate slings from damaging the roll edges. Small floatation tired ATV's are also acceptable. No tracked vehicles will be allowed on the GCL.

- Low ground pressure (LGP) equipment (average contact pressure < 4 psi) shall be used for geomembrane deployment over the GCL.

- Equipment used shall not contaminate or damage GCL or geomembrane by handling, trafficking, spilling of hydrocarbons (such as gasoline or oil) or other means. Defects in material installation arising from the use of equipment shall be repaired at the sole expense of the Geosynthetics Installer.

- Direct equipment contact with geosynthetics shall be minimized. The geomembrane shall be protected by geotextile "rub sheets", scrap geomembranes, or other suitable materials, in trafficked areas or other areas requiring geomembrane protection.

5.3.6.2 Geomembrane Placement

General

- Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane or GCL.

- Methods used to unroll panels shall not cause scratches or crimps in the geomembrane and shall not damage the GCL or cause there to be poor contact between the geomembrane and the GCL or subgrade below.

- Methods used to place panels shall minimize wrinkles (especially differential wrinkles between adjacent panels).

- The geomembrane shall be securely anchored and then rolled in such a manner as to continually keep the geomembrane in tension to preclude folding.

- The geomembrane shall be weighted with sandbags or the equivalent ballast materials, to mitigate movement caused by wind. Such sandbags shall be installed during placement and shall remain until replaced with subsequent liner system materials and/or other materials capable of providing sufficient ballast against wind uplift. In case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind uplift of panels.

- Verify that the surface beneath the geomembrane has not deteriorated since the previous acceptance.

Installation

- Follow instructions on boxes or wrapping containing geomembrane materials to ensure panels are unrolled in proper direction for seaming.

- On slopes 10H:1V and steeper, deploy geomembrane panels down-slope, in a controlled manner, with panels parallel to the slope.

- Panel sizes shall be detailed in the Geosynthetics Installer's Panel Layout Drawing showing dimensions, panel numbering and installation details.

a) Field panel is roll or portion of roll cut in field.

b) When placed, designate each roll with panel number (identification code) consistent with layout plan. Panel is unit area of geomembrane to be seamed in field (e.g., one roll may be cut into several panels). Position panels on-site as shown in Panel Layout Drawings.

- Place panels one at a time. Deploy no more panels than can be seamed on the same day. No more than one panel shall be unrolled prior to seaming, unless authorized by the Owner or Owner's Representative.

Weather Conditions:

- Do not place panels at ambient temperature below or above the manufacturer's suggested ambient temperature range for installation.

- Do not place during precipitation, in presence of excessive moisture (e.g., fog, dew), in areas of ponded water, or during excessive winds, as determined by the Owner or Owner's Representative.

Damage:

- Any panel which, in judgment of the Owner or Owner's Representative, becomes seriously damaged (such as torn or twisted permanently) shall be replaced at sole expense of the Geosynthetics Installer. Less serious damage shall be repaired as approved by the Owner or Owner's Representative.

- Remove rejected damaged panels or portions of rejected damaged panels from work area.

Materials in Contact with Geomembrane:

- Carefully install materials in contact with geomembrane surfaces to minimize potential damage. Geotextile materials may be temporarily placed loosely on top of the geomembrane for protection, if approved by the Owner or Owner's Representative.

- Clamps, clips, bolts, nuts, or other fasteners used to secure geomembrane to each appurtenance shall have life span equal to or exceeding that of the geomembrane.

- Pipes and Other Appurtenances:

    a) Install geomembrane around any appurtenances, such as pipes, protruding through geomembrane as shown on the Design Drawings. Unless otherwise specified, initially install geomembrane sleeve or apron around each appurtenance prior to geomembrane installation.

    b) After material is placed and seamed, complete final field seam connection between appurtenance sleeve or apron and geomembrane. Maintain sufficient initial overlap of appurtenance sleeve so shifts in location of geomembrane can be accommodated.

    c) Extreme care shall be taken while seaming around appurtenances because both nondestructive and destructive seam testing might not be feasible. Do not damage geomembrane while making connections to appurtenances.

5.3.6.3 Geomembrane Field Seaming

Seam Layout:

- In general, orient seams parallel to line of maximum slope, i.e., oriented along, not across the slope. In corners and odd-shaped geometric locations, minimize numbers of field seams.

- No horizontal seam shall be allowed on the slopes.

Overlapping and Temporary Bonding:

- Overlap panels a minimum of 3 in. unless otherwise recommended by the geomembrane manufacturer.

- Procedure used to temporarily bond adjacent panels together for extrusion welding, shall not damage geomembrane; in particular, temperature of air at nozzle of any spot welding apparatus shall be controlled such that the geomembrane is not damaged.

- No solvent or adhesive shall be used unless product is approved in writing by the Owner or Owner's Representative (samples shall be submitted for testing and evaluation).

Seam Preparation:

- Prior to seaming, seam shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

- If seam overlap grinding is required, process shall be completed according to Manufacturer's instructions and in a way not damaging to geomembrane.

- Align seams with least possible number of wrinkles and "fish mouths".

Seaming Equipment and Products:

Approved processes for field seaming are fusion welding and extrusion welding. Proposed alternate processes shall be documented and submitted to the Engineer for approval prior to use. Extrusion welding shall be restricted to repairs and welding applications not possible by the fusion process. Only use apparatus specifically approved by geomembrane manufacturer.

Fusion Process:

- Use automated, vehicular-mounted fusion welding apparatus suitable for HDPE geomembranes that will mitigate seams defects such as puckering.

- Equip apparatus with gauges indicating applicable temperatures and pressures.

- Maintain at least one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage, particularly in heavily trafficked areas.

- Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use. When protective material is in place, sudden stops or starts, sharp turns, and stationary churning of vehicles shall be strictly prohibited.

Extrusion Process:

- Complete grinding no more than one hour prior to seaming.
- Exposed grinding marks shall not extend more than 1/4 inch from the seamed area.
- Use only clean and dry welding rods.
- Use apparatus equipped with gauges giving temperature in apparatus and at nozzle.
- Provide documentation of extrudate to the Owner or Owner's Representative and certify that extrudate is compatible with specifications and is comprised of same resins as geomembrane.
- Maintain at least one spare operable extrusion seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.
- Purge extruder prior to beginning seam until all heat-degraded extrudate has been removed from barrel.
- Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use.
- Grind edges of cross seams to an incline prior to welding.

Weather Conditions for Seaming:

- No seaming shall be attempted below 32°F or above 122°F measured 6 inches above the liner without approval of the Owner or Owner's Representative.
- Below 32°F, seaming may be allowed if geomembrane is preheated by either the sun or by a hot air device, and if there is not excessive cooling resulting from wind. Trial welds shall be made during similar conditions as those during which the material is to be welded.
- Above 32°F, no preheating will be required.

- Geomembrane shall be dry and protected from wind.

- In the event of seaming below 32°F or above 122°F, measured 6 inches above the liner, certify in writing that low-temperature or high-temperature seaming procedures does not cause any physical or chemical modification to geomembrane that will generate any short or long-term damage to geomembrane.

General Seaming Procedures:

- Use double hot wedge welding for installation seaming wherever possible.

- Seaming shall extend to outside edge of panels to be placed in anchor trench.

- If required, provide firm substrate by using flat board, conveyor belt or similar hard surface directly under seam overlaps to achieve proper support.

- Cut "fish mouths" or wrinkles at seam overlaps along ridge of wrinkle in order to achieve flat overlap. Seam cut "fish mouths" or wrinkles. Patch any portion where overlap is inadequate with oval or round patch of same geomembrane extending a minimum of 6 in. beyond cut in each direction.

- Extrusion weld all cross seam tees a minimum distance of 4 inches on each side of the tee.

Trial Seams:

- Before the start of geomembrane welding and during welding operations, trial welds shall be made by each seamer for each piece of seaming equipment to be used during production seaming on fragment pieces of geomembrane to confirm seaming conditions are adequate. Trial seams shall be made at beginning of each seaming period and at mid-shift for each seaming apparatus used that day. Also, each seamer shall make at least one trial seam each day. The Owner or Owner's Representative may, at his/her discretion, require additional trial welds.

- The trial weld sample shall be at least 42 inches long by 1 ft wide with seam centered lengthwise. Six random test specimens will be cut, each 1-inch wide from trial seam sample. Test Specimens shall be tested for bonded

seam strength and peel adhesion (shear and peel strengths; 3 specimens for shear and 3 specimens for peel) using a digital field tensiometer. All specimens must meet the required seam properties provided in Table 5-3. One specimen failure shall result in a failure for the entire seam sample. If an additional trial seam fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until deficiencies are corrected and two consecutive successful full trial seams are achieved.

- Results of peel and shear tests shall be recorded on a trial weld form.
- Trial welds must be completed under conditions similar to those under which geomembrane panels will be welded.
- Trial welds shall be allowed to cool before being tested.
- An additional trial weld shall be performed if a wide change in temperature (±30°F), humidity, or wind speed occurs since the previous trial weld.

Nondestructive Seam Continuity Testing:

- Nondestructively test field seams over their full length using vacuum test unit or air pressure (for double hot wedge fusion process). Continuity testing shall be done as seaming work progresses, not at completion of field seaming.
- Complete required repairs.
- The following procedures shall apply to locations where seams cannot be nondestructively tested, as determined by the Owner or Owner's Representative:

    a) If the seam is accessible to testing equipment prior to final installation, seam shall be nondestructively tested prior to final installation.

    b) All such seams shall be cap-stripped with same geomembrane where possible.

    c) If seam cannot be tested prior to final installation, seaming and cap-stripping operations shall be observed by Owner or Owner's Representative for uniformity and completeness.

1. Vacuum Testing (for non-destructive testing of extrusion and single track welds):

   a) Use following equipment:

      i) Vacuum box assembly consisting of rigid housing, transparent viewing window, soft neoprene gasket attached to bottom, port hole or valve assembly, and vacuum gauge.

      ii) Steel vacuum tank and pump assembly equipped with pressure controller and pipe connections.

      iii) Rubber pressure/vacuum hose with fittings and connections.

      iv) Bucket and wide paint brush.

      v) Soapy solution.

   b) The following procedures shall be followed:

      i) Trim excess overlaps from seam.

      ii) Energize vacuum pump and establish tank pressure to minimum of 6 in. of mercury (i.e., 3-lb./sq. in. [psi] absolute).

      iii) Thoroughly wet strip of geomembrane approximately 12 in. by 36 in. with soapy solution.

      iv) Place box over wetted area.

      v) Close bleed-valve and open vacuum valve.

      vi) Ensure that a leak tight seal is created.

      vii) Examine geomembrane through viewing window for presence of soap bubbles, for period of not less than 10 sec.

      viii) If no bubble(s) appear after 10 sec, close vacuum valve and open bleed valve, move box over next

adjoining area with minimum 3-inch overlap, and repeat process.

ix) Mark areas where soap bubbles appear, and then repair those areas.

x) Test all single track welds and extrusion seams.

2. Air Pressure Testing for dual track hot wedge fusion seam, based on GRI Test Method GM6:

a) Equipment:

i) Air pump (manual or motor driven) equipped with pressure gauge capable of generating and sustaining between 21 and 37 psi.

ii) Rubber hose with fittings and connections.

iii) Sharp hollow needle or other approved pressure feed device.

b) The following GRI GM6 procedure shall be followed:

i) Seal both ends of seam to be tested.

ii) Insert needle or other approved pressure feed device into tunnel created by double hot wedge fusion weld. Place protective cushion between air pump and geomembrane.

iii) Energize air pump to a pressure between 27 and 30 for 60-mil geomembrane, close valve, and sustain pressure for 5 min. (following initial relaxation period).

iv) Observe air pressure for 5 minutes after the initial 5-minute stabilization period.

v) If pressure loss of more than 3 lb./sq. in. for 60-mil thick geomembrane is noticed, locate faulty area and repair (or as otherwise directed in GRI GM6).

vi) At end of test, puncture end of seam opposite pressure feed device and watch gauge pressure drop to zero, check for air channel obstruction and repeat air pressure test. If gauge pressure does not drop to zero after repeating air pressure testing, then locate the blockage and test seam on both sides of the blockage.

vii) Remove needle or other approved pressure feed device and seal all penetration holes.

Destructive Seam Strength Testing:

- Field Testing:

  a) Cut a 1-inch wide strip sample at the beginning and the completion of all seams. Cut samples from areas that do not require patching if possible, for example at anchor trench areas or runouts beyond slopes.

  b) Field test samples. If test fails, proceed with destructive test.

- Location and Frequency:

  a) Conduct minimum of one test per 1000 ft of seam length (at non-critical locations such as anchorage locations whenever possible).

  b) Maximum frequency of test locations shall be agreed upon by Geosynthetics Installer and Owner or Owner's Representative prior to commencement of installation.

  c) Additional test locations shall be determined during seaming at Owner or Owner's Representative's discretion. Selection of such locations may be prompted by adverse weather conditions, in sufficient overlap, failing tests, extrusion welding, the presence of excessive wrinkling in the seam area, suspicion of excess crystallinity, weld contamination, offset welds, suspect seaming equipment or techniques or other considerations.

  d) Geosynthetics Installer will not be informed in advance of locations where seam samples will be taken.

- Sampling Procedure:

    a) Cut samples as seaming progresses in order to obtain laboratory test results prior to completion of geomembrane installation. Number each sample and identify sample number and location on Panel Layout Drawings.

    b) Immediately repair holes in geomembrane resulting from destructive seam sampling. Test continuity of new seams in repaired area using the vacuum box method of non-destructive testing.

    c) Cut two 1 inch x 12 inch samples with seam centered parallel to the width with a distance between the strips of 44 inches. Field test the strips for peel and shear with a digital field tensiometer capable of quantitatively measuring shear and peel strengths.

    d) For double wedge welding, test both welds for peel and shear strength for conformance with the seam strength requirements of this Section.

    e) If one or both of the 1-inch specimens fail in either peel or shear strength, implement repair procedures specified in this Section.

    f) If the samples pass the field test remove a 12-inch wide by 42-inch long section between the two samples. Cut section into three parts and distribute as follows:

        i) One portion to the Geosynthetics Installer for laboratory testing, 12 in. x 12 in.

        ii) One portion for the Owner's independent laboratory testing, 12 in. x 18 in.

        iii) One portion to the Owner for archive storage, 12 in. x 12 in.

- Procedures for Destructive Test Seam Failure:

    a) The following procedures shall apply whenever one or both of the destructive seam samples fails field destructive test:

i) Reconstruct seam between any two passed test locations; or

ii) Retrace welding path to intermediate location, at 10 ft minimum from location of failed test in each direction, and take samples for additional field tests. If the second test passes, then seam shall be either reconstructed or cap stripped between the two passed locations. If any sample fails, the process shall be repeated.

iii) The boundary samples shall be tested in the same manner as the original sample.

b) In any case, acceptable seams shall be bounded by two passed test locations (i.e., above procedure shall be followed in both directions from original failed location), and one sample for laboratory destructive testing shall be taken within reconstructed area.

c) In event that seam sample fails laboratory destructive test (whether conducted by Owner's independent laboratory or by Geosynthetics Installer's laboratory), then above procedures shall be followed considering laboratory tests exclusively. Because final seam must be bounded by two passed test locations, it may then be necessary to take one or more samples for laboratory testing in addition to one required in reconstructed seam area.

Defects and Repairs:

- Identification: Broom or wash geomembrane if amount of dust, mud, or other debris inhibits inspection.

- Evaluation: Nondestructively test each suspect location in seam and non-seam areas. Repair each seam, pin-hole, damaged area or defect location that fails nondestructive testing.

- Repair Procedures:

a) Patching: Used to repair holes, tears, panel defects, undispersed raw materials, welds, contamination by foreign matter, and destructive sample locations.

b) Extrusion: Used to repair pinholes or other small defects (e.g., scratches, crimps). In general, this procedure should be used for defects less than ¼-inch in largest dimension.

c) Capping (Cap Strip): Used to repair lengths of failed welds or to cover seams were welds cannot be destructively tested. Cap strips 150 feet in length or greater shall be destructively tested.

d) Removal: used to replace area with large defects where preceding method are not appropriate. Also used to remove excess material from the installed geomembrane (e.g., "fishmouths", wrinkles, etc.). Areas of removal shall be patched or capped

e) Surfaces of geomembrane to be patched shall be abraded no more than 1 hour prior to extrusion repair.

f) Seams used in repairs shall be approved extrusion or fusion welded seams and may be subject to the same destructive test procedure as outlined for other seams.

g) Patches or caps shall be round or oval in shape, made of same geomembrane, extend a minimum of 6 in. beyond edge of defects, and applied using approved methods only.

- Seam Reconstruction Procedures:

a) Seam reconstruction for fusion welded seams shall be achieved by welding a top cover cap strip, 12-inches in width and centered over the seam in question.

b) Seam reconstruction for extrusion process shall be achieved by grinding and re-welding small seam sections, or by capping for large seam sections.

- Verification of Repairs:

a) Test each repair nondestructively.

b) Repairs passing nondestructive test shall be taken as indication of adequate repair.

c) Failed tests indicate repair shall be redone and re-tested until passing tests result.

5.3.6.4 Geomembrane Acceptance

Geosynthetics Installer shall retain ownership and responsibility for geomembrane until the Final Acceptance of the work, by the Owner or Owner's Representative.

5.3.6.5 Record Documentation

Record documentation specific to geomembrane installation, shall be provided as follows:

- Installation Report - The Geosynthetics Installer shall provide a report to the Owner or Owner's Representative at the conclusion of the work, including the following:

    a) Complete identification of membrane material, including type of resin, batch numbers, roll numbers, manufacturer and thickness.

    b) Complete identification of field seaming, including extrudate material, seaming method, seaming temperature, and date of fabrication of field seams.

    c) The quality control tests used as specified and/or directed.

    d) Complete description of field sampling procedure, number of test specimens, and size of test specimens.

    e) Type of test machine used, grip separation, and crosshead speed.

    f) Method of recording, loading, and determining stresses for destructive test methods.

    g) Peel and shear test values for individual specimens in pounds per inch of width, and also the average load value for each group of specimens.

    h) Manufacturers quality control testing, test results, certifications, etc.

i) Type of failure in all destructive testing, that is, within the seam, within the sheet material, clamp edge, seam edge, etc., for each individual specimen.

j) For non-destructive testing: type of non-destructive test, results, identification of failures, date of re-testing, and repairs.

k) Seam length.

l) Length of seam welded.

m) Identity of seamer.

n) Identity of seam testers.

o) Weather conditions at the time of seaming and any mitigative measures taken to address heat, cold, or wind.

p) Record drawings, in Autocad (.dwg) and Adobe Acrobat (.pdf) formats, showing actual layout of geomembrane sheets, and anchorage. Each repair shall be identified on record drawings.

q) Manufacturer's and Geosynthetics Installer's warranties.

- Letter of Certification:

a) Upon completion of the geomembrane installation, the Geosynthetics Installer shall provide a letter of certification that the installation was properly performed and in compliance with all plans and specifications. A detailed Record Panel Diagram shall accompany this certification.

5.4 Earthwork

Earthwork for the project shall be in accordance with the latest edition of the Standard Specifications for Public Works Construction, "Greenbook" or engineer-approved equivalent.

6. REFERENCES

AEI CASC, 2011. Hydrology Study for the 1,000-Year Flood Event, Hawes Compost Facility, Southeast ¼ of Section 36, Township 10 North and Range 4 West, San Bernrdino County, California.

RWQCB, 2010a. Board Order No. R6V-2010-0010, WDID No. 6B360903006, Waste Discharge Requirements and Monitoring and Reporting Program for Hawes Composting Facility. Adopted March 2010.

RWQCB, 2010b. Design Plan, Construction Quality Assurance Plan and Technical Specifications, Nursery Products Hawes Composting Facility, San Bernardino County. RWQCB comment letter dated 2 July.

RWQCB, 2010c. Design Plan, Construction Quality Assurance Plan & Technical Specifications, and Preliminary Closure and Post-Closure Maintenance Plan, Nursery Products Hawes Composting Facility, San Bernardino County. RWQCB comment letter dated 7 July.

RWQCB, 2010d. Design Plan Addendum, Nursery Products Hawes Composting Facility, San Bernardino County. RWQCB comment letter dated 7 October.

RWQCB, 2010e. Response to Design Plan – Redesign of Berm Additional Information, Nursery Products Hawes Composting Facility, San Bernardino County. RWQCB comment letter dated 24 December.

URS, 2009. Report of Waste Discharge, Nursery Products Hawes Composting Facility, San Bernardino County, California. April, Revised July 2009.

Appendices are available at the Lahontan Water Board, Victorville Office.