Construction Quality Assurance Report
ET Cover Placement
Former UPRR Slag Pile 1
Former ASARCO Smelter Site
El Paso, Texas

March 2017

Report Prepared for Project Navigator, LTD (Trustee) By:
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Phoenix, Arizona 85008
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<th>Description</th>
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<td>Cat II</td>
<td>Category II</td>
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<td>CQA</td>
<td>Construction Quality Assurance</td>
</tr>
<tr>
<td>CY</td>
<td>cubic yards</td>
</tr>
<tr>
<td>EBS</td>
<td>East Borrow Source</td>
</tr>
<tr>
<td>TCEQ</td>
<td>Texas Commission on Environmental Quality</td>
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<td>Site</td>
<td>Former ASARCO Smelter Site</td>
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<tr>
<td>UPRR</td>
<td>Union Pacific Rail Road</td>
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1. Introduction

1.1. Introduction

This construction quality assurance (CQA) report has been prepared to summarize the Evapotransporative (ET) cover construction activities at Former UPRR slag Pile 1, located at the northwest portion of the Former ASARCO Smelter Site (Site) located in El Paso, Texas. The activities have been completed in accordance with and meet the requirements as stated in the following documents (Specifications):

- Notification of Removal and Cover Activities Planned for Texas Custodial Trust (TCT) Property Between Union Pacific Railroad (UPRR) Tracks dated April 6, 2016 (Attachment 1);
2. Construction Activities

The ET Cover construction activities were completed in August 2016. The specific construction activities performed are described further in the following sections. Limits of the cover are shown on Figure 1. Representative photographs of the construction activities are presented in Attachment 3.

2.1. Subgrade Preparation

The subgrade of the former Slag Pile 1 area was completed in accordance with the Specifications after completing the removal of slag. The slag removal activities were completed as described in the narrative of Attachment 1C.6.5 TCT Pile 1 in the 2016 Soil Response Action Completion Report. Approval of the subgrade was provided by the CQA Engineer prior to commencing ET final cover fill placement.

2.2. ET Final Cover Fill Placement

Prior to ET final cover fill placement, a lightweight fabric (Conweb) was used as a demarcation between underlying Category II (Cat II) material and ET final cover soils. The 3-feet thick soil cover section ET cover soils consisted of the same section previously approved by Texas Commission on Environmental Quality (TCEQ) for the 4:1 Horizontal:Vertical slope on the plant site Boneyard from the bottom to the top; 1-foot EBS silty sand with clay, 1.5-feet EBS silty sand, 0.5-foot desert armor. Soils were excavated at East Borrow Source (EBS) and hauled to the placement location by 40-ton haul trucks. The soils were placed and compacted in accordance with the Specifications. Laboratory testing consisting of hydraulic conductivity, particle size analysis, Atterberg limits, and Modified Proctor tests were performed. A summary of laboratory testing results is presented in Table 1. Field density testing was completed to confirm ET final cover fill soils were compacted to a minimum 90 percent compaction at a moisture content +/- 3 percent of optimum moisture content in conformance with the Specifications. A summary of field density testing is presented in Table 2. All field density tests met or exceeded a minimum of 90 percent compaction.
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### Table 1

**Laboratory Test Results**
Former ASARCO Smelter Site - El Paso, Texas

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Date</th>
<th>Moisture Content (%)</th>
<th>Particle Size Summary</th>
<th>Atterberg Limits</th>
<th>Modified Proctor</th>
<th>Hydraulic Conductivity</th>
<th>Soil Description</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Gravel (%)</td>
<td>Sand (%)</td>
<td>Fines (%)</td>
<td>Liquid Limit</td>
<td>Plastic Limit</td>
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<td>UPRR Clay 080116</td>
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<td>16.8</td>
<td>4</td>
<td>39.8</td>
<td>66.2</td>
<td>39</td>
<td>15</td>
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<td>Silty Sand 080216</td>
<td>8/2/2016</td>
<td>12.5</td>
<td>2</td>
<td>59.9</td>
<td>38.1</td>
<td>23</td>
<td>14</td>
</tr>
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</table>

**Notes:**
- % = percent
- cm/s = centimeters per second
- CQA = Construction Quality Assurance
- EBS = East Borrow Source
- pcf = pounds per cubic foot
- Unified Soil Classification = CH: fat clay; CL: lean clay; GC: clayey gravel; GM: silty gravel; GP: poorly-graded gravel; GW: well-graded gravel; SC: clayey sand; SM: silty sand

**Material Specification for Final Cover:**
- Unified Soil Classification: GW, GP (Desert Armor); GM, GC, SM, or SC (Surface Layer); SM, SC, or CL (Isolation Layer)
- Maximum Particle Size: 4 inches
- Percent Particles Coarser than 1.0 Inch (Desert Armor) = Min. 25%
- Percent Particles Coarser than 1.0 Inch (Surface Layer) = Max. 25%
- Remolded Hydraulic Conductivity: Max. 5.0x10^-5 cm/s (Surface Layer); Max. 5.0x10^-6 cm/s (Isolation Layer)
## Table 2a

### Field Density Test Results

Silty Sand (1-ft-thick lifts)

Former ASARCO Smelter Site

<table>
<thead>
<tr>
<th>Test #</th>
<th>Date</th>
<th>Coordinates</th>
<th>Lift Number</th>
<th>Moisture Content (%)</th>
<th>Dry Density (pcf)</th>
<th>Percent Compaction (%)</th>
<th>Modified Proctor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8/2/2016</td>
<td>31 47' 12.82'' N 106 31' 28.64'' W</td>
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<td>11.1</td>
<td>110.2</td>
<td>90</td>
<td>123.1</td>
</tr>
<tr>
<td>2</td>
<td>8/3/2016</td>
<td>31 47' 11.05'' N 106 31' 25.79'' W</td>
<td>1</td>
<td>9.7</td>
<td>116.9</td>
<td>95</td>
<td>123.1</td>
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<tr>
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<td>9.1</td>
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<td>4</td>
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<td>31 47' 11.05'' N 106 31' 25.79'' W</td>
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<td>5</td>
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<td>31 47' 11.05'' N 106 31' 25.79'' W</td>
<td>2</td>
<td>10.9</td>
<td>114.7</td>
<td>93</td>
<td>123.1</td>
</tr>
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</table>

Notes:

- $\gamma_{\text{dry, Troxler}}$ = Dry density obtained at the field using a nuclear density gauge
- $\gamma_{\text{moist, Troxler}}$ = Wet density obtained at the field using a nuclear density gauge
- $w_{c, \text{Troxler}}$ = Moisture content obtained at the field using a nuclear density gauge
- $\gamma_{\text{dry, max}}$ = Maximum dry density obtainable when the compaction is carried out on the material at optimum moisture content

- in. = inches
- pcf = pounds per cubic foot

Minimum Field CQA Testing Requirements for Structural Fill = 1 per 1,000 yd3 of placed fill or a minimum of 2 per lift
### Field Density Test Results

Clayey Isolation Layer (1-ft-thick)
Former ASARCO Smelter Site

<table>
<thead>
<tr>
<th>Test #</th>
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<th>Coordinates</th>
<th>Moisture Content (%)</th>
<th>Dry Density (pcf)</th>
<th>Percent Compaction (%)</th>
<th>Modified Proctor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8/1/2016</td>
<td>31 47' 12.9&quot; N 106 31' 29.64&quot; W</td>
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<td>2</td>
<td>8/1/2016</td>
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<td>117.9</td>
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<tr>
<td>6</td>
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<td>112.6</td>
<td>92</td>
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</table>

Notes:

pcf = pounds per cubic foot

pcf = pounds per cubic foot
FIGURES
Attachment 1
Notification of Removal and Cover Activities Planned for Texas Custodial Trust (TCT) Property Between Union Pacific Railroad (UPRR) Tracks dated April 6, 2016
Ms. Eleanor Wehner, P.G.
Texas Commission on Environmental Quality
Remediation Division
VCP-CA Section, Mail Code MC-127
Post Office Box 13087
Austin, Texas 78753

Subject:
Notification of Removal and Cover Activities Planned for Texas Custodial Trust (TCT) Property Between Union Pacific Railroad (UPRR) Tracks

Dear Ms. Wehner:

Per our discussion last week, we are notifying Texas Commission on Environmental Quality TCEQ on behalf of the TCT of our plans to remove slag materials from the TCT Property between the UPRR tracks (see attached figure). After removal activities are complete, clean soil from the East Borrow Source (EBS) will be placed over the area. This approach was prepared in cooperation with UPRR since slag materials exist on TCT and UPRR property in this area. We understand UPRR will be notifying TCEQ of planned activities on their property under separate cover. The entire plan is provided in the summary below so that you have a complete understanding of the activities that will be completed.

Summary of Planned Removal Activities

The activities described in this section are planned for each area shown in the attached Figure 1. Although not anticipated, if Category I materials are visually encountered in the Pile 1 area during excavation, they will be removed and placed in Cell 4. Category II materials will be removed, placed and compacted on the plant site Category II area in the north portion of the south pad. Removal activities will proceed to the configurations shown in Figures 2 through 6 for the sloped area of Pile 1. In the flatter areas, removal will proceed to the depth of visible slag or to a maximum depth of 3 feet below ground surface (bgs). We will
continue to provide dust control and monitoring in accordance with our dust monitoring plan.

Removal activities will be completed in areas shown in Figure 1 as follows:

- Areas 1 TCT and 1 UPRR - Remove pile 1 material to the configurations shown in Figures 2 through 6;
- Areas 2 and 3 TCT - Scrape to remove visible slag material < 3 feet bgs;
- Areas 4 and 7 TCT – Scrape and regrade to remove visible slag material < 3 feet bgs. Final surface will be regraded to facilitate access and drainage;
- Areas 2, 3 and 5 UPRR – Scrape to remove visible slag material < 3 feet bgs;
- Areas 6 and 8 UPRR – Scrape and regrade to remove visible slag material < 3 feet bgs where possible. Final surface will be regraded to facilitate access and drainage;
- Obtain discrete soil samples (1 per TCT area shown in Figure 1) in areas where visible slag has been completely removed. Samples will be analyzed for analytes listed in Table 1.

Summary of Planned Capping Activities

A 3-feet thick soil cover section will be placed over areas 1-8 where Category II materials remain or where soil samples indicate remaining surface soils exceed commercial-industrial levels for the TCT site. EBS soil fill will also be placed to eliminate low spots to prevent ponding. The soil cover section will consist of the same section previously approved by TCEQ for the 4:1 slope on the plant site boneyard from the bottom to the top; 1-foot EBS silty sand with clay, 1.5-feet EBS silty sand, 0.5-foot desert armor. Soils will be placed and compacted to meet the approved TCT soil cover specifications. The existing procedures in the approved Construction Quality Assurance Plan will be used to document the soil cover placement activities.

We plan to proceed with these activities next week and expect to be complete within 8 weeks. Please call me at 602-438-0883 if you have any questions or need additional information.

Sincerely,

Arcadis U.S., Inc.

Scott M. Brown, P.E.
Project Manager

Attachments

Copies: Roberto Puga, Arcadis Project Team, UPRR, PBW
### TABLE 1
ANALYTES FOR CONFIRMATION SAMPLING
ON TCT PROPERTY
EL PASO, TEXAS

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<td>Antimony</td>
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<td>Chromium</td>
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<td>Cobalt</td>
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<td>Copper</td>
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<td>Iron</td>
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<td>Lead</td>
</tr>
<tr>
<td>Mercury</td>
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<tr>
<td>Molybdenum</td>
</tr>
<tr>
<td>Nickel</td>
</tr>
<tr>
<td>Selenium</td>
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<tr>
<td>Silver</td>
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<td>Zinc</td>
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Site Grading Plan –
Backfill Specifications
Texas Custodial Trust
Former ASARCO Smelter Site
El Paso, Texas

July 2012
April 2015 – Rev. 1

Report Prepared for Project Navigator, LTD (Trustee) By:

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APPENDICES

Appendix A ClosureTurf™ Specifications
1. Structural Fill

1.1. Introduction

This section addresses the material specifications and applicable Construction Quality Assurance (CQA) requirements for the structural fill that will be used to backfill excavations, holes and basements as a result of demolition and asset recovery activities at the site. The following topics are discussed in the remainder of this section:

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

1.2. Structural Fill Material Specifications

1.2.1. Material Requirements

Structural fill will consist of relatively homogeneous, granular materials that are free of debris, foreign objects and deleterious materials. Gravels, sands and crushed and or broken concrete and bricks meeting the material requirements for structural fill presented in Table 1 are acceptable. The ratio of crushed and or broken concrete and bricks shall be established by field trial but shall not exceed 30% by weight of the matrix unless approved by the Engineer of Record. All exposed reinforcing steel will be cut and removed from the broken concrete material. Recycled crushed concrete and bricks must be clean and free of staining or discoloration from industrial use. All root clumps, vegetation, and wood clusters shall be removed from the material. All wood pieces or roots larger than 0.5 inches in cross section and 2 inches in length shall be removed. Occasional wood pieces or roots less than 0.5 inches in cross section and 2 inches in length are acceptable provided the pieces are not clustered and do not comprise more than 0.003 percent of the fill volume. Material suspected of containing constituents of concern (COCs) shall not be used unless approved by the Engineer of Record as a Category II material.
1.2.2. Moisture-Density Target Compaction Requirements

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

GW, SW, and SP Materials:

- Lifts will be compacted to at least 95% of maximum dry density, as determined by modified Proctor test results (ASTM D 1557) or AASHTO T 180, Method D on the proposed material during the preconstruction testing program.

GM, GC, SM, and SC Materials:

- Lifts will be compacted to at least 95% of maximum dry density and -2 to +2 percentage points from optimum water content, as determined by modified Proctor test results (ASTM D 1557) or AASHTO T 180, Method D on the proposed material during the preconstruction testing program.

It is anticipated that moisture measurements obtained from a soil and crushed concrete matrix with the nuclear densometer will measure higher than actual due to the higher hydrogen content of the concrete depending on the ratio of the matrix. A correlation curve shall be established during construction (e.g. with sandcone results plotted versus nuclear densometer results) to determine a correction factor for this anticipated condition.

1.3. Preconstruction CQA Evaluation of Materials

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

1.4. Field CQA Evaluation/Monitoring During Construction

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

- Visual inspection of the basements and subgrade for evidence that it is free of debris, organic matter, standing (ponded) water and excessive moisture. Basement slabs shall be broken or drilled to prevent accumulation of water during filling and to facilitate drainage;
• Continuous visual inspection during subgrade proof-rolling for evidence (e.g., pumping, rutting, and deflection of subgrade surface, etc.) that the subgrade provides sufficient foundation to place and construct structural fill;

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

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

• Scarifying of the subgrade surface prior to placing the first lift of structural fill;

• Visual observation of the granular material for consistency of particle size distribution, appearance, moisture content and other physical properties with the material approved during the preconstruction qualifying process;

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

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

• Scarifying or roughening of completed lift prior to placement of next lift;

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

• Areas where excess moisture or insufficient moisture may have occurred;

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

1.5. Field CQA Testing of Work Product

1.5.1. Routine Field Testing

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

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

- The fill materials differ substantially from those specified or from the materials evaluated during preconstruction testing;
- The lift thickness is greater than specified;
- The material is at improper and/or highly variable moisture content or contains organic matter or other deleterious material;
- Fewer than the anticipated number of roller passes are made; or
- The degree of compaction is doubtful.

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

- Adverse weather conditions;
- Breakdown of equipment;
- At the start and finish of grading;
- If the material fails to meet specification requirements;
- The work area is reduced; or
- As otherwise requested by the Project Manager.

1.6. Deficiencies, Problems and Repairs

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

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

1.7. **Structural Fill Documentation**

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

- Surveys of In-Place Structures
- Daily Field Reports
- Photographic Logs
- Structural Fill Data Sheets
- Final CQA Report

Details of the required contents of each of the above types of documentation are provided in Section 6. Upon completion of all required liner system construction, a Final CQA Report that includes structural fill documentation will be prepared by the Soils CQA Consultant.
2. FINAL COVER SYSTEM

2.1. Introduction

This section addresses the material specifications and applicable CQA requirements for the final cover system. The final cover system will be a soil evapotranspirative (ET) cover consisting of a 2.0-foot thick surface layer of silty sand overlying a 1.0-foot thick isolation layer of clayey silty sand. The cover perimeter slopes will be protected from erosion by a 2-foot thick layer of Desert Armor cobbles and gravel. The following topics are discussed in the remainder of this section:

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

2.2. Final Cover Specifications

2.2.1. Material Requirements

Final cover materials will meet the requirements presented in Table 4.

2.2.2. Vegetation Requirements

The surface layer of the final cover system will be permanently vegetated with native and/or naturalized grass species and forbs included in the TxDOT Seeding for Erosion Control (TxDOT, 2004) specification for soils in rural or urban areas of TxDOT District 24, or other equivalent perennial, relatively deep-rooted vegetation compatible with the site conditions and soils. For District 24, the mixture of grass and forb species recommended by TxDOT for sandy soils, the predominant soils in the vicinity of the site, is:

- green sprangletop (*Leptochloa dubia*) [rural and urban areas];
- sand dropseed (*Sporobolus cryptandrus*) [rural and urban areas];
- lehmanns lovegrass (*Eragrostis lehmanniana*) [rural areas];

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• blue grama (*Bouteloua gracilis*) [rural and urban areas];
• indian ricegrass (*Achnatherum hymenoides*) [rural areas];
• purple prairieclover (*Dalea purpurea*) [rural areas]; and
• buffalograss (*Bouteloua dactyloides*) [urban areas].

The goal of the vegetation program is to develop vegetation over 10% of the final cover system. Seeding will be conducted at the time period appropriate for vegetation establishment. Mulch may be added to the surface layer material to encourage initial vegetative growth.

### 2.2.3. Moisture-Density Target Compaction Requirements

Each lift of final cover material will be compacted to at least 90% of maximum dry density and -3 to +3 percentage points from optimum water content, as determined by modified Proctor test results (ASTM D 1557) or AASHTO T 180, Method D on the proposed material during the pre-construction testing program.

### 2.3. Pre-Construction CQA Evaluation of Material Sources

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

### 2.4. Field CQA Evaluation/Monitoring During Construction

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

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

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

- Scarifying or roughening of completed lift prior to placement of next lift;

- Monitoring the thickness of compacted lifts to verify that the thickness is no greater than 12 inches;
• Documenting the type and level of compactive effort, including type and weight of compactor and number of passes; and
• Soil moisture conditioning as needed to adjust the in-place moisture content to within specified limits.

2.5. Field CQA Testing of Work Product

2.5.1. Routine Field Testing
Field testing (e.g., in-situ density and moisture content testing) of the layers of the final cover system will be performed by CQA personnel during construction to evaluate the Contractor's work product with respect to the requirements set forth in this Plan. The test methods and frequencies for routine CQA field testing are given in Table 6. Test locations will be selected by CQA personnel.

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

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

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

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

2.5.3. **Perforations**

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

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

All perforations of the compacted layers will be backfilled by CQA personnel with associated layer material and compacted in-place with a tamping rod. Alternatively, sodium bentonite may be used to fill perforations. CQA personnel will also verify that perforations made by the Contractor are backfilled by the Contractor.

2.6. **Deficiencies, Problems, and Repairs**

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

2.7. **Final Cover Documentation**

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

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

Details of the required contents of each of the above types of documentation are provided in Section 6 of this Plan. Upon completion of all required final cover system construction, a Final CQA Report that includes final cover system documentation will be prepared by the Soils CQA Consultant. Contents of the Final CQA Report are presented in Section 6.7 of this Plan.
3. GEOMEMBRANES

3.1. Introduction

This section addresses the material specifications and CQA requirements for the geomembrane components of the cover system: 60-mil linear low density polyethylene (LLDPE) for the North Stormwater Detention Pond liner and 40-mil LLDPE for use at select locations on the ET cover perimeter slopes. The following topics are discussed in the remainder of this section:

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

3.2. Geomembrane Specifications

3.2.1. Geomembrane Material Requirements

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

Material requirements for the 40-mil LLDPE geomembrane liner are presented in Table 7.

Material requirements for the 60-mil LLDPE geomembrane liner are presented in Table 8.

 Seam strength requirements for the constructed geomembrane are presented in Table 9.

3.2.2. Geomembrane MQC

The Geomembrane Manufacturer will implement a Manufacturer’s quality control (MQC) program for materials related to geomembrane manufacturing, which will include
MQC sampling and testing to demonstrate the geomembrane quality and suitability for use. The required MQC tests, methods, and frequencies are presented in Tables 7 and 8.

3.3. **Pre-Installation Evaluation of Material Sources**

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

- Written certification, signed by a responsible party employed by the Manufacturer. The Manufacturer will guarantee the specified roll values are met for physical, mechanical, and environmental properties corresponding to the test procedures for the required geomembrane properties listed in the specifications.
- MQC certificates with test results signed by a responsible party employed by the Manufacturer. Each quality control certificate will include date, roll identification numbers, testing procedures, and results of quality control tests performed using the methods specified and at the required frequencies given in the specifications.
- Certification statement from the Resin Supplier stating that the resin properties are met for the specified test procedures and properties listed in the specifications.
- Copies of dated quality control certificates issued by the Resin Supplier for the resin density and melt flow index at the minimum frequency of one per each resin lot for the resin used in geomembrane production.

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

3.4. **Material CQA Conformance Testing**

Conformance testing requirements for the geomembrane are presented in Table 10. Conformance testing will be performed by an independent, third-party laboratory. Conformance sampling may be performed either at the manufacturing plant or upon delivery of rolls to the site, as requested by the Project Manager. Conformance samples will be taken across the entire roll width. All conformance test results will be reviewed by CQA personnel prior to deployment of the material. Any nonconformance will be immediately reported to the Project Manager. When a sample fails a conformance test,
the material from the lot represented by the failing test should be considered out-of-
specification and rejected.

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

3.5. Field CQA Evaluation/Monitoring During Installation

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

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

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

3.5.4. Field Panel Identification
Each field panel will be given an identification code, which will be used for CQA
records. CQA personnel will monitor field panel placement and will record the field
panel identification code, Manufacturer’s roll number, location, date of installation, and
dimensions of each field panel. CQA personnel will label each panel in the field with its
panel identification number using a semi-permanent marker (e.g., paint stick).
3.5.5. **Geomembrane Deployment**

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

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

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

3.5.6. **Field Panel Seaming**

3.5.6.1. **Panel Layout**

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

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

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

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

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

3.5.6.3. Seam Preparation
CQA personnel will monitor that:

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

3.5.6.4. Overlapping and Temporary Bonding
CQA personnel will monitor that:

- the panels of geomembrane have a finished overlap of a minimum of 3 inches (or as otherwise recommended by the Manufacturer) for both extrusion and fusion welding, but in any event sufficient overlap will be provided to allow peel tests to be performed on the seam;
- no solvent or adhesive is used; and
- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any spot welding apparatus is controlled such that the geomembrane is not damaged.

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

<table>
<thead>
<tr>
<th>Allowable Equipment Ground Pressure (psi)</th>
<th>Minimum Thickness of Soil Overlying Geosynthetics (in.)</th>
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</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>12</td>
</tr>
<tr>
<td>&lt;10</td>
<td>18</td>
</tr>
<tr>
<td>&lt;20</td>
<td>24</td>
</tr>
<tr>
<td>&gt;20</td>
<td>36</td>
</tr>
</tbody>
</table>

3.6. **Field CQA Testing of Work Product**

3.6.1. **Trial Seams**

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

3.6.2. **Nondestructive Seam Testing**

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

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

CQA personnel will notify the Installer of any required repairs. Any required seam repairs identified as a result of failed nondestructive seam testing will be made by the Installer in accordance with the specifications, and CQA personnel will:
• observe the repair procedures;
• observe the retesting procedures; and
• document the results with the same information as above for the initial test.

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

3.6.3. Destructive Testing

3.6.3.1. Location and Frequency
CQA personnel will select all destructive seam test sample locations in order to accomplish the sampling and testing frequencies given in Table 9. Sample locations will be established by CQA personnel according to the guidelines given below.

• Test locations will be determined during seaming at CQA personnel’s discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.
• The Installer will not be informed in advance of the locations where the seam samples will be taken.

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

• The full destructive sample should be located between the two field test strips. The sample should typically be 12 inches wide by 42 inches long with the seam centered lengthwise. The sample will be cut into three parts and distributed as follows:
  • one 12 inch by 12 inch portion will be retained by the Installer;
  • one 12 inch by 12 inch portion will be archived by CQA personnel; and
  • one 12 inch by 18 inch portion will be forwarded immediately by CQA personnel to the CQA Geosynthetics Testing Laboratory.
All holes in the geomembrane resulting from destructive seam test sampling will be immediately repaired by the Installer in accordance with repair procedures described in the specifications. The continuity of the new seams in the repaired area will be nondestructively tested.

### 3.6.3.3. Field Testing

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

### 3.6.3.4. Laboratory Testing

Destructive test samples will be tested by the independent, third-party Geosynthetics Testing Laboratory. The methods are given in Table 9. Results will be reviewed by CQA personnel as soon as they become available. The CQA Engineer and Project Manager will be notified of any inconsistencies or nonconformances.

### 3.6.3.5. Procedures for Destructive Test Failure

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

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

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

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

3.7. Deficiencies, Problems, and Repairs

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

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

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

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

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

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

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

Details of the required contents of each of the above types of documentation are provided in Section 6 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes geomembrane documentation will be prepared by the Geosynthetics CQA Consultant. Contents of the Final CQA Report are presented in Section 6.7 of this Plan.
4. GEOTEXTILES

4.1. Introduction

This section addresses the material specifications and CQA requirements for the geotextile components of the final cover system: 10-oz nonwoven cushioning geotextile and 2-oz and 6-oz nonwoven separation geotextiles. The following topics are discussed in the remainder of this section:

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

4.2. Geotextile Specifications

4.2.1. Geotextile Material Requirements

Material requirements for the 10-oz nonwoven cushioning geotextile are presented in Table 11.

Material requirements for the 2-oz and 6-oz nonwoven separation geotextiles are presented in Table 12.

4.2.2. Geotextile MQC

The Geotextile Manufacturer will implement a MQC program for the geotextile, which will include MQC sampling and testing to demonstrate the geotextile quality and suitability for use. The required MQC tests, methods, and frequencies are presented in Table 13.

4.3. Pre-Installation Evaluation of Material Sources

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

- Written certification, signed by a responsible party employed by the Manufacturer. The Manufacturer will guarantee the specified roll values are met for physical, mechanical, and environmental properties corresponding to the test procedures for the required geotextile properties listed in the specifications.
- MQC certificates with test results signed by a responsible party employed by the Manufacturer. Each quality control certificate will include date, roll identification numbers, testing procedures, and results of quality control tests performed using the methods specified and at the required frequencies given in the specifications.

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

4.4. Material CQA Conformance Testing

Conformance testing requirements for the geotextiles are presented in Table 16. Conformance testing will be performed by an independent, third-party laboratory. Conformance sampling may be performed either at the manufacturing plant or upon delivery of rolls to the site, as requested by the Project Manager. Conformance samples will be taken across the entire roll width. All conformance test results will be reviewed by CQA personnel prior to deployment of the material. Any nonconformance will be immediately reported to the Contractor and Project Manager. When a sample fails a conformance test, the material from the lot represented by the failing test should be considered out-of-specification and rejected.

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

4.5. Field CQA Evaluation/Monitoring During Installation

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

- geotextiles are not placed during inclement weather such as high winds or rain;
- immediately prior to geotextile placement, the underlying geosynthetics are free of sharp protrusions or other obstructions that could potentially damage the material;
- in the presence of wind, geotextiles are temporarily weighted with sandbags (or equivalent), and the weights remain until the material is secured with an overlying layer;
- geotextiles are kept continually under slight tension to minimize the presence of wrinkles, and if necessary, the material is positioned by hand after being unrolled to minimize wrinkles;
- geotextiles are placed in the locations and to the dimensions shown on the applicable design details and drawings;
- a visual examination of the material is carried out over the entire surface, after installation, to verify that no potentially harmful foreign objects, such as needles or tools, are present;
- proper orientation and joining techniques are used:
  - on slopes shallower than 10H:1V, geotextiles can be overlapped 6 inches and either seamed with polymeric thread with properties equal or exceeding those of the geotextile or thermally bonded;
- holes or tears in the geotextile are repaired by spot-seaming a patch in place with a minimum of 24 inches overlap in all directions; and
- the geotextiles are not left exposed for longer than the maximum allowable period (as recommended by the Manufacturer) after placement unless a longer exposure period is approved by the Design Engineer and the Project Manager.

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

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

Equipment or vehicles will not be operated above the geosynthetics unless the equipment or vehicles meets the following ground pressure requirements and the corresponding minimum thickness of soil is present overlying the geosynthetics.
### Allowable Equipment Ground Pressure (psi) vs. Minimum Thickness of Soil Overlying Geosynthetics (in.)

<table>
<thead>
<tr>
<th>Ground Pressure</th>
<th>Minimum Thickness of Soil Overlying Geosynthetics</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>12</td>
</tr>
<tr>
<td>&lt;10</td>
<td>18</td>
</tr>
<tr>
<td>&lt;20</td>
<td>24</td>
</tr>
<tr>
<td>&gt;20</td>
<td>36</td>
</tr>
</tbody>
</table>

#### 4.6. Geotextile Documentation

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

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

Details of the required contents of each of the above types of documentation are provided in Section 6 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes geotextile documentation will be prepared by the Geosynthetics CQA Consultant. Contents of the Final CQA Report are presented in Section 6.7 of this Plan.
5. CLOSURETURF™

5.1. Introduction
This section addresses the material specifications and CQA requirements for the ClosureTurf™ component of the cover system, to be installed on the Boneyard side slope. ClosureTurf™ is a patented, three-component system comprised of a structured LLDPE geomembrane, an engineered turf, and a sand infill.

5.2. ClosureTurf™ Material Specifications and CQA Requirements
Refer to Appendix A for the material specifications, CQA requirements, and documentation requirements for the ClosureTurf™ system.

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

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

Details of the required contents of each of the above types of documentation are provided in Section 6 of this Plan. Upon completion of all required liner system construction, a Final CQA Report that includes geomembrane documentation will be prepared by the Geosynthetics CQA Consultant. Contents of the Final CQA Report are presented in Section 6.7 of this Plan.
6. CQA Documentation

6.1. Introduction

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

CQA personnel will prepare the following types of documentation:

- Surveys of In-Place Structures
- Daily Field Report
- Photographic Log
- Soils CQA Records (observation logs and testing data sheets)
- Geosynthetics CQA Records (observation logs and testing data sheets); and,
- Final CQA Report

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

6.2. Surveys of In-Place Structures

It is anticipated that the site will be redeveloped with commercial and industrial buildings, roads and facilities. To assure that future developers are aware of subsurface conditions, surveys of recently changed topography (that differ from the latest topographic maps prepared in April 2011 and/or July, 2012) shall be completed before backfill is placed and compacted. In addition, structures (e.g., footers, foundations, slabs) that are left in-place shall be surveyed and described in field documentation. Other features deemed important to future development of the site shall also be surveyed and described in field documentation. Survey data and descriptions shall be accumulated on a site map for inclusion in the Final CQA Report.

6.3. Daily Field Report

The CQA Consultant(s) will prepare a brief Daily Field Report for each day of liner system or final cover system construction. This report will be prepared by the CQA Site Manager (or their designee). The Daily Field Report may include information such as the following:
• Date, project name, location and other identification;
• A brief narrative of the events and activities, including construction activities, meetings and observations that occurred during a given day;
• A summary of the locations where construction and installation occurred during the day or reference to other logs showing/desccribing their location;
• A reduced-scale site map, if necessary;
• Weather conditions;
• Equipment and personnel in each work area, including subcontractors;
• Name of parties to any discussions;
• Relevant subject matter or issues;
• Activities planned and performed;
• Constraints or suggestions;
• A description of concerns or potential problems, as follows:
  o A description of the situation or deficiency;
  o The location and probable cause of the situation or deficiency;
  o How and when the situation or deficiency was found or located;
  o Documentation of the response to the situation or deficiency;
  o Final results of any responses;
  o Any measures taken to prevent a similar situation for occurring in the future;
• Scheduling information;
• Offsite materials received, including quality verification documentation;
• Decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality; and
• The signature of the CQA personnel who authored the report.

6.4. Photographic Documentation

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

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

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

6.6. **Geosynthetics Field CQA Records**

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

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

6.7. Final CQA Report

Upon completion of all required construction and evaluation, and before placing a completed area into service, the CQA Consultant(s) will prepare and submit a Final CQA Report to the Project Manager.

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

• A summary narrative of the construction activities, including a discussion of required CQA and CQC testing (procedures, protocols, required and actual testing frequencies, failed tests, procedures to correct failed areas, documentation of re-tests, etc.);
• Observation logs and testing data sheets showing all testing results, including documentation of any failed tests and documentation that areas represented by failed tests were corrected and re-tested;
• A discussion of changes from design and material specifications;
• Record Drawings; and
• A certification statement sealed and signed by each licensed Texas P.E. who served as the CQA Engineer(s), indicating that the facility was constructed in accordance with the permitted design as reflected on the construction documents (drawings, specifications, Plan, etc.) and any properly authorized clarifications or changes.
### TABLE 1

**MATERIAL SPECIFICATIONS FOR STRUCTURAL FILL**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>QUALIFIER</th>
<th>UNITS</th>
<th>SPECIFIED VALUES</th>
<th>TEST METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unified Soil Classification</td>
<td>Classification</td>
<td>--</td>
<td>GW, GM, GC, SW, SP, SM, SC</td>
<td>ASTM D 2487</td>
</tr>
<tr>
<td>Maximum Particle Size</td>
<td>Maximum</td>
<td>Inch</td>
<td>3</td>
<td>ASTM D 422 or ASTM C 136</td>
</tr>
<tr>
<td>Percent Passing #200 Sieve</td>
<td>Maximum</td>
<td>Percent</td>
<td>30</td>
<td>ASTM D 422 or ASTM D 1140</td>
</tr>
<tr>
<td>Liquid Limit (LL)</td>
<td>Maximum</td>
<td>Percent</td>
<td>45</td>
<td>ASTM D 4318</td>
</tr>
<tr>
<td>Plasticity Index (PI)</td>
<td>Maximum</td>
<td>Percent</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>In-Situ As-Compacted Moisture Content and Dry Density</td>
<td>Range</td>
<td>Percent</td>
<td>See Section 1.2.2</td>
<td>ASTM D 1557 or AASHTO T 180, Method D&lt;sup&gt;(1)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Organic Content</td>
<td>Maximum</td>
<td>See Section 1.2.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>(1)</sup> Use ASTM D 1557 for materials with 30% or less particles by weight retained on the 3/4-inch sieve. For materials with more than 30% particles retained on the 3/4-inch sieve, use AASHTO T 180, Method D corrected with AASHTO T 224 for the maximum density determinations.
# Table 2

## Preconstruction Testing Requirements for Structural Fill

<table>
<thead>
<tr>
<th>Test</th>
<th>Method</th>
<th>Minimum Frequency of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size Analysis (sieve)</td>
<td>ASTM D 422 or ASTM C 136</td>
<td>1 test per 2,500 yd³ or change of material</td>
</tr>
<tr>
<td>Atterberg Limits</td>
<td>ASTM D 4318</td>
<td>1 test per 2,500 yd³ or change of material</td>
</tr>
<tr>
<td>Unified Soil Classification</td>
<td>ASTM D 2487</td>
<td>1 test per 2,500 yd³ or change of material</td>
</tr>
<tr>
<td>Natural (as-received) Moisture Content</td>
<td>ASTM D 2216</td>
<td>1 test per 2,500 yd³ or change of material</td>
</tr>
<tr>
<td>Moisture Content and Dry Density Relationship</td>
<td>ASTM D 1557 or AASHTO T 180, Method P&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>1 test per 2,500 yd³ or change of material</td>
</tr>
</tbody>
</table>

<sup>(1)</sup> Use ASTM D 1557 for materials with 30% or less particles by weight retained on the 3/4-inch sieve. For materials with more than 30% particles retained on the 3/4-inch sieve, use AASHTO T 180, Method D corrected with AASHTO T 224 for the maximum density determinations.
# TABLE 3

## FIELD CQA TESTING REQUIREMENTS FOR STRUCTURAL FILL

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>MINIMUM FREQUENCY OF TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Place Density and In-Place Moisture Content (Nuclear Gauge)</td>
<td>ASTM D 2922, ASTM D 3017</td>
<td>1 per 1,000 yd³ of placed fill or a minimum of 2 per lift</td>
</tr>
<tr>
<td>Oven Moisture Content</td>
<td>ASTM D 2216</td>
<td>As necessary to verify nuclear gauge density results</td>
</tr>
<tr>
<td>Microwave Oven Moisture Content</td>
<td>ASTM D 4643</td>
<td>As necessary to verify nuclear gauge density results</td>
</tr>
<tr>
<td>In-Place Density (Sand Cone, Rubber Balloon or Drive Cylinder Method)</td>
<td>ASTM D 1556 or ASTM D 2167 or ASTM D 2937</td>
<td>As necessary to verify nuclear gauge density results</td>
</tr>
</tbody>
</table>
TABLE 4
MATERIAL SPECIFICATIONS FOR FINAL COVER

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>QUALIFIER</th>
<th>UNITS</th>
<th>SPECIFIED VALUES</th>
<th>TEST METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unified Soil Classification</td>
<td>Classification</td>
<td>--</td>
<td>GW, GP (Desert Armor)</td>
<td>ASTM D 2487</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GM, GC, SM, or SC (Surface Layer)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SM, SC, or CL (Isolation layer)</td>
<td></td>
</tr>
<tr>
<td>Maximum Particle Size</td>
<td>Maximum</td>
<td>Inch</td>
<td>4 (Surface and Isolation layers)</td>
<td>ASTM D 422 or ASTM C 136</td>
</tr>
<tr>
<td>Percent Particles Coarser than 1.0 Inch (Desert Armor)</td>
<td>Minimum</td>
<td>Percent</td>
<td>25</td>
<td>ASTM D 422 or ASTM C 136</td>
</tr>
<tr>
<td>Percent Particles Coarser than 1.0 Inch (Surface Layer)</td>
<td>Maximum</td>
<td>Percent</td>
<td>25</td>
<td>ASTM D 422 or ASTM C 136</td>
</tr>
<tr>
<td>Remolded Hydraulic Conductivity</td>
<td>Maximum, based on running average of three(3)</td>
<td>cm/s</td>
<td>5.0x10^-4 (Surface Layer)</td>
<td>ASTM D 5084(1)(2)</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>cm/s</td>
<td>5.0x10^-5 (Isolation Layer)</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
(1) Hydraulic conductivity testing shall be performed using tap water or a 0.05N solution of CaSO_4. Use effective stress of 2 psi. Distilled or deionized water shall not be used. The permeant should be deaired. Testing procedures in Appendix VII of the Corps of Engineers Manual EM 1110-2-1906 may be used as an alternative method.
(2) Perform remolded hydraulic conductivity test as appropriate for the type of compaction equipment planned for use on a remolded sample that is compacted greater than or equal to 90% of the maximum dry density and at 3 percentage point dry of optimum as determined from the modified Proctor test. If a sample with a higher dry density or moisture content is tested, the conditions for that sample become the moisture and density conditions that need to be met in the field.
(3) Average of current test result plus the previous two results.
### TABLE 5

**PRECONSTRUCTION TESTING REQUIREMENTS FOR FINAL COVER SURFACE AND ISOLATION LAYERS**

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>MINIMUM FREQUENCY OF TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size Analysis (sieve)</td>
<td>ASTM D 422 or ASTM C 136</td>
<td>1 test per 10,000 yd³ or change of material</td>
</tr>
<tr>
<td>Atterberg Limits</td>
<td>ASTM D 4318</td>
<td>1 test per 10,000 yd³ or change of material</td>
</tr>
<tr>
<td>Unified Soil Classification</td>
<td>ASTM D 2487</td>
<td>1 test per 10,000 yd³ or change of material</td>
</tr>
<tr>
<td>Remolded Hydraulic Conductivity</td>
<td>ASTM D 5084</td>
<td>1 test per 10,000 yd³ or change of material</td>
</tr>
</tbody>
</table>
# TABLE 6

## FIELD CQA TESTING REQUIREMENTS FOR FINAL COVER

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>MINIMUM FREQUENCY OF TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Place Density and In-Place Moisture Content</td>
<td>ASTM D 6938</td>
<td>1 per 2,000 yd$^3$ of placed material</td>
</tr>
<tr>
<td>(Nuclear Gauge)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oven Moisture Content</td>
<td>ASTM D 2216</td>
<td>As necessary to verify nuclear gauge density results</td>
</tr>
<tr>
<td>In-Place Density (Sand Cone, Rubber Balloon, or</td>
<td>ASTM D 1556 or</td>
<td>As necessary to verify nuclear gauge density results</td>
</tr>
<tr>
<td>Drive Cylinder Method)</td>
<td>ASTM D 2167 or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASTM 2937</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

(1) In-lieu of in-place moisture and density tests, the Contractor may use a test pad to determine the construction conditions (e.g., compaction equipment, number of passes) required to meet the specified compaction criteria. If compaction is determined by test pad performance criteria, CQA personnel must document that the same procedures are used to construct the cover layers.
### TABLE 7

**MATERIAL SPECIFICATIONS FOR 40-MIL TEXTURED LLDPE GEOMEMBRANES**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>QUALIFIER</th>
<th>UNITS</th>
<th>SPECIFIED VALUES</th>
<th>TEST METHOD</th>
<th>MQC TESTING FREQUENCY (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness: Nominal</td>
<td>min. avg.</td>
<td>mil</td>
<td>40(^{(1)})</td>
<td>ASTM D 5994</td>
<td>per roll</td>
</tr>
<tr>
<td>8 out of 10 values must exceed</td>
<td></td>
<td></td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>all 10 values must exceed</td>
<td></td>
<td></td>
<td>34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asperity Height(^{(2)})</td>
<td>min. avg.</td>
<td>mil</td>
<td>10</td>
<td>ASTM D 7466</td>
<td>every 2\textsuperscript{nd} roll(^{(3)})</td>
</tr>
<tr>
<td>Density</td>
<td>min. avg.</td>
<td>g/cc</td>
<td>0.939</td>
<td>ASTM D 1505, ASTM D 792</td>
<td>200,000 lb</td>
</tr>
<tr>
<td>Tensile Properties (each direction)</td>
<td></td>
<td></td>
<td></td>
<td>ASTM D 6693 Type IV</td>
<td>20,000 lb</td>
</tr>
<tr>
<td>Break Strength</td>
<td>min. avg.</td>
<td>lb/in.</td>
<td>60</td>
<td></td>
<td>20,000 lb</td>
</tr>
<tr>
<td>Break Elongation</td>
<td></td>
<td>percent</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2% Modulus</td>
<td>maximum</td>
<td>lb/in.</td>
<td>2400</td>
<td>ASTM D 5323</td>
<td>per formulation</td>
</tr>
<tr>
<td>Tear Resistance</td>
<td>min. avg.</td>
<td>lb</td>
<td>22</td>
<td>ASTM D 1004</td>
<td>45,000 lb</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>min. avg.</td>
<td>lb</td>
<td>44</td>
<td>ASTM D 4833</td>
<td>45,000 lb</td>
</tr>
<tr>
<td>Axi-Symmetric Break Resistance Strain</td>
<td>minimum</td>
<td>percent</td>
<td>30</td>
<td>ASTM D 5617</td>
<td>per formulation</td>
</tr>
<tr>
<td>Carbon Black Content</td>
<td>range</td>
<td>percent</td>
<td>2.0 to 3.0</td>
<td>ASTM D 4218(^{(4)})</td>
<td>20,000 lb</td>
</tr>
<tr>
<td>Carbon Black Dispersion</td>
<td>cat.</td>
<td>note(^{(5)})</td>
<td></td>
<td>ASTM D 5596</td>
<td>45,000 lb</td>
</tr>
</tbody>
</table>
TABLE 7
MATERIAL SPECIFICATIONS FOR 40-MIL TEXTURED LLDPE GEOMEMBRANES
(Continued)

<table>
<thead>
<tr>
<th>PROPERTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUALIFIER</td>
</tr>
<tr>
<td>UNITS</td>
</tr>
<tr>
<td>SPECIFIED VALUES</td>
</tr>
<tr>
<td>TEST METHOD</td>
</tr>
<tr>
<td>MQC TESTING FREQUENCY (Minimum)</td>
</tr>
<tr>
<td>Oxidative Induction Time (OIT)</td>
</tr>
<tr>
<td>Standard OIT; or</td>
</tr>
<tr>
<td>High Pressure OIT</td>
</tr>
<tr>
<td>Oven Aging at 85°C and 90 days</td>
</tr>
<tr>
<td>Standard OIT; or</td>
</tr>
<tr>
<td>High Pressure OIT</td>
</tr>
<tr>
<td>UV Resistance at cycle of 20 hr UV at 75°C then 4 hr condensation at 60°C</td>
</tr>
<tr>
<td>High Pressure OIT at 1600 hrs</td>
</tr>
</tbody>
</table>

Notes:
(1) The average of the 10 readings shall meet or exceed the nominal specified thickness of 40 mils.
(2) Of 10 readings, 8 of 10 must be > 7 mils and lowest individual reading must be > 5 mils.
(3) Alternate the measurement side for double-sided textured sheet.
(4) Other methods are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
(5) Carbon black dispersion for 10 different views shall have 9 (min) in Categories 1 or 2 and 1 (max) in Category 3.
(6) This specification is based on the Geosynthetic Research Institute (GRI) GM-17 Specification, currently the industry standard. Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for 40 mil textured LLDPE geomembranes.
## TABLE 8

**MATERIAL SPECIFICATIONS FOR 60-MIL TEXTURED LLDPE GEOMEMBRANES**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>QUALIFIER</th>
<th>UNITS</th>
<th>SPECIFIED VALUES</th>
<th>TEST METHOD</th>
<th>MQC TESTING FREQUENCY (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness: Nominal</td>
<td>min. avg.</td>
<td>mil</td>
<td>60(^{(1)})</td>
<td>ASTM D 5994</td>
<td>per roll</td>
</tr>
<tr>
<td>8 out of 10 values must exceed</td>
<td></td>
<td>mil</td>
<td>54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>all 10 values must exceed</td>
<td></td>
<td>mil</td>
<td>51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asperity Height(^{(2)})</td>
<td>min. avg.</td>
<td>mil</td>
<td>10</td>
<td>ASTM D 7466</td>
<td>every 2(^{nd}) roll(^{(3)})</td>
</tr>
<tr>
<td>Density</td>
<td>min. avg.</td>
<td>g/cc</td>
<td>0.939</td>
<td>ASTM D 1505, ASTM D 792</td>
<td>200,000 lb</td>
</tr>
<tr>
<td>Tensile Properties (each direction)</td>
<td>min. avg.</td>
<td>lb/in.</td>
<td>90</td>
<td>ASTM D 6693 Type IV</td>
<td>20,000 lb</td>
</tr>
<tr>
<td>Break Strength</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break Elongation</td>
<td></td>
<td>percent</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2% Modulus</td>
<td>maximum</td>
<td>lb/in.</td>
<td>3600</td>
<td>ASTM D 5323</td>
<td>per formulation</td>
</tr>
<tr>
<td>Tear Resistance</td>
<td>min. avg.</td>
<td>lb</td>
<td>33</td>
<td>ASTM D 1004</td>
<td>45,000 lb</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>min. avg.</td>
<td>lb</td>
<td>66</td>
<td>ASTM D 4833</td>
<td>45,000 lb</td>
</tr>
<tr>
<td>Axi-Symmetric Break Resistance Strain</td>
<td>minimum</td>
<td>percent</td>
<td>30</td>
<td>ASTM D 5617</td>
<td>per formulation</td>
</tr>
<tr>
<td>Carbon Black Content</td>
<td>range</td>
<td>percent</td>
<td>2.0 to 3.0</td>
<td>ASTM D 4218(^{(4)})</td>
<td>20,000 lb</td>
</tr>
<tr>
<td>Carbon Black Dispersion</td>
<td>cat.</td>
<td>note(^{(5)})</td>
<td></td>
<td>ASTM D 5596</td>
<td>45,000 lb</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Minimum average thickness is 60 mil, with 8 out of 10 values exceeding 54 mil and all 10 values exceeding 51 mil.

\(^{(2)}\) Asperity height minimum average is 10 mil.

\(^{(3)}\) Every 2\(^{nd}\) roll testing frequency.

\(^{(4)}\) ASTM D 4218 testing frequency per formulation.

\(^{(5)}\) Carbon Black dispersion noted as cat. for note.
### TABLE 8

**MATERIAL SPECIFICATIONS FOR 60-MIL TEXTURED LLDPE GEOMEMBRANES**

(Continued)

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>QUALIFIER</th>
<th>UNITS</th>
<th>SPECIFIED VALUES</th>
<th>TEST METHOD</th>
<th>MQC TESTING FREQUENCY (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxidative Induction Time (OIT)</td>
<td>min. avg.</td>
<td>minutes</td>
<td>100</td>
<td>ASTM D 3895</td>
<td>200,000 lb</td>
</tr>
<tr>
<td>Standard OIT; or</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Pressure OIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oven Aging at 85°C and 90 days</td>
<td>min. avg.</td>
<td>% ret.</td>
<td>35</td>
<td>ASTM D 3895</td>
<td>per formulation</td>
</tr>
<tr>
<td>Standard OIT; or</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Pressure OIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UV Resistance at cycle of 20 hr UV at 75°C then 4 hr condensation at 60°C</td>
<td>min. avg.</td>
<td>% ret.</td>
<td>35</td>
<td>ASTM D 5885</td>
<td>per formulation</td>
</tr>
<tr>
<td>High Pressure OIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. The average of the 10 readings shall meet or exceed the nominal specified thickness of 60 mils.
2. Of 10 readings, 8 of 10 must be > 7 mils and lowest individual reading must be > 5 mils.
3. Alternate the measurement side for double-sided textured sheet.
4. Other methods are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
5. Carbon black dispersion for 10 different views shall have 9 (min) in Categories 1 or 2 and 1 (max) in Category 3.
6. This specification is based on the Geosynthetic Research Institute (GRI) GM-17 Specification, currently the industry standard. Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for 60 mil textured LLDPE geomembranes.
### TABLE 9

**WELDED SEAM SPECIFICATIONS FOR GEOMEMBRANES**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>QUALIFIER</th>
<th>UNITS</th>
<th>VALUES$^{(3, 4)}$</th>
<th>TEST METHOD$^{(5)}$</th>
<th>CQA TESTING FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>40 mil LLDPE</td>
<td>60 mil LLDPE</td>
<td></td>
</tr>
</tbody>
</table>

#### Fusion Seams

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>psi</th>
<th>30 psi pressure, 5 minute hold, pressure must not drop by 3 psi</th>
<th>ASTM D 5820</th>
<th>Observe Installer testing 100% of fusion seams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Test</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear Strength</td>
<td>Minimum</td>
<td>lb/in.</td>
<td>60</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Shear Elongation at Break</td>
<td>Minimum</td>
<td>%</td>
<td>50</td>
<td>50</td>
<td>(1) and (2)</td>
</tr>
<tr>
<td>Peel Strength</td>
<td>Minimum</td>
<td>lb/in.</td>
<td>50</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Peel Separation</td>
<td>Minimum</td>
<td>%</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

#### Extrusion Seams

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>psi</th>
<th>5 psi vacuum, 10 second hold</th>
<th>ASTM D 5641</th>
<th>Observe Installer testing 100% of extrusion seams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum Test</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear Strength</td>
<td>Minimum</td>
<td>lb/in.</td>
<td>60</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Shear Elongation at Break</td>
<td>Minimum</td>
<td>%</td>
<td>50</td>
<td>50</td>
<td>(1) and (2)</td>
</tr>
<tr>
<td>Peel Strength</td>
<td>Minimum</td>
<td>lb/in.</td>
<td>44</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Peel Separation</td>
<td>Minimum</td>
<td>%</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. Trial seams will be made at start of each day and at re-start after breaks, shift change, etc. Elongation/separation measurements may be eliminated for field testing.
2. Destructive tests will be taken at a minimum frequency of one per 500 linear feet of welded production seam.
3. For all destructive tests, 4 of 5 samples must meet or exceed the above values, and all samples must meet or exceed 80% of the above values for a test to pass.
4. Locus-of-break patterns will meet the acceptable break codes given in GRI GM-19. The following are unacceptable break codes: fusion – AD, AD-Brk >25%; extrusion – AD1, AD2, AD-WLD (if strength is not achieved)
5. This specification is based on the Geosynthetic Research Institute (GRI) GM-19 Specification, currently the industry standard for welded geomembrane seams. Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geomembrane seams.
### TABLE 10

**CQA CONFORMANCE TESTING REQUIREMENTS FOR GEOMEMBRANES**

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>MINIMUM FREQUENCY OF CQA TESTING&lt;sup&gt;(1)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness – Lab Measurement</td>
<td>ASTM D 5994</td>
<td>1 per 100,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sheet Density</td>
<td>ASTM D 1505/D 792</td>
<td>1 per 100,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tensile Properties</td>
<td>ASTM D 6693 Type IV</td>
<td>1 per 100,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Carbon Black Content</td>
<td>ASTM D 4218</td>
<td>1 per 100,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Carbon Black Dispersion</td>
<td>ASTM D 5596</td>
<td>1 per 100,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Interface Shear Strength</td>
<td>ASTM D 5321</td>
<td>1 per interface specified in Table 8&lt;sup&gt;(2)&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**Notes:**

1. CQA testing frequency will also be at a minimum of one per resin lot.
2. See Table 12 for information on testing conditions.
3. Specified test methods and parameters may be replaced by Design Engineer to be consistent with the industry standard for geomembranes.
<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>QUALIFIER</th>
<th>UNITS</th>
<th>SPECIFIED VALUES</th>
<th>TEST METHOD</th>
<th>MINIMUM FREQUENCY OF MQC TESTING&lt;sup&gt;(1)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Per Unit Area</td>
<td>minimum</td>
<td>oz/yd&lt;sup&gt;2&lt;/sup&gt;</td>
<td>10</td>
<td>ASTM D 5261</td>
<td>1 per 100,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Grab Tensile Strength</td>
<td>minimum</td>
<td>lbs</td>
<td>230</td>
<td>ASTM D 4632</td>
<td>1 per 100,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Trapezoidal Tear Strength</td>
<td>minimum</td>
<td>lbs</td>
<td>95</td>
<td>ASTM D 4533</td>
<td>1 per 100,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Puncture Strength</td>
<td>minimum</td>
<td>lbs</td>
<td>120</td>
<td>ASTM D 4833</td>
<td>1 per 100,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Apparent Opening Size</td>
<td>minimum</td>
<td>sieve size</td>
<td>100</td>
<td>ASTM D 4751</td>
<td>1 per 500,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Water Permeability</td>
<td>minimum</td>
<td>cm/s</td>
<td>0.1</td>
<td>ASTM D 4491</td>
<td>1 per 500,000 ft&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>UV Resistance</td>
<td>minimum</td>
<td>percent ret. @ 500 hrs</td>
<td>70</td>
<td>ASTM D 4355</td>
<td>per formulation</td>
</tr>
</tbody>
</table>

Notes:
1. CQA testing frequency will also be at a minimum of one per resin lot.
2. Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geotextiles.
3. This specification is based on the Geosynthetic Research Institute (GRI) GT-12(a) Specification, currently the industry standard for nonwoven geotextiles. Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geotextiles.
### TABLE 12

**MATERIAL SPECIFICATIONS FOR NONWOVEN SEPARATION GEOTEXTILES**

Geotextile Properties Class 3 (Low Survivability)

<table>
<thead>
<tr>
<th>Property(1)</th>
<th>ASTM Test</th>
<th>Unit</th>
<th>Elongation &lt;50%</th>
<th>Elongation ≥50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab Tensile Strength</td>
<td>D4632</td>
<td>lb</td>
<td>180</td>
<td>113</td>
</tr>
<tr>
<td>Trapezoid Tear Strength</td>
<td>D4533</td>
<td>lb</td>
<td>68</td>
<td>41</td>
</tr>
<tr>
<td>CBR Puncture Strength</td>
<td>D6241</td>
<td>lb</td>
<td>380</td>
<td>230</td>
</tr>
<tr>
<td>Permittivity</td>
<td>D4491</td>
<td>sec-1</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Apparent Opening Size</td>
<td>D4751</td>
<td>in.</td>
<td>0.024</td>
<td>0.024</td>
</tr>
<tr>
<td>Ultraviolet Stability(2)</td>
<td>D7238</td>
<td>% Str. Ret. @ 500 lt. hrs.</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

(1) All values are minimum average roll values (MARV) except AIS which is a maximum average roll value (MaxARV) and UV stability which is a minimum average value.

(2) Evaluation to be on 50mm strip tensile specimens after 500 hours exposure.

(3) This specification is based on the Geosynthetic Research Institute (GRI) GT-13(a) Specification, currently the industry standard for separation geotextiles. Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geotextiles.
# TABLE 13

**CQA CONFORMANCE TESTING REQUIREMENTS FOR GEOTEXTILES**

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>MINIMUM FREQUENCY OF CQA TESTING&lt;sup&gt;(1)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Per Unit Area</td>
<td>ASTM D 5261</td>
<td>1 per 250,000 ft²</td>
</tr>
<tr>
<td>Grab Tensile Strength</td>
<td>ASTM D 4632</td>
<td>1 per 250,000 ft²</td>
</tr>
<tr>
<td>Trapezoidal Tear Strength</td>
<td>ASTM D 4533</td>
<td>1 per 250,000 ft²</td>
</tr>
<tr>
<td>Puncture Strength</td>
<td>ASTM D 4833</td>
<td>1 per 250,000 ft²</td>
</tr>
</tbody>
</table>

Notes:

(1) CQA testing frequency will also be at a minimum of one per resin lot.

(2) Specified test methods and parameters may be modified by the Design Engineer to be consistent with changes to the industry standard for geotextiles.
APPENDIX A

CLOSURETURF™ SPECIFICATIONS

Source: Watershed Geosynthetics™

November 2012
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</tbody>
</table>

**1.0 INTRODUCTION**

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<td>21</td>
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<td>22</td>
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<td>22</td>
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<tr>
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<td>22</td>
</tr>
<tr>
<td>2.4.3 Manufacturer Quality Control</td>
<td>23</td>
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1.0 INTRODUCTION

1.1 Purpose

This Construction Quality Assurance (CQA) Plan has been prepared to provide the Owner, Operator, Design Engineer, Construction Quality Assurance Professional of Record (POR), and the Contractor the means to govern the construction quality and to satisfy the environmental protection requirements under current State regulations. More specifically, the CQA Plan addresses the soil and geosynthetic components of the final cover system for the closure area. This installation manual addresses both the ClosureTurf™ and HydroTurf™ products.

This CQA Plan is divided into the following parts:

- Section 1 – Introduction
- Section 2 – Construction Quality Assurance for Geosynthetics
- Section 3 – Sand Installation
- Section 4 – HydroTurf™ Installation
- Section 5 – Reporting

1.2 Definitions

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

ASTM

American Society for Testing and Materials.

Construction Quality Assurance (CQA)

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

These are representatives of the POR who work under direct supervision of the POR. The CQA monitor is responsible for quality assurance monitoring and performing onsite tests and observations. The CQA monitor is on site full-time during construction and reports directly to the POR. The CQA monitor performing daily QA/QC observation and testing shall be NICET-certified in geotechnical engineering technology at level two or higher for soils and FML testing; a CQA monitor with a minimum of four years of directly related experience; or a graduate engineer or geologist with one year of directly related experience. Field observations, testing, or other activities associated with CQA may be performed by the CQA monitor(s) under the direction of the POR. Additional CQA monitors may be used. If working under the direction of a CQA monitor, the second CQA monitor will have a minimum of one year of directly related experience.

Construction Quality Assurance Professional of Record (POR)

The POR is an authorized representative of the Operator and has overall responsibility for construction quality assurance and confirming that the facility was constructed in general accordance with plans and specifications approved by the permitting agency and contract documents. The POR must be licensed as a Professional Engineer where the project is located and experienced in geosynthetics testing and its interpretations. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance, and quality control testing, and hydrogeology. The POR must show competency and experience in certifying like installations, and be approved by the permitting agency, and be presently employed by or practicing as a geotechnical engineer in a recognized geotechnical/environmental engineering organization. The credentials of the POR must meet or exceed the minimum requirements of the permitting agency. Any references to monitoring, testing, or observations to be performed by the POR should be interpreted to mean the POR or CQA monitors working under the POR’s direction. The POR or his designated representative will be on-site during all final cover system construction.

The POR may also be known in applicable regulations and guidelines as the CQA Engineer, Resident Project Representative, or the Geotechnical Professional (GP).

Contract Documents

These are the official set of documents issued by the owner or operator. The documents include bidding requirements, contract forms, contract conditions, specifications, contract drawings, addenda, and contract modifications.

Contract Specifications

These are the qualitative requirements for products, materials, and workmanship upon which the contract is based.
**Contractor**

This is the person or persons, firm, partnership, corporation, or any combination, private or public, who, as an independent contractor, has entered into a contract with the Operator and who is referred to throughout the contract documents by singular number and masculine gender.

**Design Engineer**

These individuals or firms are responsible for the design and preparation of the project construction drawings and specifications. Also referred to as "designer" or "engineer."

**Earthwork**

This is a construction activity involving the use of soil materials as defined in the construction drawings and specifications.

**Final Cover System Evaluation Report (FCSER)**

Upon completion of closure activities, the certification will be in the form of the FCSER which will be signed by the POR and include all the documentation necessary for certification closure.

**Film Tear Bond (FTB)**

A failure in the geomembrane sheet material on either side of the seam and not within the seam itself.

**Fish Hook**

A semi-conical opening of the seam that is formed by an edge wrinkle in one sheet of the geomembrane.

**Geomembrane Liner (GM)**

This is a synthetic lining material, also referred to as geomembrane, membrane liner, or sheet. The term Flexible Membrane Liner (FML) is also used for GM.

**Turf**

This is a synthetic structured material consisting of one or more geotextiles tufted with polyethylene yarns that resemble grass blades.

**Geosynthetics Contractor**

This individual is also referred to as the "contractor" or “installer”, and is the person or firm responsible for geosynthetic construction. This definition applies to any person installing FML or other geosynthetic materials, even if not his primary function.
Independent Testing Laboratory

A laboratory that is independent of ownership or control by the permittee or any party to the construction of the final cover or the manufacturer of the final cover products used.

Manufacturing Quality Assurance (MQA)

A planned system of activities that provides assurance that the raw materials were constructed (manufactured) as specified.

Manufacturing Quality Control (MQC)

A planned system of inspection that is used to directly monitor and control the manufacture of a material.

Nonconformance

This is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformances include, but are not limited to, physical defects, test failures, and inadequate documentation.

Operator

The organization that will operate the disposal unit.

Operator’s Representative

This is the person that is an official representative of the operator responsible for planning, organizing, and controlling the design and construction activities.

Panel

This is a unit area of the GM or FML or Turf, which will be seamed in the field.

Quality Assurance

This is a planned and systematic pattern of procedures and documentation to ensure that items of work or services meet the requirements of the contract documents. Quality assurance includes quality control. The POR and CQA monitor will perform quality assurance.

Quality Control

These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents. The contractor will perform quality control.
Representative Sample

A representative sample of FML or Turf material consists of 1 or more specimens (commonly referred to as coupons) from the same rectangular portion of FML or Turf material, oriented along a seam that is removed for field or laboratory testing purposes.

Specimen

(With respect to FML destructive testing) – A specimen is the individual test strip (sometimes called coupon) from a sample location. A sample location usually consists of many specimens.
2.0 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

2.1 Introduction

This section describes CQA procedures for the installation of geosynthetic components of the Closure Turf™.

The scope of geosynthetic-related construction quality assurance includes the following elements:

- Geomembrane Liner Component
  - 50-mil Structured Linear Low-Density Polyethylene (LLDPE) or High Density Polyethylene (HDPE) – Agru Super Grip Net (or equivalent) with the spikes placed on the landfill surface on top slopes and side slopes. Minimum required material properties for the geomembrane are listed in Table 2.2.

- Synthetic Turf Component
  - Woven polypropylene geotextiles tufted with polyethylene yarns. The required material properties are shown in Table 2.3.

The overall goal of the geosynthetics quality assurance program is to assure that proper construction techniques and procedures are used, the geosynthetic contractor implements his quality control plan in accordance with this CQA Plan, the construction and testing of all elements of the final cover are performed in accordance with this CQA Plan and the Closure Plan, and that the project is built in accordance with the project construction drawings and technical specifications. The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are avoided and/or corrected before construction is complete. The final documentation, prepared after project completion, will confirm that the construction meets design intent and specifications and that all final cover construction and Quality Assurance/Quality Control (QA/QC) testing are performed in accordance with this CQA Plan.

2.2 Geosynthetics Quality Assurance

A structured geomembrane is the geosynthetic component for the final cover system. All testing requirements and minimum required properties are listed in Tables 2.1 and 2.2. Construction quality control for the geosynthetic installation will be performed by the geosynthetic installation contractor. Construction quality assurance for the geosynthetic installation will be performed by the POR to assure the geosynthetic is constructed as specified in the design. Construction must be conducted in accordance with the project
construction drawings, which will be developed in accordance with this CQA Plan and in
accordance with specifications outlined in this CQA Plan. To monitor compliance, a
quality assurance program will include the following:

- A review of the manufacturer’s quality control submittals;
- Material conformance testing;
- Field and construction testing; and
- Construction monitoring.

The manufacturer’s quality control submittals will include resin and physical material
testing. Conformance testing refers to verification tests conducted by an independent
third party laboratory to confirm the material meets the required specification prior to
acceptance of the geosynthetic from the manufacturer. Field and construction testing
includes testing that occurs during geosynthetics installation.

Quality assurance testing will be conducted in accordance with this CQA Plan, the
project construction drawings, and specifications. The CQA monitor will observe field-
testing. Documentation must meet the requirements of this CQA Plan.

2.3 Geomembrane Component

This section describes handling, testing, and installation of geomembrane. Agru 50-mil
LLDPE Super Grip Net (or equivalent HDPE) with the spikes placed on the landfill or
soil subgrade surface will be used on top slopes and side slopes.

2.3.1 Delivery

Upon delivery of the geomembrane, the CQA monitor will observe that:

- The geomembrane is delivered in rolls and is not folded. Folded geomembrane is
  not acceptable because the highly crystalline structure of the geomembrane will
  be damaged if it is folded. Any evidence of folding (other than from the
  manufacturing process) or other shipping damage is cause for rejection of the
  material.
- Equipment used to unload and store the rolls or pallets does not damage the
  geomembrane.
- The geomembrane is stored in an acceptable location in accordance with the
  specifications and stacked not more than five rolls high. The geomembrane is
  protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions,
  excessive heat, or other damage.
- Manufacturing documentation required by the specifications has been received
  and reviewed for compliance with the specifications. This documentation will be
  included in the FCSER.
- The geosynthetics receipt log form has been completed for materials received.
Damaged geomembrane may be rejected and removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until documentation has been received, reviewed, and accepted.

**Table 2.1**

**Required Testing for Structured LLDPE Geomembrane Component**

<table>
<thead>
<tr>
<th>Responsible Party</th>
<th>Type of Test</th>
<th>Standard Test Method</th>
<th>Frequency of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin Manufacturer</td>
<td>Resin Density</td>
<td>ASTM D 1505</td>
<td>Per manufacturer quality control and every resin lot</td>
</tr>
<tr>
<td></td>
<td>Melt Flow Index</td>
<td>ASTM D 1238 (90/2.16 and 190/21.6)</td>
<td>Per manufacturer’s quality control specifications</td>
</tr>
<tr>
<td></td>
<td>Resin/Compound Quality Evaluation</td>
<td>Per manufacturer’s quality control specifications</td>
<td>Per manufacturer’s quality control specifications</td>
</tr>
<tr>
<td>Geomembrane</td>
<td>Manufacturer’s Quality Control</td>
<td>Testing per GRI Standard, GRI Test Method GM17 for 50 mil LLDPE</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Conformance Testing by 3rd Party Independent Laboratory</td>
<td>Thickness²</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td></td>
<td>Drainage Stud Height</td>
<td>GRI GM12 ASTM D7466</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td></td>
<td>Friction Spike Height</td>
<td>GRI GM12 ASTM D7466</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td></td>
<td>Specific Gravity/Density</td>
<td>ASTM D 792, Method B</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td></td>
<td>Carbon Black Content</td>
<td>ASTM D 5994</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td></td>
<td>Carbon Black Dispersion</td>
<td>GRI GM12 ASTM D7466</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td></td>
<td>Tensile Properties</td>
<td>ASTM D 4218</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D 5596</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D 6693 Type IV Specimen</td>
<td>Per manufacturer quality control requirements and every resin lot</td>
</tr>
<tr>
<td>3rd Party CQA</td>
<td>Destructive Seam Field Testing³⁺</td>
<td>ASTM D 6392</td>
<td>Various for field, lab, and archive</td>
</tr>
<tr>
<td></td>
<td>Shear &amp; Peel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd Party CQA</td>
<td>Non-Destructive Seam Field Testing</td>
<td>GRI GM6</td>
<td>All dual-track fusion weld seams</td>
</tr>
<tr>
<td></td>
<td>Air Pressure</td>
<td></td>
<td>All non-air pressure tested seams when possible</td>
</tr>
<tr>
<td></td>
<td>Vacuum</td>
<td>ASTM D 4437</td>
<td>Concurrence of State</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ UV Resistance testing not required for geomembrane, which is to be immediately covered.
² Field thickness measurements for each panel must be conducted. Use ASTM D 5994 and perform 1 series of measurements among the leading edge of each panel, with individual measurements no greater than 5 feet apart. No single measurement will be less than the required nominal thickness in order for the panel to be acceptable.
³ Only near spherical agglomerates for 10 views: 9 views in category 1 or 2, and 1 view in category 3.
⁴ Break elongation calculated using 2-inch initial gauge length.
⁵ Passing criteria for seams are listed in Table 2.2.
### Table 2.2
Minimum Required Properties of the Structured LLDPE Geomembrane Component

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Minimum Required Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness, mils</td>
<td>ASTM D 5994</td>
<td>47.5</td>
</tr>
<tr>
<td>Minimum average</td>
<td></td>
<td>42.5</td>
</tr>
<tr>
<td>Lowest individual reading</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Lowest individual of 8 of 10 readings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density, g/cc (maximum)</td>
<td>ASTM D 792, Method B</td>
<td>0.939</td>
</tr>
<tr>
<td>Drainage Stud Height (min. ave.)</td>
<td>GRI GM12</td>
<td>130</td>
</tr>
<tr>
<td>Friction Spike Height (min. ave.)</td>
<td>GRI GM12</td>
<td>175</td>
</tr>
<tr>
<td>Tensile Properties¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break Strength, lb./in (min. ave.)</td>
<td>ASTM D 6693, Type IV</td>
<td>105</td>
</tr>
<tr>
<td>Break Elongation, % (min. ave.)</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>Tear Resistance, lb. (min. ave.)</td>
<td>ASTM D 1004</td>
<td>30</td>
</tr>
<tr>
<td>Puncture Resistance, lb. (min. ave.)</td>
<td>ASTM D 4833</td>
<td>55</td>
</tr>
<tr>
<td>Break Resistance Strain, % (min)</td>
<td>ASTM D 5617</td>
<td>30</td>
</tr>
<tr>
<td>Carbon Black Content², %</td>
<td>ASTM D 1603</td>
<td>2.0 – 3.0</td>
</tr>
<tr>
<td>Oxidative Induction Time (OIT) (min. ave.)</td>
<td>ASTM D 3895</td>
<td>≥100</td>
</tr>
<tr>
<td>Standard OIT, minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Black Dispersion³, Category</td>
<td>ASTM D 5596</td>
<td>1 or 2 and 3</td>
</tr>
<tr>
<td>Oven Aging at 85°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard OIT – % retained after 90 days</td>
<td>ASTM D 5721</td>
<td>35</td>
</tr>
<tr>
<td>or High Pressure OIT – % retained after 90 days</td>
<td>ASTM D 3895</td>
<td></td>
</tr>
<tr>
<td>Seam Properties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear Strength, lb./in</td>
<td>ASTM D 6392</td>
<td>100</td>
</tr>
<tr>
<td>Peel Strength, lb./in</td>
<td></td>
<td>76 (65, Extrusion Weld)</td>
</tr>
</tbody>
</table>

¹ Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.

² Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.

³ Only near spherical agglomerates for 10 views: 9 views in Category 1 or 2, and 1 view in Category 3.

⁴ The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

⁵ UV resistance is based on percent-retained value regardless of the original HP-OIT value.
2.3.2 Conformance Testing

One geomembrane sample will be obtained for every resin lot of material supplied and for each 100,000 square feet of geomembrane. The material will be sampled at the manufacturer plant by the CQA monitor before the rolls are shipped to the site. The samples will be forwarded to the third-party laboratory for the following conformance tests:

- Density (ASTM D 792, Method B)
- Carbon black content (ASTM D 4218)
- Carbon black dispersion (ASTM D 5596)
- Thickness (ASTM D 5994)
- Tensile properties (ASTM D 6693/Type IV Specimen)

No material shall be delivered to the site until all the independent laboratory analysis conforms to the material specifications.

The density of the geomembrane must be less than 0.939 g/cc; the carbon black content must be between 2 percent and 3 percent; and recycled or reclaimed material must not be used in the manufacturing process.

The design engineer may require additional test procedures and will inform the third party laboratory in writing. The POR must review all test results and report any nonconformance to the design engineer prior to product installation. In addition to the conformance thickness tests shown above, field thickness measurements must be taken at maximum 5-foot intervals along the leading edge of each geomembrane panel. No single measurement may be less than 10 percent below the required nominal thickness for the panel to be accepted (i.e., for 50-mil geomembrane a minimum thickness of 45 mils is required), and the average must be at least 47.5 mils.

**Sampling Procedure.** Samples will be taken across the entire roll width. Unless otherwise specified, samples should be approximately 15 inches long by the roll width. The CQA monitor must mark the machine direction and the manufacturer's roll identification number on the sample. The CQA monitor must also assign a conformance test number to the sample and mark the sample with that number.

2.3.3 Anchor Trench Backfill

General fill material placed in anchor trenches will be placed in uniform lifts, which do not exceed 12 inches in loose thickness and are compacted. In-place moisture/density tests may be taken at the discretion of the CQA monitor to evaluate the quality of the backfill. The test results will not be required as part of the final documentation. Slightly rounded corners will be provided in anchor trenches where the geomembrane enters the trench so as to avoid sharp bends in the geomembrane. No loose soil (e.g., excessive water content) will be allowed to underlie the anchored components of final cover system. Vertical anchor trenches as well as anchor trenches along the toe shall not be backfilled until sand infill of the synthetic turf is in place.

ClosureTurf™ Patent #7,682,105 and other Patents
HydroTurf™: Patent Pending
2.3.4 Geomembrane Installation

Surface Preparation. Prior to any geomembrane installation, the subgrade (e.g., intermediate cover soil) should be inspected by the CQA and geosynthetics contractor. The POR or CQA monitor must observe the following:

Prior to deployment of the geomembrane the subgrade shall be inspected by the CQA monitor to insure that the final grades on the slopes as well as benches dimension and grades conforms with the design grades of the closure. Survey shots as well as drawings as-built shall be carefully reviewed and evaluated to insure the surface grades will drain as intended in the design drawings. As built drawings shall show the slope and with dimensions of the drainage benches and down chute details

- The intermediate cover soil is free of surface irregularities and protrusions.
- The intermediate cover soil surface does not contain stones or other objects that could damage the geomembrane. The surface will be smooth and free of foreign and organic material, sharp objects, stones greater than 3/8 inches, or other deleterious material.
- The anchor trench dimensions have been checked, and the trenches are free of sharp objects and stones.
- The geomembrane will not be placed during inclement weather such as rain or high winds.
- Construction stakes and hubs have been removed and the resultant holes have been backfilled. There are no rocks, debris, or any other objects on the foundation soil surface.
- The geosynthetics contractor, POR or his representative, and the permittee or his representative have certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Prior to the installation of the geomembrane, the contractor must submit drawings showing the panel layout, indicating panel identification number, both fabricated (if applicable) and field seams, as well as details not conforming to the drawings. The POR must review field conditions and approve revised panel layout plan if the field conditions vary from the original plan layout.

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations.

During panel placement, the POR or CQA monitor must:

- Observe that the geomembrane is placed in direct and uniform contact with underlying intermediate cover soil or subgrade soil.
· Record roll numbers, panel numbers, and dimensions on the panel or seam logs. Measure and record thickness of leading edge of each panel at 5-foot maximum intervals. No single thickness measurement can be less than the required nominal thickness.

· Observe the sheet surface, as it is deployed and record panel defects and repair of the defects (panel rejected, patch installed, extradite placed over the defect, etc.) on the repair sheet. Repairs must be made in accordance with the specifications and located on a repair drawing.

· Observe that support equipment is not allowed on the geomembrane during handling (See Section 2.3.9).

· Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance.

· Observe that there are no stones, construction debris, or other items beneath the geomembrane that could cause damage to the geomembrane.

· Observe that the geomembrane is not dragged across a surface that could damage the material. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, as necessary.

· Record weather conditions including temperature, wind, and humidity. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, geomembrane seaming operation should not be performed when the air temperature is less than 35°F or greater than 104°F, or when standing water or frost is on the ground, unless these requirements are waived by the design engineer. Excessive wind is that which can lift and move the geomembrane panels.

· The CQA monitor may consider welding at temperatures outside the recommended values only after demonstration by the welding crew that the weld trials can accomplished the required welding specifications.

· Observe that people working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.

· Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind (the contractor is responsible for any damage to or from windblown geomembrane). Excessive wrinkles should be walked-out or removed at the discretion of the CQA monitor as described in section 2.3.7 and 2.3.8.

· Observe that no more panels are deployed than can be seamed on the same day.

· Observe that horizontal or cross seams on the side slope are staggered in order not to produce a long horizontal seam across the slope. Adjacent panels should be continuous in as much as possible on both sides of the horizontal seam.
**Field Seaming.** The contractor must provide the POR with a seam and panel layout drawing and update this drawing daily as the job proceeds. No panels should be seamed until the panel layout drawing has been accepted by the POR. A seam numbering system must provide a unique number for each seam and be agreed to by the POR and contractor prior to the start of seaming operations. One procedure is to identify the seam by adjacent panels. For example, the seam located between Panels 306 and 401 would be Seam No. 306/401.

Prior to geomembrane welding, each welder and welding apparatus (both wedge and extrusion welder) must be tested, at a minimum, at daily start-up and immediately after any break, and/or anytime the machine is turned off for more than 30 minutes in accordance with the specifications to determine if the equipment is functioning properly. The final documentation should include the names for each seamer and the time and the temperatures for each seaming apparatus used each day. One trial weld will be taken prior to the start of work. In addition, a trial weld will also be obtained prior to seaming the tie-in. The trial weld sample must be 3 feet long and 12 inches wide, with the seam centered lengthwise. The minimum number of specimens per trial weld test must be two coupons for shear and two coupons for peel. Both the inner and outer welds of dual track fusion welds must be tested for each peel test coupon (or additional coupons will be required). Trial weld samples must comply with “Passing Criteria for Welds” included in Section 2.3.5 – Construction Testing. The CQA monitor must observe welding operations, quantitative testing of each trial weld for peel and shear, and recording of the results on the trial weld form. The trial weld will be completed under conditions similar to those under which the panels will be welded. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392:

- **Hot Wedge:** AD and AD-Brk>25%
- **Extrusion Fillet:** AD1, AD2, AD-WLD (unless strength is achieved)

Additionally, there should be no apparent weld separation (i.e., greater than 1/8 inch). The third party strength tests must meet the manufacturer’s specifications for the sample sheets, or percentage of the manufacturer’s parent sheet strength as determined by the manufacturer. For dual-track fusion welds, both sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test. If, at any time, the CQA monitor believes that an operator or welding apparatus is not functioning properly, a weld test must be performed. If there are wide changes in temperature (±30°F Fahrenheit), humidity, or wind speed, the test weld should be repeated. The test weld must be allowed to cool to ambient temperature before testing. If a weld test fails the shear or peel test, the length of the non-passing weld will be identified at a 10-foot interval, and the failed area will be patched. Patching will be performed by placing additional geomembrane material over the failed area or removing the failed geomembrane weld and patching it with additional geomembrane per POR’s direction. The welding for patches must comply with the welding passing criteria requirements outlined in this section.
Construction quality assurance documentation of trial seam procedures will include, at a minimum, the following:

- Documentation that trial seams are performed by each welder and welding apparatus prior to commencement of welding and prior to commencement of the second half of the workday.
- The welder, the welding apparatus number, time, date, ambient air temperature, and welding machine temperatures.

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

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Equipment used for welding will not damage the geomembrane.
- The extrusion welder is purged prior to beginning a weld until the heat degraded extradite is removed (extrusion welding only).
- Seam grinding has been completed less than one hour before seam welding, and the upper sheet is beveled (extrusion welding only).
- The ambient temperature, measured 6 inches above the geomembrane surface, is between 35°F and 104°F, or manufacturer’s recommended temperature limits if they are more stringent.
- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only).
- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture prior to welding.
- The weld is free of dust, rocks, and other debris.
- The seams are overlapped a minimum of 3 inches for extrusion and hot wedge welding, or in accordance with manufacturer's recommendations, whichever is more stringent. Panels should be overlapped (shingled) in the downgrade direction.
- No solvents or adhesives are present in the seam area.
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- The panels are being welded in accordance with the plans and specification. Seams should be oriented parallel to the line of maximum slope with no horizontal seams on side slopes. In corners and odd-shaped geometric locations, the number of field seams should be minimized.
- There is no free moisture in the weld area.
- Measure surface sheet temperature every two hours.
Observe that at the end of each day or installation segment, unseamed edges are anchored with sandbags or other approved device. Penetration anchors will not be used to secure the geomembrane.

2.3.5 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive testing is to detect discontinuities or holes in the seam. It also indicates whether a seam is continuous and non-leaking. Nondestructive tests for geomembrane include vacuum testing for extrusion welds and air pressure testing for dual-track fusion welds. Nondestructive testing must be performed over the entire length of the seam.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to observe and document that testing performance is in compliance with the specifications and document any seam defects and their repairs.

Nondestructive testing procedures are described below.

- For welds tested by vacuum method, the weld is placed under suction utilizing a vacuum box made of rigid housing with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section that has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner, to ensure a leak-tight seal. The vacuum pump is energized, and the vacuum box pressure is reduced to approximately 3 to 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than ten seconds.

- Air pressure testing is used to test double seams with an enclosed air space. Both ends of the air channel should be sealed. The pressure feed device, usually a needle equipped with a pressure gauge, is inserted into the channel. Air is then pumped into the channel to a minimum pressure of 30 psi. The air chamber must sustain the pressure for five minutes without losing more than 4 psi. Following a passed pressure test, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive testing, the CQA monitor must perform the following work:

- Review technical specifications regarding test procedures.
- Observe that equipment operators are fully trained and qualified to perform their work.
- Observe that test equipment meets project specifications.
• Observe that the entire length of each seam is tested in accordance with the specifications.
• Observe all continuity testing and record results on the appropriate log.
• Observe that testing is completed in accordance with the project specifications.
• Identify the failed areas by marking the area with a waterproof marker compatible with the geomembrane and inform the contractor of any required repairs, then record the repair area on the repair log.
• Observe that repairs are completed and tested in accordance with the project specifications.
• Record completed and tested repairs on the repair log and the repair drawing.

**Destructive Seam Testing.** Destructive seam tests for geomembrane seams will be performed at a frequency of at least one test for each 500 linear feet of seam length. At a minimum, a destructive test will be completed for each welding machine used for seaming. A destructive test will also be completed for individual repairs (or additional seaming for the failed welds) of more than 10 feet of seam length. The CQA monitor must perform additional tests if he suspects a seam does not meet specification requirements. Reasons for performing additional tests may include, but are not limited to the following:

- Wrinkling in seam area
- Non-uniform weld
- Excess crystallinity
- Suspect seaming equipment or techniques
- Weld contamination
- Insufficient overlap
- Adverse weather conditions
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam
- Failing tests

There are two types of destructive testing required for the geomembrane installation: peel adhesion (peel) and bonded seam strength (shear) in accordance with ASTM D 6392. The purpose of peel and shear tests is to evaluate seam strength and to evaluate long-term performance. Shear strength measures the continuity of tensile strength through the seam and into the parent material. Peel strength determines weld quality. Test welds must be allowed to cool naturally to ambient temperature prior to testing.

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

- A minimum of one stratified location for every 500 feet of field seam length or major fraction thereof.
• Sample locations should not be disclosed to the contractor prior to completion of the seam.

• A maximum frequency must be agreed to by the contractor, POR, and the Operator at the pre-construction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the POR. Samples taken as the result of failed tests do not count toward the total number of required tests.

**Sampling Procedures.** The contractor will remove samples at locations identified by the CQA monitor. The CQA monitor must:

- Observe sample cutting.
- Mark each sample with an identifying number that contains the seam number and destructive test number.
- Record sample location on the panel layout drawing and destructive seam log.
- Record the sample location, weather conditions, and reason sample was taken (e.g., random sample, visual appearance, result of a previous failure, etc.).

For each destructive test obtain one sample approximately 45 inches long by 12 inches wide, with the weld centered along the length. Cut two 1-inch-wide coupons from each end of the sample (a total of 4 coupons). The contractor must test two of these coupons in shear and two in peel (one shear and one peel from each end) using a tensiometer capable of quantitatively measuring the seam strengths. For double wedge welding, both sides of the air channel will be tested in peel. The CQA monitor must observe the tests and record the results on the destructive seam test log. A geomembrane seam sample passes the field testing when the break is a film tear bond (FTB) and the seam strength meets the required strength values for peel and shear given previously in Table 2.2 and below in the subsection “Passing Criteria for Welds” for both field testing and third party laboratory testing. As previously discussed, both welds have to pass for dual-track welds. Also, it is recommended that additional samples be obtained as discussed in the following paragraph if there is apparent separation of the weld (i.e., greater than 1/8 inch) during peel testing.

If one or both of the 1-inch specimens fail in either peel or shear, the contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations, or (2) take two additional test samples 10 feet or more in either direction from the point of the failed test and repeat this procedure. For tracking purposes the additional samples should be identified by assigning an identifying letter to the initial destructive test sample number (e.g., DS-6A and B). Only satisfactory tests count toward the required minimum number, and additional tests (i.e., A and B) count as one test, if passing. If the second set of tests pass, the contractor can reconstruct or cap-strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly, and appropriate corrective action must be taken immediately.
If the field test coupons are satisfactory, divide the remaining sample into three parts: one 12inch by 12inch section for the contractor, one 12inch by 16inch section for the third party laboratory for testing, and one 12inch by 12inch section for the Operator to archive. The laboratory sample will be shipped to the third party laboratory for delivery and subsequent testing.

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

Third Party Laboratory Testing. Destructive samples can be shipped to a third party laboratory for seam testing or tested at the site with the installer equipment tensiometer under the supervision of the CQA monitor. Testing for each sample will include five bonded seam shear strength tests and five peel adhesion tests (ten for dual-track welds). For dual-track welds each peel test specimen (coupon) will be tested on both sides of the air channel (i.e., the inner and outer welds). At least four of the five specimens tested in peel and shear will meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the manufacturer’s specifications. Additionally, 4 of 5 of the peel test coupons must have no greater than 25 percent seam separation. For dual-track welds if either weld exhibits greater than 25 percent separation or does not meet the required strength, that coupon is considered out of compliance and two out of compliance coupons cause the weld to fail. The third party laboratory must provide test results in timely manner, in writing or via telephone, to the POR. Certified test results are to be provided within five days. The CQA monitor must immediately notify the POR in the event of a calibration discrepancy or failed test results.

Passing Criteria for Welds. Passing criteria are established by Geosynthetic Institute GRI Test Method GM-19 for geomembrane seams. A passing extrusion or fusion-welded seam will be achieved when the following values are tested. The following values listed for shear and peel strengths are for 4 out of 5 test specimens (the 5th specimen can be as low as 80 percent of the listed values) for 50-mil LLDPE geomembrane. Elongation measurements should be omitted for field-testing.

- Shear strength (lb./in) 100
- Shear elongation at break (%) 50
- Peel strength (lb./in) 76 (65 extrusion weld)
- Peel separation (%) 25

2.3.6 Repairs

Any portion of the geomembrane with a detected flaw, or which fails a nondestructive or destructive test, or where destructive tests were cut, or where nondestructive tests left cuts or holes, must be repaired in accordance with the specifications developed for each...
phase of final cover construction and consistent with application parts (e.g., material requirements, installation, testing, etc.) of Section 2 of this CQA Plan. The CQA monitor must locate and record all repairs on the repair sheet and panel layout drawing. Repair techniques include the following:

- **Patching** – used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- **Extrusion** – used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 3/8-inch in the largest dimension.
- **Capping** – used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested.
- **Removal** – used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fish mouths, intersections, etc.) from the installed geomembrane. Areas of removal will be patched or capped.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one hour prior to the repair.
- Clean and dry surfaces at the time of repair.
- Extend patches or caps at least 6 inches beyond the edge of the defect, and round corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches prior to extrusion welding.
- Perform testing on repair seams consistent with Section 2.3.5 – Construction Testing.

### 2.3.7 Wrinkles

Wrinkles must be walked-out or removed as much as possible prior to field seaming. Any wrinkles which can fold over must be repaired either by cutting out excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane, which could result in the geomembrane folding. The CQA monitor must monitor geomembrane for wrinkles and notify the contractor if wrinkles are being formed above the maximum tolerance level as described below. The CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

Wrinkles occur during the geomembrane installation due to changes in liner temperatures and deployment methods. The wrinkles may interfere with the installation of the synthetic turf layer as well as the final appearance of the closure turf cover.

Minimizing wrinkles through a formal CQA wrinkle management program can greatly reduce problems resulting from geomembrane wrinkles and bridging. The program should provide specific guidance to the CQA monitors. Large wrinkles typically start at the welding seams and extend from that point across the geomembrane width. For this
reason after each panel welding the sheet should be hand pull in order to avoid the formation of ridging along the vertical seams. This technique is typically referred to as “snapping” and shall be implemented after welding every geomembrane panel. Additionally, slightly pretension pulling may be necessary at certain lower areas of the geomembrane panel to reduce diagonal wrinkles. The CQA monitor shall implement a wrinkle management program to include the following guidelines:

- Enforce snapping procedures after welding or seaming every panel as described above.
- After panel deployment and before welding, any horizontal wrinkles must be walked down or wiggled down the slope to minimize wrinkles after welding.
- Limit maximum wrinkle height to 4 inches during warmer ambient temperatures and potentially less wrinkle height of 2 to 3 inches in cooler temperatures.
- No geomembrane wrinkle should be folded over. See next section
- Ensure snapping techniques are implemented after each panel is welded.
- Physically remove wrinkles by walking them or by pretension pulling on the sheet after welding each panel.
- Avoid backfilling the anchor trenches until the synthetic grass and sand infill placement of the closure turf component. This will allow to make correction in the field during the deployment of both the geomembrane and the synthetic grass component. Note that wrinkles will travel down the slopes and cannot be redistributed up slopes, so it is important that both top and bottom anchor trenches remain open so that pulling adjustments can be made.
- Mechanically remove fish mouths larger than 5 inches in height by cutting, overlapping, flattening, and extrusion welding a patch over the affected geomembrane.

Avoid backfilling the anchor trenches until the synthetic grass and sand infill placement of the closure turf component. This will allow making correction in the field during the deployment of both the geomembrane and the synthetic grass component. Note that wrinkles will travel down the slopes and cannot be redistributed up slopes, so it is important that bottom anchor trenches remain open so that pulling adjustments can be made.

2.3.8 Folded Material

Folded geomembrane must be removed. Remnant folds evident after deployment of the roll that are due to manufacturing process are acceptable.
2.3.9. Equipment on Geomembrane Materials

Construction equipment on the final cover system will be minimized to reduce the potential for geosynthetics liner material puncture. The CQA monitor will verify that small equipment such as generators are placed on scrap geomembrane material (rub sheets) above geosynthetic materials in the final cover system.

Unless otherwise specified by the POR, rubber tire/track equipment over geosynthetics proposed by contractor shall be approved by the engineer. No equipment will be left running and unattended over the constructed geomembrane. Rubber tired / tracked ATV’s and trucks are acceptable if wheels pressure is less than 5 psi.

Driver shall check for sharp edges embedded rocks, or other foreign materials stuck into or protruding from tires/track prior to driving on the geomembrane. Path driven on geomembrane shall be as straight as possible with no sharp turns, sudden stops or quick starts.

2.3.10 Geomembrane Anchor Trench

The geomembrane anchor trench will be left open until seaming and placement of the synthetic grass and sand infill placement have been completed. Expansion and contraction of the geomembrane should be accounted for in the geomembrane placement. Prior to backfilling, the depth of penetration of the geomembrane into the anchor trench must be verified by the CQA monitor at a minimum of 100foot spacing along the anchor trench. The anchor trench should be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

2.3.11 Geomembrane Acceptance

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

- The installation is finished.
- Seams have been inspected and verified to be acceptable.

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HydroTurf™: Patent Pending
• Required laboratory and field tests have been completed and reviewed.
• Required contractor-supplied documentation has been received and reviewed.
• As built record drawings have been completed and verified by the POR. The as built drawings show the true panel dimensions, the location of seams, trenches, pipes, appurtenances, and repairs.

2.4 Turf Component

The turf layer installation consists of the placement and seaming of the synthetic grass component (two woven geotextiles made of polypropylene 13 and 18 pic tufted with polyethylene yarns) overlying the geomembrane drain liner on the top slopes and side slopes. The CQA monitor will provide on-site observation of the installation. The POR will make sufficient site visits during the drainage layer installation to document the installation in the final documentation. The Turf will meet the material property requirements listed in Table 2.3.

2.4.1 Delivery

Upon delivery the CQA monitor must observe the following:

• The turf is wrapped in rolls with protective covering.
• The rolls are not stacked more than 3 high.
• The rolls are not damaged during unloading.
• Protect the turf from mud, soil, dirt, dust, debris, cutting, or impact forces.
• Each roll must be marked or tagged with proper identification.

Any damaged rolls will be rejected and removed from the site or stored at a location separate from accepted rolls, designated by the Operator. Rolls that do not have proper manufacturer’s documentation will also be stored at a separate location until documentation has been received and approved.

2.4.2 Testing

The turf manufacturer (or supplier) will conduct quality control testing and certify that materials delivered to the site comply with project specifications for each phase of final cover construction.
<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Minimum Required Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn count (Denier)</td>
<td>ASTM D 1907</td>
<td>8000 (min 7300)</td>
</tr>
<tr>
<td>Tensile Grass @ Break lbs. (N)</td>
<td>ASTM D 2256</td>
<td>15 lbs (MARV)</td>
</tr>
<tr>
<td>Elongation @ Break %</td>
<td>ASTM D 2256</td>
<td>30-80%</td>
</tr>
<tr>
<td>CBR Puncture</td>
<td>ASTM D6241</td>
<td>900 Lbs (MARV)</td>
</tr>
<tr>
<td>Tape thickness (micron)</td>
<td>ASTM D 3218</td>
<td>100</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>N/A</td>
<td>Varies based on client request</td>
</tr>
<tr>
<td>Tensile Product</td>
<td>ASTM D4595</td>
<td>1 to 2 mm</td>
</tr>
<tr>
<td>Coating Temp</td>
<td>N/A</td>
<td>1000 Lb/ft. (MARV)</td>
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<tr>
<td>Yarn Weight Minimum (grams per sq. cm)</td>
<td>ASTM D 5261</td>
<td>19 oz./sy (0.063) (MARV)</td>
</tr>
<tr>
<td>Double 13/18 Pic Polybag (grams per sq. cm)</td>
<td>ASTM D 5261</td>
<td>6 oz./sy (0.023) (MARV)</td>
</tr>
<tr>
<td>Product Weight w/o ballast (grams per sq. cm)</td>
<td>ASTM D 5261</td>
<td>25 oz./sy (0.091) ±1oz/sy</td>
</tr>
<tr>
<td>Pile Height Minimum (cm)</td>
<td>N/A</td>
<td>1.25 in (3.17)</td>
</tr>
<tr>
<td>Tufting Gauge (cm)</td>
<td>N/A</td>
<td>0.5 (1.27) to 3/4 inch (1.9)</td>
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<tr>
<td>Transmissivity with underlying structured geomembrane</td>
<td>ASTM D 4716</td>
<td>2.5E-03 m²/sec, Minimum</td>
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<tr>
<td>Normal stress 50 psf and 0.33 gradient (m2/sec)</td>
<td>N/A</td>
<td></td>
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<tr>
<td>Internal Friction of combined components</td>
<td>ASTM D 5321</td>
<td>35 degrees, Minimum</td>
</tr>
<tr>
<td>UV Resistance and Stability. Tensile testing after weathering</td>
<td>ASTM G 147 (02)</td>
<td>55% Retained Strength, 30 year exposure</td>
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<tr>
<td>Climate Zone 200W/m² 30 years exposure –accelerated or projected</td>
<td>N/A</td>
<td>Minimum</td>
</tr>
<tr>
<td>Sand in-fill Gradation and Ballast</td>
<td>ASTM D 6913</td>
<td>SP/SW at a minimum of half inch as ballast weight to be approved by Engineer-of-Record prior to installation</td>
</tr>
</tbody>
</table>

### 2.4.3 Manufacturer Quality Control

Turf manufacturer shall provide inspection records of the tufting procedures for the Turf material. These will include visual inspection records of the following properties every 150,000 sq. ft:

- Tufting Gauge
- Pile height
- Roll Length and roll numbers.

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Manufacturer shall also provide documentation on the geotextile product and yarn manufacturer minimum properties.

2.4.4 Conformance Testing

One Turf sample will be obtained for every 400,000 sq. ft of material supplied to the site. The material will be sampled at the site or at the plant by a CQA representative. The samples will be forwarded to the third-party laboratory for the following conformance tests:

- Yarn Weight ASTM D5261
- CBR Puncture ASTM D6241
- Tensile Product ASTM D 4595
- Tensile Strength of Yarn ASTM D2256

2.4.5 Turf Installation

Surface Preparation. Prior to turf installation, the CQA monitor must observe the following:

- The bottom liner has been prepared in accordance with the specifications and the geomembrane has been installed as outlined in Section 2.3.4.
- The geomembrane installation documentation has been completed over the areas that will be covered by the synthetic turf.
- The supporting surface (i.e., the geomembrane) does not contain stones or debris that could damage the turf.

Turf Placement. Prior to the installation of the turf, the contractor shall submit drawings showing the panel layout, indicating panel lengths, direction of deployment and the sequence proposed for flipping the panels after seaming. The POR must review field conditions and approve the panel sequencing placement and the proposed direction of flipping after sewing as well as any revision to the panel layout. During panel placement, the POR or CQA monitor must:

- Observe the Turf as it is deployed and record defects and disposition of the defects (panel rejected, patch installed, etc.). Repairs are to be made in accordance with the specifications.
- Verify that equipment used does not damage the turf or underlying geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.
• Verify that all panels are deployed from the top of the slope in a way that the leading edge of the roll stays at the top of the slope with the grass filaments always pointing upwards.

• Verify that the turf is anchored to prevent movement by the wind (the contractor is responsible for any damage resulting to or from windblown turf.

• Verify that the turf remains free of contaminants such as soil, grease, fuel, etc.

• Observe that the turf is laid smooth and free of tension, stress, folds, wrinkles, or creases.

• Observe that on slopes the turf is secured with sand bag anchoring at the top of the slope and then rolled down the slope.

• Observe the deployment of the panels to insure proper flipping in order to expose the grass surface up after seaming operations. Deployment should be done on the adjacent turf panel to avoid damage.

• Observe that the seaming operation is performed using a 4-inch overlap and fastened with heavy-duty textile stitching machine. A single stitch prayer type seam is constructed using Nulong sewing machine or equivalent. The thread shall be 207 Polyester or equivalent. Sewing should occur between the 1st and 2nd row of stitches to avoid exposure of the black geotextile after flipping the panel.

• The CQA monitor shall review the specifications of the thread to be used for sewing the turf.

• Observe that after seaming operations, the ends of the Synthetic Turf panels are permanently anchored in the perimeter anchor trenches and covered with a minimum of two feet of soil.

2.4.6 Turf Repair Procedure:

• All turf repairs will be completed by using a heatbonded seam. This can be accomplished by using a hand held leister or a Varimat V2 leistering machine.

• All seams with considerable length should use the Varimat V2 leistering machine. This gives consistent pressure (77 lbs) throughout the seam. Seam strength is a combination between weight and temperature. The temperature of the Varimat V2 leistering machine should be discussed prior to use because temperature control is a variable that can be increased/decreased depending on weather conditions.

• A hand held leister should be used in smaller/concentrated areas. This may include areas around well heads or patches where turf was cut.
2.4.7 Equipment on the Turf:

No equipment shall be allowed on slopes exceeding 15% until the sand infill is in place. In flatter slopes, such as top decks, ATV and vehicles will be allowed prior to infill placement if the tire pressure is less than 30 psi. Post construction drivability tire pressures should be limited on the slopes to 30 to 60 psi based on slope angle. Allowable tire pressures may be increased to 80 psi depending on subgrade conditions and engineer of record approval.
3.0 SAND INSTALLATION

The sand layer will be of ½-inch thick nominal. The sand will be worked into the Turf layer as in-fill between the synthetic yarn blades. The physical characteristics of the sand layer will be evaluated through visual observation (and laboratory testing if deemed necessary by the POR) before construction and visual observation during construction. Additional testing during construction will be at the discretion of the POR.

The sand layer may be placed using any appropriate equipment capable of completing the work and should only receive minimal compaction required for stability. No equipment shall be allowed on slopes exceeding 15% until the sand infill is in place. In flatter slopes, such as top decks, ATV and vehicles will be allowed prior to infill placement if the tire pressure is less than 15 psi.

Conveyor Systems and or Express Blowers can be used to spread and place the sand in-fill. Contractor shall explain in detail in the pre-construction meeting the method of sand deployment to be used. The method shall be approved by the Engineer. For slopes 3H:1V or steeper the sand infill shall be placed using long reach conveyors belts or using water or air express blower methods.

The CQA monitor will verify that the geosynthetics are not displaced while the sand layer is being placed.

The sand aggregate to be used shall consist of highly permeable sand with an SW or SP curve specification. The curve should indicate the material consisting of medium sand having approximately 10% coarse and 10% fine sand.

The minimum initial lift of sand infill will be determined based on the type of placement equipment, and the slope and geometry considerations of the slope. An average of 0.5 to 0.75 inches is recommended for equipment with light ground pressure of less than 30 psi.

The sand placement shall be done in front of the deployment equipment to improve the bearing capacity of the cover system below.

An average thickness of ½ inch of sand infill shall be applied before allowing lightweight vehicles on the turf. This is particularly important on slopes steeper than 3H to 1V where light rubber or tracked vehicles could start pulling on the turf before the sand infill is in place.

Let it be noted that sand placement cannot occur with snow or ice on turf. Rain or wet conditions do not hamper the placement of sand (ballast) onto the turf, however wet sand or turf conditions severely hinder the ability to broom the sand in correctly. The sand will dry very quickly when spread evenly and exposed to atmospheric conditions conducive to drying the material. The sand can then be broomed into the sand correctly.
During construction the CQA monitor will:

- Verify that grade control is performed prior to work.
- Verify that underlying geosynthetic installations are not damaged during placement operations. Mark damaged geosynthetics and verify that damage is repaired.
- Verify that average thickness of ½ inch (nominal) of sand is placed on the synthetic turf. Frequency will be 20 measurements per acre of final cover installed.
4.0 HydroBinder Installation

HydroTurf™ installation for down chutes requires placement of the geomembrane panel through the channel surface and into the adjacent vertical trenches designed for anchoring the system. If the panel is not wide enough to cover the channel additional panels should be seamed in accordance with the regulatory approval method and be secure into the vertical anchor trenches at the edges of the panels. Do not backfill until turf has been installed.

Once the membrane is placed, any noticeable wrinkles should be pulled to the toe of channel or the adjacent vertical anchor trenches. The membrane should lay flat and be free of measureable wrinkles before the turf is placed. If the turf roll is not wide enough to cover the channel and be secured into the vertical anchor trenches, a sewn seam must be performed to ensure the turf seam is wide enough. All noticeable turf wrinkles should also be pulled to the toe of the channel or the adjacent anchor trenches. Once the membrane and turf are placed into the down chute the top horizontal anchor trench should be backfilled and compacted.

Infill should be placed in between the synthetic grass. The material will be blown or spread with mechanical equipment. The infill layer may be placed using any appropriate equipment capable of completing the work and should only receive minimal compaction required for stability. The infill is to be spread using low ground pressure equipment and 3 point spreader or a pull-behind spreader. Alternative Conveyor Systems and or Express Blowers can be used to spread and place the in-fill. Contractor shall explain in detail in the pre-construction meeting the method of infill deployment to be used. The Engineer shall approve the method.

The cement sand mix shall comprise of either a Quickcrete product (Sand Topping Mix) or a Sackcrete product (Sand Mix). These are the only two approved products to be used as infill for the HydroTurf™ system. Both products can be delivered in either pallet form of 60 lb. bags or 2000 lbs. super sac. The cement product should be installed into the turf while it is in a dry state. The cement shall be worked into the tufts so the tufts are in an upright position with the infill at a measurable ½ to ¾ inch nominal depth. This is achieved with common shop broom and yard rakes. Once the cemented infill is installed as described, the cemented infill must then be hydrated. The hydration process must occur the day of the cemented infill placement. The cemented infill is hydrated thoroughly with a ‘misted’ spray type to avoid displacement of the non-hydrated infill.

The installer must also be aware not to overhydrate the in-fill so that water begins to runoff and cause loss of cemented infill during the process. The general objective is to soak the area to start the hydration process but not to inundate with water beyond saturation.

Once hydration is completed as described, backfill and compaction of the vertical anchor trenches should be backfilled. The HydroTurf™ channel will be at minimum performance levels within 24 hours and continue to increase in strength over the next few weeks.
5.0 Reporting

The POR on behalf of the Operator will submit to the State a final documentation for record of the constructed final cover system.

The quality assurance plan depends on thorough monitoring and documentation of construction activities. Therefore, the POR and CQA monitor will document that quality assurance requirements have been addressed and satisfied. Documentation will consist of daily record keeping, testing and installation reports, nonconformance reports, progress reports, photographic records, and design and specification revisions. The appropriate documentation will be included the FCSER.

Preparation of Final Documentation

The POR, on behalf of the Operator, will submit to the State Regulatory Agencies a FCSER for record of finale cover system constructed.

Testing, evaluation, and submission of the FCSER for the final cover system during construction will be in accordance with this CQA Plan. The construction methods and test procedures documented in the FCSER will be consistent with this CQA Plan.

At a minimum, the documentation will contain:

- A summary of all construction activities.
- All laboratory and field-test results.
- Manufacturer’s certifications for all geosynthetics.
- Documentation of thickness verification of sand layer.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- A statement of compliance with the permit CQA plan and construction plans.
- The reports will be signed and sealed by a professional engineer(s) licensed in the State where the work is performed.

The as-built record drawings will accurately site the constructed location of work items, including the anchor trenches. The POR will review and verify that as built drawings are correct. As built drawings will be included in the final documentation.

The FCSER will be signed and sealed by the POR, signed by the site operator, and submitted to the MSW Permits Section of the Waste Permits Division of the State for approval.
Attachment 3
Representative Project Photographs
<table>
<thead>
<tr>
<th>Photo No.</th>
<th>Date</th>
<th>Direction Photo Taken</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>08-01-16</td>
<td>View SE</td>
<td>View of TCT portion of former Slag Pile 1 area. Demarcation fabric installed and ET clayey soil layer being placed and compacted.</td>
</tr>
<tr>
<td>2</td>
<td>08-02-16</td>
<td>View east</td>
<td>Dozers placing clayey sand while sheepfoot compactor compacts fill.</td>
</tr>
</tbody>
</table>
PHOTOGRAPHIC LOG

Photo No. 3  
Date: 08-02-16

Direction Photo Taken:
View east

Description:
Dozer placing EBS silty sand portion of ET final cover.

PHOTOGRAPHIC LOG

Photo No. 4  
Date: 08-04-16

Direction Photo Taken:
View NE

Description:
ET final cover completion on former UPRR/TCT Slag Pile 1 area.
<table>
<thead>
<tr>
<th>Photo No.</th>
<th>Date</th>
<th>Direction Photo Taken</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>12-08-16</td>
<td>View west</td>
<td>View of ET final cover completion between UPRR tracks and former slag Pile 1 area.</td>
</tr>
</tbody>
</table>