APPENDIX B

CONSTRUCTION MATERIALS SPECIFICATIONS

1. CONSTRUCTION MATERIALS SPECIFICATIONS

This presentation of construction materials specifications is supplemental to such information provided in project drawings. In the event that information being included herein is in any way incomplete or conflicts with that provided in project drawings, the project drawings are to be considered primary.

2. SOIL MATERIALS

Soil materials will consist of the predominantly sand and gravel soils obtained from stockpiles and the Trench 12 excavation area, supplemented as needed with imported soil materials. Materials that cannot be satisfactorily placed and/or compacted to a stable condition will be designated as unsuitable. Unsuitable materials will include trash, organic substances, large rocks (more than six inches in diameter) or other materials determined to be unsuitable by the Project Manager. These materials will be removed from the fill material and segregated from suitable soil.

2.1 SPECIFICATION FOR SURFACE SOIL LAYER IMPROVEMENT

Soil materials for replacement of the loose surface soil layer will consist of site materials with no materials larger than six inches, 95% smaller than 3.0 inches, and not less than 10% and not more than 20% passing the #200 sieve. Suitable materials from direct excavation or stockpiles will be placed in lifts not exceeding 12 inches thick and compacted to 95 percent MDD by ASTM D 1557 at a moisture content between the OMC and OMC +2 percent. Mixture with fine-grained soil amendment(s) is not required if the natural material satisfies the grain size specification.

2.2 SPECIFICATION FOR LINER SUBGRADE ON TRENCH FLOOR AND IN SUMPS

Soil materials for the liner subgrade layer will consist of site materials, amended as necessary with imported fine-grained materials to achieve the grain size specification. The final subgrade soil will have not more than 10 percent (by weight) coarser than 1.0 inch and not less than 10 percent (by weight) smaller than the #200 sieve. Suitable materials from direct excavation or stockpiles will be placed in lifts not exceeding 12 inches thick (before compaction) and compacted to 90 percent MDD by ASTM D 1557 at a moisture content between the OMC and OMC +2 percent.

2.3 SPECIFICATION FOR PERIMETER STARTER BERM SOIL

Soil materials for the compacted soil starter berms will contain no materials larger than six inches, 95% smaller than 3.0 inches, and not less than 10% passing the #200 sieve. Suitable materials from direct excavation or stockpiles will be placed in lifts not exceeding 12 inches thick and compacted to 90 percent MDD by ASTM D 1557 at a moisture content between the OMC and OMC +2 percent.

2.4 GRAVEL MATERIALS FOR LDS/LCRS SUMPS

Gravel materials for use in LDS/LCRS sumps will consist of screened site materials with 95% falling within the size range between 1.0 and 3.0 inches and not more than 5% passing the #4 sieve. All gravel material will be stockpiled and placed in such a manner as to minimize the intrusion of fines and to minimize segregation of various gravel sizes. Gravel materials for LDS and LCRS sumps, and for placement along LCRS piping, will be loosely placed with no compaction or moisture content specification.

2.5 SELECT WASTE OPERATIONS LAYER

The operations layer is not a bottom liner component, but its presence and material type are significant in hydrologic calculations completed as part of LCRS design. It is the initial 30 inches of material placed above the liner across the bottom of each disposal cell (Phases 12A, 12B, and 12C). The operations layer is to be an SM (silty sand) material, by Universal Soil Classification System (ASTM D2487), can be comprised of clean soil, select waste, or a combination of clean soil and select waste. The first foot (12 inches) of operations layer above the liner will be primarily (i.e., greater than 50 percent) sand, with a total of less than 50 percent gravel and silt/clay size particles. It will contain no particles larger than one inch. The next 1.5 feet (18 inches) also should be SM material, but can contain particles up to 6.0 inches in diameter. The select waste operations layer should be placed in two lifts (as noted above), as dry as is practical, and with as little passage of heavy equipment as is practical (before the full layer is in placed). This layer has no compaction or moisture content specifications.

3. LINER MATERIAL

3.1 GEOTEXTILE

Minimum specifications geotextile for use in this project will consist of non-woven polypropylene or polyester materials designed and fabricated to meet the various thickness requirements of the project. All geotextile is to be stored and applied in such a way as to prevent degradation by direct sunlight, wind, or mechanical damage. Polyester or ultra-violet-resistant polypropylene geotextile should be used whenever the project requires exposure to direct sunlight for more than two weeks.

Unless otherwise indicated, specifications for geotextile materials are included in the tables below.

Minimum Specifications for 16 ounce geotextile.

Property	Test Method	Value
Thickness	ASTM D5199	155 mil (0.155 inch)
Mass per Unit Area	ASTM D5261	16.0 oz/sq yard
Grab Tensile strength	ASTM D4632	390 lbs
Grab Elongation	ASTM D4632	50%
Puncture Strength	ASTM D4833	240 lbs
Trapezoidal Tear	ASTM D4533	150 lbs
UV Resistance	ASTM D4355	70% after 500 hours

Minimum Specifications for 10 ounce geotextile.

Property	Test Method	Value
Thickness	ASTM D5199	100 mil (0.100 inch)
Mass per Unit Area	ASTM D5261	10.0 oz/sq yard
Grab Tensile strength	ASTM D4632	260 lbs
Grab Elongation	ASTM D4632	50%
Puncture Strength	ASTM D4833	165 lbs
Trapezoidal Tear	ASTM D4533	100 lbs
UV Resistance	ASTM D4355	70% after 500 hours

Minimum Specifications for 8 ounce geotextile.

Property	Test Method	Value
Thickness	ASTM D5199	80 mil (0.080 inch)
Mass per Unit Area	ASTM D5261	8.0 oz/sq yard
Grab Tensile strength	ASTM D4632	220 lbs
Grab Elongation	ASTM D4632	50%
Puncture Strength	ASTM D4833	120 lbs
Trapezoidal Tear	ASTM D4533	95 lbs
UV Resistance	ASTM D4355	70% after 500 hours

3.2 GEONET

The geonet materials will be made of new, high-density polyethylene (HDPE) or very flexible polyethylene (VFPE) materials, as required by the design drawings, manufactured specifically for the purpose of liquid conveyance. The geonet will have, unless otherwise indicated in these specifications or project drawings, the following minimum property values.

Property	Test Method	Minimum Property Value
Thickness, mil	ASTM D 5199	200 (0.200 inch)
Density, min., g/cc	ASTM D 1505	0.940
Carbon Black Content, %	ASTM D 1603	2.0
Tensile Strength, (Peak, MD), lb/in	ASTM D 7179	45
Transmissivity, (MD), gal/min·ft	ASTM D 4716	9.66

3.3 GEOMEMBRANE

The flexible membrane liner (FML) or geomembrane materials will be made of new, high-density polyethylene (HDPE) or very flexible polyethylene (VFPE or LLDPE) materials, as required by the design drawings, manufactured specifically for the purpose of liquid containment. All geomembrane liner materials will have sufficient strength and resistance to chemical or ultraviolet radiation attack for the intended use. Minimum specifications, unless otherwise indicated, for HDPE materials are included in the table below.

Minimum Specifications for 80 mil High Density Polyethylene Liner – Textured on both sides

Property	Test Method	Value
Thickness, minimum average, mil	ASTM D5994	76 (0.076 inch)
Density	ASTM D1505	0.94 gm/cm^3
Tensile strength @ yield	ASTM D6693	168 lb/in-width
Tensile strength @ break	ASTM D6693	120 lb/in-width
Elongation @ yield	ASTM D6693	12%
Elongation @ break	ASTM D6693	100%
Puncture Resistance, lb	ASTM D4833	120
Tear Resistance, lb	ASTM D1004	56
Percent carbon black	ASTM D1603	2.0%

Minimum Specifications for 80 mil High Density Polyethylene Liner – Textured on one side

Property	Test Method	Value
Thickness, minimum average, mil	ASTM D5994	76 (0.076 inch)
Density	ASTM D1505	0.94 gm/cm^3
Tensile strength @ yield	ASTM D6693	168 lb/in-width
Tensile strength @ break	ASTM D6693	120 lb/in-width
Elongation @ yield	ASTM D6693	12%
Elongation @ break	ASTM D6693	100%
Puncture Resistance, lb	ASTM D4833	120
Tear Resistance, lb	ASTM D1004	56
Percent carbon black	ASTM D1603	2.0%

Minimum Specifications for 60 mil High Density Polyethylene Liner – Textured on both sides

Property	Test Method	Value
Thickness, minimum average, mil	ASTM D5994	57 (0.057 inch)
Density	ASTM D1505	0.94 gm/cm^3
Tensile strength @ yield	ASTM D6693	126 lb/in-width
Tensile strength @ break	ASTM D6693	90 lb/in-width
Elongation @ yield	ASTM D6693	12%
Elongation @ break	ASTM D6693	100%
Puncture Resistance, lb	ASTM D4833	90
Tear Resistance, lb	ASTM D1004	42
Percent carbon black	ASTM D1603	2.0%

The Manufacturer will certify that the geomembrane has been inspected and quality-control tested during the manufacturing process, and that the materials are free of holes, blisters, undispersed raw materials, and contamination by foreign materials.

In addition, the Manufacturer will certify that the geomembrane meets all strength and resistance requirements for the intended use.

Documentation must be provided verifying that all factory welds meet the requirements for field seaming, and that the destructive and non-destructive testing required for field seaming has been performed also for factory seams.

3.4 GEOCOMPOSITE

The geocomposite is a geonet sandwiched between two layers of geotextile to create a double-sided geocomposite. The geocomposite final product and its components will have the following property values.

Minimum specifications for the geocomposite material comprised on a 200 mil geonet bonded to two 6 ounce geotextile layers.

Property	Test Method	Minimum Property Value
Transmissivity, (MD), gal/min·ft	ASTM D4716	0.48
Ply Adhesion, lb/in	ASTM D7005	1

Minimum specifications for the geonet component.

Property	Test Method	Minimum Property Value
Thickness, mil	ASTM D5199	200
Density, min., g/cc	ASTM D1505	0.940
Carbon Black Content, %	ASTM D1603	2.0
Tensile Strength, (Peak, MD), lb/in	ASTM D5035	45
Transmissivity, (MD), gal/min·ft	ASTM D4716	9.66

Minimum specifications for the geotextile component.

Property	Test Method	Minimum Property Value
Unit Weight, oz/yd^2	ASTM D5261	6
Grab tensile strength, lb	ASTM D4632	170
Puncture strength, lb	ASTM D4833	90
Permittivity, sec^{-1}	ASTM D4491	1.5
Flow rate, gal/min/ft	ASTM D4491	110
UV Resistance	ASTM D4355	70% after 500 hours
AOS, USC Sieve (mm)	ASTM D4751	70

Minimum specifications for the geocomposite material comprised on a 300 mil geonet bonded to two 8 ounce geotextile layers.

Property	Test Method	Minimum Property Value
Transmissivity, (MD), gal/min·ft	ASTM D4716	4.35
Ply Adhesion, lb/in	ASTM D7005	1

Minimum specifications for the geonet component.

Property	Test Method	Minimum Property Value
Thickness, mil	ASTM D5199	300
Density, min., g/cc	ASTM D1505	0.940
Carbon Black Content, %	ASTM D1603	2.0
Tensile Strength, (Peak, MD), lb/in	ASTM D5035	75
Transmissivity, (MD), gal/min·ft	ASTM D4716	38.64

Minimum specifications for the geotextile component.

Property	Test Method	Minimum Property Value
Unit Weight, oz/yd^2	ASTM D5261	8
Grab tensile strength, lb	ASTM D4632	220
Puncture strength, lb	ASTM D4833	120
Permittivity, sec^{-1}	ASTM D4491	1.5
Flow rate, gal/min/ft	ASTM D4491	110
UV Resistance	ASTM D4355	70% after 500 hours
AOS, USC Sieve (mm)	ASTM D4751	80

3.5 GEOSYNTHETIC CLAY LINER (GCL)

This liner system component is a reinforced GCL consisting of a layer of sodium bentonite between two nonwoven geotextiles. The final product will have the following minimum values.

Property	Test Method	Value
Bentonite Swell Index, mL/2g	ASTM D5890	24 (min)
Bentonite Fluid Loss, ml	ASTM D5891	18 (max)
Bentonite Mass/Area, lb/ft^2	ASTM D5993	0.75 (min)
GCL Grab Strength, lbs/in MARV	ASTM D6768	50
GCL Peel Strength, lbs/in	ASTM D6496	3.5 (min)
GCL Index Flux, m^3/m^2/sec	ASTM D5887	1x10^{-8} (max)
GCL Hydraulic Conductivity, cm/sec	ASTM D5887	5 x 10^{-9} (max)
GCL Hydrated Internal Shear Strength, psf	ASTM D5321 & D643	500 @ 200 psf
Textile Backing Weight, oz/sy	ASTM D3776	6

The bentonite will be bonded between the confining geotextiles in a manner to ensure that the bentonite will not be displaced during handling, transportation, storage and installation, including cutting, patching, and fitting around penetrations.

4. PIPING

Pipe used for LCRS collectors, LCRS risers, and LDS risers will consist of steel, HDPE, and polyethylene pipe materials of the type and diameters specified in project drawings. Collection piping will be of the diameter, wall thickness, and perforation detail indicated in project drawings. Non-perforated riser piping will be 12-inch diameter with a minimum standard dimensional ratio (SDR) or 17.0. All piping connections will be made in accordance with manufacturer recommendations.

APPENDIX C

CONSTRUCTION METHOD SPECIFICATIONS

1. INTRODUCTION

The Construction Specifications document provides detailed discussion and specifications for the construction of the at-grade and below-grade features of Trench 12. Within this Construction Specifications document, the following reference convention is used:

- References to material specifications are to Appendix B of the CQA Plan; and
- References to design drawings are to Appendix A of the CQA Plan. Drawings are referenced by the last three digits of their sequential number, e.g., Drawing NV12-07-007 is referred to as Drawing 007.

This presentation of Construction Specifications is supplemental to such information provided in project drawings. In the event that information being included herein is in any way incomplete or conflicts with that provided in project drawings, the project drawings are to be considered primary.

2. PHYSICAL LAYOUT

This work will consist of the layout of excavation area limits and other construction details. All components will be laid out in accordance with the location, lines and grades, and construction details shown on the project plans. Staking will be verified in accordance with the plans using standard surveying and inspection techniques.

Verification of the constructed dimensions (line, grade, and elevation) of the excavated trench will be accomplished in accordance with the following:

- As-constructed cross-sections of the excavated trench surveyed for each 100 linear feet of cover dimension in both the transverse and longitudinal directions or by other survey method providing equivalent dimensional accuracy; and
- The CQA Officer will be responsible for verifying construction by checking survey data for compliance with the design drawings. Any significant differences will be noted by the CQA Officer, and the Project Manager will be notified.

Changes to line and grade will have the approval of the Project Engineer prior to implementation.

3. EARTHWORK

Trench 12 site excavation activities include excavation and improvement of the surface soil layer, trench excavation, and excavation of LCRS riser recesses. Trench 12 will be excavated in three phases, with the westernmost portion planned to be the initial phase, and the middle and easternmost portions as the second and third phases (respectively). The eastern portion of the Trench 12 footprint overlies the existing site entrance, office, water storage tank, and other facilities. The facilities in this area must be completely relocated before Phase 12C excavation is done, but removal and relocation of some of these facilities might be required to provide access to the Trench 12 work area prior to Phase 12C.

3.1 EXCAVATION LIMITS

The excavation plan and horizontal limits of grading for Trench 12 are provided in Drawings 003 and 004.

3.1.1 Surface Soil Recompaction Excavation Limit

Drawing 003 shows the estimated horizontal limit of the excavation around the Trench 12 perimeter for surface soil removal and recompaction. The actual horizontal limits of the soil recompaction excavation will be based on field determination of the depth of the loose surface soil layer.

3.1.2 Anchor Trench Excavation Limit

The inside horizontal limit of the Trench 12 liner system anchor trench excavation is 5.0 feet outside of the HCL (away from the excavation crest) as shown on Drawing 004.

3.1.3 Trench 12 Excavation Limit

The excavation plan and horizontal limit of excavation for Trench 12 are provided in Drawing 004. Excavation slopes do not differ from those considered in the 1996 Trench 12 design (which was reviewed and approved by NDEP) and slope stability was fully addressed in the 1996 Design and supporting documents, as referenced by the current RCRA Permit. Trench bottom elevations and grades shown on Drawing 004 are those for the top of the subgrade, that

also corresponds approximately to the top of the liner system (excluding the 2.5-feet thick operations layer that will overlie the liner system).

Trench bottom grades are controlled by the elevation of the three LDS/LCRS sumps, with minimum floor slopes set at one percent in Phase 12A and most of Phase 12C, and at two percent in portions of Phase 12B and Phase 12C. Floor slopes facilitate leachate drainage into each of the three sumps. Bottom grading for Phase 12B and part of Phase 12C differs from one percent because of geometry constraints (see Drawing 004).

A horizontal control line (HCL) provides the lateral limit of excavation as shown on Drawings 002 and 004. The HCL is determined from constraints on the lateral extent of waste as described in Chapter 1.0 of the CQA Plan. The position of the HCL is consistent with the property lease agreement between USEN and the State of Nevada, and is about 20 feet inside the permitted facility boundaries (north and west sides), 50 feet inside the boundary with the closed LLRW disposal facility, and 50 feet from the western limit of disposed waste in Trench 11.

Trench depth (maximum) is about 75 feet. Sidewalls are designed with 0.5:1.0 (H:V) slopes, except at curved sections where constant-radius curves (which do not vary with elevation) are specified in order to facilitate efficient construction and a smooth transition for the lining system. These curved sections have slopes that are flatter than 0.5 1.0.

Excavated soil materials will be stockpiled off-site to the north of Trench 12. Some materials will be segregated by gradation, including materials that will be selectively screened on-site before reuse as Trench 12 construction materials.

3.2 SURFACE SOIL RECOMPACTION AREA – TRENCH PERIMETER

3.2.1 Surface Soil Recompaction Excavation Limit

Calculations provided with the 1996 Design documentation (as approved by NDEP in the previous and current RCRA Permits) conclude that this surface soil layer needs to achieve a cohesion value of approximately 1,000 pounds per square foot (PSF). Additional slope stability calculations done to complete the 2007 Final Design (Engineering Report Supplement, Attachment 3) indicate that this criterion is overly conservative, and that sufficient stability can be achieved by removing and recompacting the surface soil layer to achieve a cohesion value of

about 250 PSF. Laboratory testing conducted using Trench 12 area soil indicates that this cohesive strength can be achieved using the natural surface soil when recompacted to 90% MDD (by ASTM D 1557). These material amendment and compaction specifications are provided in Section 2.1 of Appendix B. Removal and recompaction of the surface soil around the Trench 12 perimeter must be completed prior to trench excavation.

Appendix A, Drawing 003 shows the expected limits of surface soil excavation. The Project Engineer or CQA personnel will determine the actual depth of the surface soil recompaction excavation as excavation proceeds. The horizontal and vertical limits of this excavation will be controlled to be as small an area (and volume) as is practical while assuring that the volume (and footprint) of surface soil recompaction is sufficiently large to include: 1) the horizontal control line (HCL) defines the lateral limit of the Trench 12 excavation, 2) the limits of the liner anchor trench, and 3) the limits of the compacted soil starter berm. The minimum horizontal limits of the surface soil recompaction excavation, as shown on Drawing 003, are designed to include these features.

Surface soil recompaction inspection activities that will be conducted during fill conditioning, placement, and compaction include:

- Testing of fill material characteristics;
- Measurement of loose lift thickness;
- Testing of the density and moisture content of the compacted fill;
- Ensuring that the fill contains no organic or other deleterious materials; and
- Observation of type of compaction equipment, number of passes, and uniformity of compaction coverage.

Sampling and testing of the fill materials will be accomplished periodically to verify type, gradation, and compaction curves to ensure the fill materials meet the applicable construction and materials specifications. The following minimum testing frequencies will be used.

- Moisture-density tests and grain-size determinations will be done to confirm that the material is acceptable and to determine fill compaction requirements. At least three sets of such tests will be done. The test results will be compared to the properties of materials tested during the development of the 2007 Design, as provided in Attachment 3 of the

Engineering Report Supplement, to confirm that an acceptable cohesive strength can be obtained using natural materials

- In-situ density tests will be performed at a minimum of one test per compacted lift or one test for every 2,000 cubic yards placed, whichever is less.

A schedule of the soil placement inspection requirements is attached as Table C-1. If the grain size analysis test results do not satisfy project specifications, the Project Engineer will be contacted to determine the acceptability of the fill material.

In the event that density testing indicates that the target density is not achieved, the area within 100 feet of the failing testing will be recompacted and retested. Confirmation of satisfactory compaction in a re-compacted area will be by done by three satisfactory density tests, at locations selected to represent the entire 100 by 100 feet area, passing the density specification.

3.3 TRENCH SIDEWALLS

3.3.1 Sidewall Preparation

The possible irregularity of the excavated surface of Trench 12 sidewalls was addressed by USEN and NDEP in a series of questions and responses concerning the 1996 Design. At that time, it was agreed that some sidewall surface irregularities might require application of a filler material, such as a sprayed concrete surfacing e.g., gunite). A criterion for determining which such irregularities would require filler was developed during the exchange of information between USEN and NDEP. That criterion was that the yield strength of the weakest geosynthetic material should not be exceeded. This yield-based criterion is considered to be overly conservative for the following reasons.

1. On the basis of strain at yield, the HDPE geomembranes are the weakest liner system components. The 60-mil geomembrane yields at about 12 percent strain. However, material yield is not the same as material failure. An HDPE stretched past its yield strain still is an effective hydraulic barrier until it fails (tears), and the HDPE geomembrane will stretch to about 100 percent strain before failing.

2. Though deviations from a planar surface could be common in the excavated Trench 12 sidewalls, such irregularities are expected to be isolated. As such, zones within the geomembrane that might experience strains that exceed the yield criterion when waste is placed against the liner are not likely to be continuous over a long distance. Small yielded areas are not likely to significantly affect the overall strength of the liner system.

3. Loading against the liner system that could cause geomembrane components to stretch will be caused only by waste placement. If a small portion of the geomembrane is stretched to the point of exceeding its yield strength, there will be little load placed on the yield liner system member from materials lower on the sidewall since the placed wastes below the yielded area actually will be supporting the liner.

To reduce the possibility for surface irregularities to cause liner material strain, the Trench 12 sidewalls will be smoothed with a dragged chain or other method that can remove sharp or abrupt edges. As necessary, projecting objects, such as large or sharp-surfaced rocks, will be mechanically or manually removed. Deep sidewall depressions that cannot be satisfactorily smoothed will be filled with gunite or other suitable material. The determination that the sidewall surface has been satisfactorily smoothed or that further action, such as filling, will be made and documented by CQA personnel.

3.3.2 Slope Riser Trenched Recesses

As shown in Section C on Drawing 007, shallow recesses will be excavated into the trench sidewalls for placement of the LDS riser pipes that extend up the sidewalls from each of the three LDS sumps. The trenched recesses will allow the primary liner system (components above the primary HDPE geomembrane) to be installed above the secondary liner system and flush with trench sidewalls. The trenched recesses will be cut by backhoe or excavator as excavation proceeds. Light-weight concrete (or other satisfactory fill material) will be used as necessary to fill the trenched recesses after the secondary liner and LDS piping are placed and restore a suitable sidewall surface over which the primary liner system can be placed.

3.4 TRENCH BOTTOM SUBGRADE PREPARATION

The excavated trench bottom locations will be overlain by a compacted subgrade material that will be a minimum of 9.0 inches thick beneath all portions of the trench bottom except for sump areas, and will be a minimum of 36.0 inches thick beneath the sump areas (See Sections A and B of Drawing 007, and Sections A, B, and C of Drawing 008). The horizontal limits of the prepared subgrade layer will be the base of the trench sidewalls. The prepared subgrade layer will not be placed on trench sidewalls.

The purposes of this prepared subgrade layer are to provide:

- A smooth bearing surface for the geosynthetic components of the liner system;
- A low permeability stratum (1 x 10^{-5} cm/sec hydraulic conductivity) as required by the RCRA Permit, and
- Additional leachate adsorption capacity to supplement that of the GCL components.

Included in the Engineering Report Supplement is a summary of laboratory testing of Trench 12 soil materials conducted in accordance with RCRA Permit requirements. A portion of these required soil tests were conducted to confirm that the required hydraulic conductivity of subgrade materials could be achieved using either natural materials excavated from Trench 12 or natural materials mixed with another soil material. This testing confirmed that the specified hydraulic conductivity can be achieved using soil excavated from Trench 12 when not more than 10 percent (by weight) of these soil materials is more coarse than about 1.0-inch and at least 10 percent (by weight) is smaller than the #200 sieve (silt and clay size particles). USEN expects to segregate and stockpile excavated materials satisfying the necessary grain-size specification for subgrade construction. As necessary to achieve the grain-size specification, the natural materials will be screened (on site) and amended (as necessary) with fine grained soil.

The capacity of the proper gradation of subgrade material to achieve the hydraulic conductivity specification is documented in the Engineering Report Supplement. Quality control testing to confirm that the material stockpiled has the proper gradation will be determined by grain-size analyses of randomly located stockpile samples done at a frequency of one test per 2,000 cubic yards of material stockpiled. If the grain size analysis test results do not satisfy project specifications, the Project Engineer will be contacted to determine the acceptability of the fill material.

The layer will be placed and compacted to 90 percent of maximum dry density at a moisture content between the OMC and OMC +2%, as determined by ASTM D1557. The achievement of the proper subgrade compaction requirement will be determined by in-situ density tests performed at a minimum of one test per each one test for every 10,000 square feet of subgrade placed. A schedule of the subgrade placement inspection requirements is attached as Table C-1.

In the event that density testing indicates that the target density is not achieved, the area within 100 feet of the failing testing will be recompacted and retested. Confirmation of satisfactory

compaction in a re-compacted area will be by done by three satisfactory density tests, at locations selected to represent the entire 100 by 100 feet area, passing the density specification.

3.5 COMPACTED EARTH FILL PERIMETER BERM

The compacted earth fill perimeter berm (starter berm) will be constructed of soil materials meeting the requirements of Appendix B, compacted in nine-inch to 12-inch lifts to a density of at least 90 percent MDD and at a moisture contents between the OMC and OMC +2%, as determined by ASTM D-1557.

In-situ density tests will be performed at a minimum of one test per compacted lift or one test for every 2,000 cubic yards placed, whichever is less. In the event that density testing indicates that the target density is not achieved, the area within 100 feet of the failing testing will be recompacted and retested. Confirmation of satisfactory compaction in a re-compacted area will be by done by three satisfactory density tests, at locations selected to represent the entire 100 by 100 feet area, passing the density specification.

A schedule of the soil placement inspection requirements is attached as Table C-1. If the grain size analysis test results do not satisfy project specifications, the Project Engineer will be contacted to determine the acceptability of the fill material.

4. GEOSYNTHETIC MATERIALS (GENERAL)

The supplier of the geosynthetic materials will provide documentation confirming that the raw materials comply with the physical properties and performance requirements specified in Appendix B. The CQA Officer will review this information to ensure that the test results indicate that the materials meet these specifications. Documentation of the test results will be provided to the Project Engineer. Any non-conformance will be documented and reported to the Project Manager for corrective action recommendations.

5. GEOSYNTHETIC CLAY LINER (GCL)

The GCL materials will comply with the properties listed in Appendix B.

5.1 LABELING, PACKAGING, TRANSPORTATION AND STORAGE

CQA personnel will verify that the proper documentation accompanies each delivery of GCL to the job site and that the GCL is properly stored and protected from damage. The geomembrane material will be inspected by the CQA Officer to confirm that it is not damaged or to ensure that any damage observed is corrected. Damage could include:

- Puncture from nails or splinters;
- Tears from operation of equipment or inadequate packaging;
- Exposure to temperature extremes resulting in unusable material; or
- Crumpling or tearing from inadequate packaging support.

When damage to protective wrappers or outer material layers has occurred, careful examination of the underlying material by CQA personnel is required. If damage is found, CQA personnel will carefully examine the entire shipment for damage and document the defect. The Project Manager will be informed immediately of any damage to the geomembrane material.

Labeling - Each GCL roll delivered should be labeled with the following, as a minimum:

- Manufacturer's Name;
- Product Identification;
- Batch or lot number;
- Roll Number; and
- Roll length and width.

Any roll delivered to the site without the proper labeling will, at the Project Manager's discretion, be rejected and subsequently removed from the site at the expense of the Manufacturer or Installer.

Packaging - The GCL will be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.

All rolls will be labeled and bagged in packaging that is moisture-proof and resistant to photo-degradation by UV radiation.

Transportation - The Manufacturer assumes responsibility for initially loading the GCL. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling and storage of the GCL are the responsibility of the Installer.

A visual inspection of each roll should be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage.

The party responsible for unloading the GCL should contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.

Storage - Storage of the GCL rolls will be the responsibility of the Installer. A dedicated storage area will be selected at the job site that is away from high traffic areas and is level, dry and well-drained.

Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks or the dunnage shipped between rolls. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four).

All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.

The integrity and legibility of the labels will be preserved during storage.

5.2 SUBGRADE PREPARATION

The subgrade should be compacted (trench bottom) and graded or otherwise made smooth (trench bottom and sidewalls) prior to placement of the GCL. The subgrade will be free of debris and possible damaging material, such as

- Vegetation,
- Construction Debris,
- Sticks,
- Sharp rocks,
- Void spaces,
- Ice,
- Abrupt elevation changes,
- Standing water,
- Cracks larger than one-quarter inch in width,
- Any other foreign matter that could contact the GCL.

Immediately prior to GCL deployment, the subgrade will be final-graded to fill in voids or cracks to provide a relatively smooth surface for the GCL. At completion of this activity, no wheel ruts, footprints or other irregularities will exist in the subgrade. Furthermore, all protrusions extending more than one-inch (2.54 cm) from the surface will be removed, crushed or pushed into the surface manually or with a smooth-drum compactor. Areas that are judged to be too rough for GCL placement will be covered with at least one layer of geotextile material at least 0.100 inch thick.

On a continuing basis, the project CQA Officer will certify acceptance of the subgrade. It will be the GCL Installer's responsibility thereafter to indicate to the Project Manager any change in the condition of the subgrade that could cause the subgrade to be out of compliance with any of the requirements listed in this section.

5.3 GCL INSTALLATION

GCL rolls should be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging should be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) should be in accordance with the Project Manager's recommendations. However, unless otherwise specified, the GCL should be installed such that the product name printed on one side of the GCL faces up.

The CQA Officer will verify that GCL installation is performed in accordance with the specification. During installation, the following observations will be performed.

- Observations to ensure that workers are not engaging in any activity that could damage the liner.
- Observations to verity that the material is not damaged during the installation process.
- Observations of the anchor trench to ensure that it has been constructed as specified in the design drawings. Trench corners will be rounded to prevent stressing the geomembrane. Backfilling of the trench will be performed as soon as possible and compacted with care so as not to damage the GCL.
- The GCL will be installed to minimize instances of excessive tension or wrinkles.
- GCL panels should be placed so that edges are oriented parallel to steep slopes (trench sidewalls only). In corners and other tight areas, panel deployment will be performed such that field seams are minimized.
- Observations of the weather conditions (i.e., temperature, humidity, precipitation, and wind) to ensure that they are acceptable for GCL placement.
- Measurements to confirm that required overlaps of adjacent GCL panels were achieved, that proper temporary anchorage was used (e.g., sand bags or tires).

As each GCL panel is placed, it will be inspected visually for tears, punctures, or other damage. To accomplish this, the panels will be traversed by CQA personnel in such a way that the entire surface is inspected. Any defects will be marked for repair.

The GCL must be dry when installed and will not be installed in standing water or during rain. The GCL will be covered with the overlying geomembrane as soon as is practical to prevent exposure to weather. GCL that becomes hydrated must be replaced before placement of the overlying geomembrane.

Equipment that could damage the GCL will not be allowed to travel directly on top of the material. Acceptable installation, therefore, can be accomplished such that the GCL is unrolled in front of the backwards-moving equipment. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues. GCL rolls will not be released on the slope and allowed to unroll freely by gravity.

Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary geosynthetic subgrade covering, commonly known as a slip sheet or rub sheet, may be used to reduce friction damage during placement.

All GCL panels should lie flat on the underlying surface, with no wrinkles or folds, especially at the exposed edges of the panels. The GCL will be installed in a relaxed condition and will be free of excessive tension or stress upon completion of the installation. Stretching of the GCL to fit will not be allowed. The GCL will be pulled tight to smooth out creases or irregularities in the runs.

Only as much GCL will be deployed as can be covered at the end of the working day with soil, a geomembrane, or a temporary waterproof tarpaulin. The GCL will not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it may be necessary to remove and replace the hydrated material. The Project Manager, CQA Officer, and GCL fabricator should be consulted for specific guidance if premature hydration occurs.

5.4 JOINING GCL PANELS

The GCL will be placed so that panel edges are parallel to the direction of the slope. Panel ends at the juncture between sidewalls and trench bottom should be overlapped by at least three feet. Joining of panel ends on steep sidewall slopes (i.e., trench 0.5:1.0 sidewalls) will not be allowed. Thus, full length seamless panels, overlapped by at least six inches on edges, are required for Trench 12 sidewalls. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.

For joining panels on the trench floor, bentonite-enhanced seams are to be emplaced between the overlapping adjacent panels. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the six-inch line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap. The bentonite will be applied at a minimum application rate of about one quarter pound per lineal foot of panel edges and ends.

The granular bentonite or bentonite sealing compound used for seaming, penetration sealing, and repairs will be made from the same natural sodium bentonite as used in the GCL and will be as recommended by the GCL fabricator.

5.5 DETAIL WORK AND PATCHING

The GCL will be sealed around penetrations and embedded structures embedded in accordance with the design drawings.

Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid damage to the geotextile components of the GCL during the cutting process or damage to any underlying geosynthetic materials.

If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch will be obtained from a new GCL roll and will be cut to size such that a minimum overlap of 12 inches is achieved around all of the damaged area. Dry bentonite or bentonite mastic should be applied around the damaged area prior to placement of the patch. It may be desirable to use an adhesive to affix the patch in place so that it is not displaced during cover placement. These repair pieces should not be stapled.

6. GEOCOMPOSITE/GEONET

The geocomposite and geonet materials will comply with the properties listed in Appendix B.

6.1 LABELING, PACKAGING, TRANSPORTATION AND STORAGE

The CQA Officer will check all delivery tickets and Manufacturer's quality control documentation to verify that all required shipping information is provided and to verify that the geocomposite/geonet rolls received meet the project specifications in Appendix B. The geocomposite/geonet material also will be inspected by the CQA Officer to confirm that it is not damaged and to ensure that any damage is corrected. Damage may include:

- Puncture from nails or splinters;
- Tears from operation of equipment or inadequate packaging;
- Exposure to temperature extremes resulting in unusable material; or
- Crumpling or tearing from inadequate packaging support.

When damage to a protective wrapping or outer material layer has occurred, careful examination of the underlying material by CQA personnel is required. If damage is found, CQA personnel will carefully examine the entire shipment for damage and document the defect. The Project Manager will be informed immediately of any damage to the geocomposite/geonet material.

Labeling - Each geocomposite/geonet roll delivered must be labeled with the following, as a minimum:

- Manufacturer's Name;
- Product Identification;
- Batch or lot number;
- Roll Number; and
- Roll length and width.

Any roll delivered to the site without the proper labeling will, at the Project Manager's discretion, be rejected and subsequently removed from the site at the expense of the Manufacturer or Installer.

Packaging - The geocomposite/geonet rolls will be wrapped in a plastic cover. The rolls will be shipped to the job site in a manner not to damage the rolls. The geocomposite/geonet will be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.

Transportation – The Manufacturer assumes responsibility for initially loading the geocomposite/geonet. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling and storage of the geocomposite/geonet are the responsibility of the Installer.

A visual inspection of each roll should be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage.

The party responsible for unloading the geocomposite/geonet should contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.

Storage - Storage of the geocomposite/geonet rolls will be the responsibility of the Installer. A dedicated storage area will be selected at the job site that is away from high traffic areas and is level, dry and well-drained. Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks or by use of the dunnage shipped between rolls. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four).

The integrity and legibility of the labels will be preserved during storage.

6.2 SUBGRADE PREPARATION

Geocomposite/geonet placement will be on top of other geosynthetic members of the liner system. Thus, only minimal surface preparation is expected to be necessary, such as sweeping or manual removal of soil, rock, or other solid material particles. Before installing geocomposite/geonet material, the Installer will provide written certification to the CQA Officer that the surface on which that geosynthetic material will be installed is acceptable. It will be the Installer's responsibility thereafter to indicate to the Project Manager any change in the condition of this surface that could cause the geocomposites/geonet to be out of compliance with any of the requirements listed in this section.

6.3 GEOCOMPOSITE/GEONET INSTALLATION

Rolls should be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging should be carefully removed without damaging the material. The subgrade should be free of foreign and organic material, sharp objects, or debris of any kind, which could potentially damage the geocomposite/geonet. The rolls should be deployed using a spreader bar assembly attached to a loader bucket or by other methods approved by the Project Engineer. The orientation of the geocomposite/geonet panels should be in accordance with the Project Manager's recommendations. On side slopes, the rolls must be deployed in the general direction of the maximum slope. The deployment equipment must not damage the underlying subgrade or geosynthetic materials. A smooth rub sheet may be needed for installation of the geocomposite/geonet over a textured geomembrane. The rub sheet is placed between the geocomposite/geonet and the textured geomembrane to prevent damage to geocomposite/geonet during positioning. The rub sheet must be removed after deployment. Drainage net and geocomposite/geonet should be placed and secured in an anchor trench as shown on the project drawings. Sandbags should be placed on leading edges of the panels to prevent wind uplift.

Observations of the anchor trench should be made to ensure that it has been constructed as specified in the design drawings. Trench corners will be rounded to prevent stressing the geocomposite/geonet. Backfilling of the trench will be performed as soon as possible and compacted with care so as not to damage the geocomposite/geonet.

6.4 JOINING GEOCOMPOSITE/GEONET PANELS

As each geocomposite/geonet panel is placed, it will be inspected visually for tears, punctures, or other damage or defect. To accomplish this, the panels will be traversed by CQA personnel in such a way that the entire surface is inspected. Any defects will be marked on the geocomposite/geonet for repair. Other general installation requirements include the following.

- Works should not engage in any activity that could damage the material.
- The geocomposite/geonet will be installed to minimize instances of excessive tension or wrinkles.
- The geocomposite/geonet panels will be placed such that seams will be oriented parallel to steep slopes (trench sidewalls only). In corners and other tight areas, panel deployment will be performed such that field seams are minimized.
- Weather conditions (i.e., temperature, humidity, precipitation, and wind) will be observed to ensure that they are acceptable for geocomposite/geonet placement and seaming.
- Measurements will be made to confirm that required overlaps of adjacent geocomposite/geonet e sheets were achieved, that proper temporary anchorage was used (e.g., sand bags or tires), and that specified temporary and final seaming materials/techniques were used.

Geocomposite/geonet panels must be overlapped by a minimum of 2 inches. Non-black (for visibility) plastic ties should be used at 5-feet intervals in the direction of the roll length to tie the drainage net panels. Metallic ties will not be allowed. Joining of panel ends on steep side slopes (i.e., 0.5:1.0 trench sidewalls) will not be allowed. Thus, full length seamless panels (or panels incorporating only factory seams with complete QC documentation) are required on sidewalls. The geotextile flaps of the adjacent panels should be continuously heat-bonded or sewn on all sides.

The CQA Officer will perform the following inspections and observations to verify that field seaming operations are in accordance with these construction specifications.

6.5 DETAIL WORK AND PATCHING

Cutting the geocomposite/geonet should be performed using a sharp utility knife. Care must be taken to avoid damage to any underlying geosynthetic materials.

If the geocomposite/geonet is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch will be obtained from a new material roll and will be cut to size such that a minimum overlap of 12 inches is achieved around all of the damaged area.

All repairs will be performed as soon as practicable and in accordance with the design specifications. Each repair will be non-destructively tested for continuity. All repairs will be documented including date, location, type, method used, operator, and apparatus.

6.6 LINER MATERIAL COVER

The trench floor geocomposite/geonet comprising the top of the liner system should be covered with a Select Waste Operations Layer (Section 2.5 of Appendix B) as soon as possible after placement. The covering operation must not damage the geocomposite/geonet. The cover material must be free of foreign and organic material, sharp objects, or debris of any kind that potentially could damage the geocomposite/geonet. No construction equipment or machinery will be allowed to operate directly on top of the geocomposite/geonet. The use of lightweight machinery (e.g., carts or wheeled generators) with low ground pressure is allowed.

7. GEOMEMBRANE

This item will consist of the installation of 60-mil (0.060 inch thick) and 80-mil (0.080 inch thick) high density polyethylene (HDPE) flexible membrane liners meeting the materials requirements of Appendix B at locations shown on the project drawings (Appendix A). The Manufacturer will provide certification that these materials meet the design requirements. The Installer will provide a geomembrane panel layout prior to material placement.

7.1 GEOMEMBRANE LABELING, DELIVERY, STORAGE, AND HANDLING

The CQA Officer will check all delivery tickets and Manufacturer's quality control documentation to verify that all required shipping information is provided and to verify that the geomembrane rolls received on site meet the project specifications.

The geomembrane material also will be inspected by the CQA Officer to confirm that it is not damaged and to ensure that any damage is corrected. Damage could include:

- Puncture from nails or splinters;
- Tears from operation of equipment or inadequate packaging;
- Exposure to temperature extremes resulting in unusable material;
- Blocking: the bonding together of adjacent membrane layers, that may be caused by excessive heat; or
- Crumpling or tearing from inadequate packaging support.

When damage to protective wrappers or outer material layers has occurred, careful examination of the underlying material by CQA personnel is required. If damage is found, CQA personnel will carefully examine the entire shipment for damage and document the defect. The Project Manager will be informed immediately of any damage to the geomembrane material.

Geomembrane material will be handled and stored on-site in accordance with this section. The CQA Officer will inform the Project Manager if secure storage is not being provided.

The checks and inspections required by this section will be recorded on an inventory control record that will be retained until the project is certified.

Labeling - Each roll of geomembrane delivered to the site will be labeled by the Manufacturer. The label will clearly state the Manufacturer's name, product identification, thickness, length, width and roll number. The label will be found on either of the end caps, an inside edge of the roll core, and outside the roll core.

Delivery - The rolls of liner will be packaged and shipped by appropriate means to prevent damage to the material and to facilitate off-loading.

Storage - The on-side storage location for geomembrane material should be level, smooth, elevated and dry. The storage place should be protected from damage by vehicles and equipment or vandalism. The Operator will provide a suitable storage site.

Handling - The materials are to be handled so as to prevent damage. Instructions for moving geomembrane rolls will be provided by the Manufacturer upon request.

7.2 SURFACE PREPARATION

Geomembrane placement will be on top of other geosynthetic members of the liner system. Thus, only minimal surface preparation is expected to be necessary, such as sweeping or manual removal of soil, rock, or other solid material particles. Before installing geomembrane material, the Installer will provide written certification to the CQA Officer that the surface on which that geosynthetic material will be installed is acceptable. It will be the Installer's responsibility thereafter to indicate to the Project Manager any change in the condition of this surface that could cause the geomembrane to be out of compliance with any of the requirements listed in this section.

7.3 GEOMEMBRANE INSTALLATION

7.3.1 Panel Layout

The Installer will submit a panel layout drawing for each geomembrane layer to be installed to the Project Manager for review a minimum of one week prior to the pre-construction meeting. The drawings submitted should be of sufficient size and detail to distinguish the geomembrane

panels. The Project Manager reserves the right to reject any drawing submitted and/or to request additional information to be submitted to satisfy the intent of this specification.

No geomembrane installation work will be allowed without the submission and review of the panel layout drawings as required by this specification.

The submitted panel layout will be considered a guideline for both the Installer and the Project Manager to follow. Minor deviations from the submitted layout will be allowed. However, marked deviations to the submitted and reviewed geomembrane panel layout will not be permitted without prior submission of a modification of such to the Project Manager. Any substantial modifications to the geomembrane configuration should be presented, in writing or drawing, by the Installer a minimum of three days in advance of the work to be performed.

7.3.2 Weather Conditions

Geomembrane placement will not proceed:

- At ambient temperatures below 34°F as measured at a pre-determined location acceptable to all parties.
- During precipitation events, in the presence of excessive moisture (humidity), or in areas of ponded water.
- In the presence of excessive wind as agreed upon by all parties or as determined by the performance of panels during the placement process.

Any damage incurred by the geomembrane material as a result of excessive wind will be repaired or removed by the Installer at the Installer's expense.

7.3.3 General Placement

Assign each panel a simple and logical identifying code. The coding system will be subject to approval and will be determined at the job site.

Visually inspect the geomembrane during placement for imperfections and mark faulty or suspect areas.

The geomembrane will be placed by the Installer in accordance with the following procedures.

- Motorized equipment used to move or place the geomembrane should not be in direct contact with the geomembrane or damage it by leaking fluids or other means. Areas that are damaged in this manner will be removed or repaired at the Installer's expense.
- Unroll geomembrane panels using methods that will not damage geomembrane and will protect underlying surface from damage.
- Personnel working on the geomembrane will not smoke, wear damaging shoes, throw equipment or engage in other activities that could damage the material.
- Do not allow heavy vehicular traffic directly on geomembrane. Rubber-tired ATVs and trucks are acceptable if wheel contact is less than six psi.
- Protect geomembrane in areas of heavy traffic by placing protective cover over the geomembrane.
- The geomembrane panels will be installed to allow for geomembrane expansion and contraction such that there will be neither excessive tension nor excessive wrinkling.

The panels will be placed in such a manner that the geomembrane is not scratched or crimped. Any such damage will be repaired or removed in accordance with the procedures described in this section.

As each geomembrane panel is placed, it will be inspected visually for tears, punctures, and thin spots. To accomplish this, the panels will be traversed by CQA personnel in such a way that the entire surface, including all factory seams, is inspected. Any defects will be marked on the geomembrane for repair. In addition, the thickness determinations for each panel will be performed by the CQA personnel using a micrometer. The panel thickness will be determined at five locations along each edge and each side of the panel. The average thickness along each side and each edge must be at least the nominal thickness, and the thickness for any single reading may not be less than 90 percent of the nominal thickness. If these criteria are not met, the panel must be rejected.

7.3.4 Geomembrane Anchoring

The Installer is responsible for both temporary and permanent geomembrane anchorage.

Temporary anchors: Geomembrane panels will be adequately, temporarily anchored by sand bags, rubber tires or a comparable means that does not damage the material, and does not degrade during the time it is in use.

Permanent anchors: The geomembrane panels covering the trench sidewalls will be permanently anchored by placement in anchor trench and being covered with soil as shown in Detail 3 in Drawing 008.

7.3.5 Panel Placement and Alignment

The geomembrane will be placed by the Installer in accordance with these procedures or alternate procedures approved in advance by the CQA Officer. As a minimum, the procedures outlined in the following paragraphs will be followed.

- The geomembrane panels will be placed and aligned in general accordance with the panel layout submitted by the Installer, or as modified and made part of this document. In general, the geomembrane panels will be configured to minimize the number of field seams, particularly in corners, odd-shaped geometric locations, and outside corners.

- Geomembrane panels will be placed in a controlled manner, such as pulling, hoisting, or rolling. Uncontrolled placement methods, such as "free-falling" will not be allowed.

- Adjacent geomembrane panels (horizontally adjacent on sidewalls or adjacent in any direction of trench bottom) will be overlapped by a minimum of three inches before seaming is completed. This minimum overlap or greater will be marked by the Installer (such as with chalk or high-visibility marker) at intervals of 25 feet or less on the exposed surface of the lower geomembrane. These markings will facilitate overlap inspection after the geomembrane panels are placed and aligned.

- Geomembrane seams with insufficient overlap will be repaired or replaced by, and at the expense of, the Installer in accordance with the procedures outlined in this section.

- Geomembrane panels placed on trench sidewalls will be continuous (unseamed) or factory seamed panels. Welding of horizontal seams (seams that are not parallel to slope) on the sideswalls will not be allowed.

- Geomembrane panels will be placed to minimize horizontal (cross-panel) seams on slopes steeper than 10 horizontal to 1 vertical. In addition, geomembrane panels placed on slopes that are flatter than 10:1 will be overlapped from top to bottom in the down-slope direction. In this configuration, the up-slope geomembrane panel will overlie the immediately adjacent down-slope panel. The geomembrane panels will be placed and aligned such that the resulting seam locations are, at a minimum, five feet from the toe of slopes and other abrupt changes in grade.

7.3.6 Panel Identification

As each geomembrane panel is placed, the Installer will label each in bold print visible from a distance of approximately 30 feet. In general, these markings will be placed in an area that will remain unobscured until overlying geosynthetic layers are placed. It is suggested that the labels be located near each end of the panels across the floor of the landfill area; and, on the crest, just below the crest, and just above the toe of the panels placed on the landfill sidewalls.

The labels will include, as a minimum, the following information.

- A sequential panel number based upon a pre-determined system agreed upon by Installer and CQA Officer.
- The roll number from which the panel was obtained. The Operator reserves the right to reject any geomembrane roll without the proper labeling. Additionally, any portion of a geomembrane roll that cannot be positively identified will be rejected.
- The date the panel was placed.
- The labeling will be made using marking materials that are compatible with the HDPE geomembrane or that is approved by the geomembrane Manufacturer. A sample of the materials used will be submitted to the Project Manager for archiving with the permanent record of construction.

7.3.7 Installation Schedule

The Installer will be responsible for seaming all geomembrane panels placed each day or providing adequate temporary anchoring in accordance with this section until such time as they can be seamed.

The Installer will be responsible for tracking and updating the installation schedule as submitted prior to the start of the work. This schedule will be updated, as a minimum, weekly and will be presented to the Project Manager in progress meetings.

7.4 FIELD SEAMING

These field-seaming requirements apply to any field seams made in HDPE geomembrane components of the liner system, including, in most aspects, the sacrificial liner materials. However, the sacrificial liner materials may be field seamed on sidewall slopes and quality control testing of seams in the sacrificial liner material is not required.

The CQA Officer will perform and document the required inspections and observations to verify that field seaming operations are in accordance with these construction specifications. Each seam will be observed for seam completeness. Documentation for each seam will include seam identification number, date, weather conditions, identification of seamer and apparatus, and approximate length of seam.

The CQA Officer will verify that the geomembrane has been installed in accordance with all plans and specifications and that all welds have passed both the laboratory strength tests and field tests prior to acceptance of the project by the Project Manager.

7.4.1 Geomembrane Panel Alignment

The geomembrane panels will be overlapped and aligned in accordance with this specification. In general, the panels should be installed such that the field seams are aligned parallel to slope (i.e., down and not across slope). Field-welded seams (i.e., seams made on the steep sidewalls) will not be allowed on trench sidewalls.

7.4.2 Personnel Requirements

All Installer personnel performing seaming operation will have a minimum of 1,000,000 square feet of experience using the same primary welding technique on HDPE or VFPE liner. In addition, the Installer will have at least one individual with, as a minimum, 2,000,000 square feet of similar experience, including experience at a hazardous waste management facility. No seaming operations will be performed without this individual present.

7.4.3 Weather Conditions

Seaming will not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. Installer will demonstrate that acceptable seaming can be performed by completing acceptable trial welds.

Field seaming of the geomembrane will not be performed at ambient temperatures below 50°F unless the geomembrane seam area is pre-heated, by sun or hot air device, to a temperature higher than 50°F. However, in any case, field seaming of the geomembrane will not be performed at ambient temperatures below 34°F.

The ambient temperature will be measured by a thermometer at a pre-determined location that will be mutually agreed upon by all parties in the pre-construction meeting. The temperature will be recorded at regular, periodic intervals by the CQA Officer.

7.4.4 Test Seams

All personnel responsible for seaming will perform test seams on geomembrane samples to verify welding equipment is operating properly. No welding equipment or welder will be allowed to perform production welds until equipment and welders have successfully completed a trial weld. Test seams should be made under the same surface and environmental conditions as the production welds (i.e., in contact with subgrade and similar ambient temperature).

A minimum of two test seams per day, per welding apparatus will be performed, one made prior to the start of work and one completed at mid- shift. A test seam also will be performed whenever seaming is discontinued for more than one hour.

Test seams will be performed on "fragment" pieces of geomembrane and will be a minimum of 12 inches in width by about three feet in length with a minimum of a three-inch overlap and the seam centered along the length.

The Installer will cut two adjacent specimens from near each end of the test seam (four samples total). The specimens will be cut in a controlled manner, by die or template, to a predetermined width. One of each pair of specimens will be tested in shear, the other in peel. In the case of dual-tracked fusion welding, both tracks of the weld will be tested in peel. (Note: Specimens cut in an uncontrolled fashion to a random width will not be acceptable as the strength of test seams is required to be determined).

All test seam specimens will be tested by the Installer in the field for shear and peel using an electrically operated tensiometer, with the capability of registering the force imparted on a geomembrane test specimen. The test seam specimens will be tested at a cross-head rate of two inches per minute. (Note: A hand-operated tensiometer is not acceptable.)

Recent calibration of the load registering device and the cross-head speed will be performed. Documentation of such calibration will be presented prior to the first use of the apparatus.

The Installer will record the following information for the testing performed on each test seam:

- Test seam sample number;
- Date and time of test;
- Welder performing test seam;
- Cross-head rate;
- Specimen number and the peak yield load and failure mode; and
- The force per unit width in pounds per inch. An accurate thickness measurement will be required to calculate stress in pounds per square inch.

7.4.5 Test Seam Evaluation Criteria

The criteria for evaluating test seams is as follows:

7.4.5.1 Shear

Two test seam specimens will be tested in shear. Each must fail at a strength equal to or greater than 90 percent of the rated strength of the parent sheet material, or 1,500 psi, whichever is greater. The test seam will be designed as unacceptable if the failure occurs in the weld. If both of these criteria are not met, the entire test seam will be considered failing.

7.4.5.2 Peel

Two test seam specimens will be tested in peel. The peel test will be designated unacceptable if the failure in either specimen occurs in the weld area. If this criterion is not met, the entire test seam will be considered failing.

If a test seam fails, the entire test seam procedure will be repeated after the appropriate adjustments to the welding apparatus have been made. This process will be repeated until a successful test seam has been achieved. Alternatively, if a successful test seam is not achieved the welding apparatus and/or the welder will be rejected by the CQA Officer and will not be used for seaming until such time as the deficiencies are resolved.

7.4.6 General Seaming Procedures

The following general seaming procedures must be met by the Installer:

- All geomembrane seams will extend to the end of each panel to be placed in the anchor trench.
- If geomembrane seaming operations are performed at night, adequate lighting will be provided for such as well as for inspection of the seaming conditions and the seams.
- All geomembrane seams will be clean and free of moisture, dust, dirt, debris of any kind, and foreign matter at the time of welding.
- "Fishmouths" and wrinkles at geomembrane seam overlaps will be cut along the ridge of such. Areas with sufficient overlap will be welded in accordance with this specification. Areas of insufficient overlap will be repaired in accordance with the procedures detailed in this section.

7.4.7 Extrusion Seaming Requirements

The extrusion welding apparatus will be equipped with temperature gauges that indicate the temperature of the extrudate in the machine.

The extruder will be purged to remove heat-degraded material prior to the beginning of seaming and whenever the extruder is stopped for an appreciable length of time.

7.4.8 Fusion Process

The fusion welding apparatus will be a vehicular mounted, automated device.

7.5 FACTORY SEAMS

If factory seamed materials are used, that seaming must satisfy the same requirements as field seams. Documentation must be provided that factory seams have been 100 percent non-destructively tested using recommended techniques before the geomembrane material is shipped from the fabrication plant. Rejected seams must be repaired and re-tested before being shipped, or must be re-tested on-site. The CQA Officer will review fabricator's quality control documentation to ensure that proper seaming procedures were followed and the resulting geomembrane material seams are of the specified quality. The CQA Officer will destructively test at least one factory seam sample for each 500 lineal feet of geomembrane factory seam. The CQA Officer will review the quality control documentation. Any necessary repairs to the

geomembrane will be in accordance with approved techniques, and the repaired areas will be non-destructively tested to verify their integrity.

7.6 DEFECTS AND REPAIRS

7.6.1 General

All seam and non-seam areas of the geomembrane will be visually inspected for signs of defective seams, blisters, punctures, undispersed raw materials, and any sign of contamination by foreign matter. Any problems discovered in both seam and non-seam areas will be marked, repaired and re-tested or reevaluated in accordance with this document. The geomembrane surface will be clean at the time of these inspections.

Any sheets that become seriously damaged (torn or twisted permanently) will be replaced at the Installer's expenses. Less serious damage (inadvertent punctures during installation) will be repaired by welding a piece of geomembrane over the damaged area. The repairs must pass non-destructive tests to be considered adequate.

7.6.2 Evaluation

Each suspect location in both seam and non-seam areas will be inspected and, where appropriate, non-destructively tested using the methods described in this document. Work will not proceed with any materials that will cover the locations that require repair or that have been repaired but require testing with passing results. Each patch repair will be numbered and logged.

7.6.3 Procedures for Repair

All repairs will be performed as soon as practicable and in accordance with the design specifications. Each repair will be non-destructively tested for continuity. All repairs will be documented including date, location, type, method used, operator, and apparatus.

The repair procedures will be in accordance with these specifications. The details of the specific repair procedures to be followed will be discussed in the pre-construction meeting. Procedures available include the following:

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

- Abrading and Re-welding - Used to repair small sections of deficient seams and small surface blemishes that do not penetrate the entire thickness of the geomembrane. The geomembrane surfaces requiring repair will be abraded no more than one hour prior to the repair being made. Grinding will be performed only within the area requiring repair and care will be taken not to significantly damage the liner.

- Spot Welding - Used to repair pinholes or other minor, localized flaws or where geomembrane thickness has been reduced.

- Capping - Used to repair large lengths of failed seams.

- Flap Welding - Used to extrusion weld the flap (excess outer portion) of a fusion weld in lieu of a full cap.

- Removing the unacceptable seam and replace with new material.

In addition, the following procedures will be observed.

- Surfaces of the HDPE that are to be repaired by extrusion welds will be lightly abraded to assure cleanliness.

- All geomembrane surfaces will be clean and dry at the time of repair. As a minimum, patches and caps (a cap is a patch with an extended length) will extend a minimum of six inches for extrusion weld and four inches for wedge weld beyond the limits of the defect, and all corners of patches and caps will be rounded with a radius of approximately one inch.

The seams associated with caps of long lengths may be destructively tested, if deemed necessary by the CQA Officer.

7.7 NON-DESTRUCTIVE SEAM CONTINUITY TESTING

Observations are necessary to verify that non-destructive tests are performed on 100 percent of the field seams. Failed seams will be recorded as to location and seaming crew. The data will be reviewed for possible patterns. Repairs will be made by the Installer in accordance with approved techniques and re-tested to verify their integrity.

7.7.1 General

All factory and field seams (except in sacrificial liner material) will be non-destructively tested over their entire length using the pressure test method or the vacuum test method, as appropriate, or other approved method. It is unacceptable for any portion of a seam to remain untested by

one of these methods. Non-destructive testing may be carried out as the seaming progresses or at completion of all field seaming.

Areas thought to be potentially inaccessible to non-destructive continuity testing equipment will be brought to the Project Manager's attention prior to the start of work with the submittal of the geomembrane panel layout drawings.

The non-destructive continuity testing of factory seams will be performed prior to the geomembrane rolls being delivered to the site. The non-destructive continuity testing of field seams will be performed by the Installer as the work progresses to provide the opportunity for immediate re-welding and re-testing as necessary. All defects discovered will be marked, repaired and re-tested by the Installer in accordance with these specifications.

7.7.2 Testing Procedures

The Installer will submit the proposed specific non-destructive testing procedures to be employed on this project to the Project Manager. The testing procedures will be consistent with the requirements of this specification. The testing procedures must be approved by the Project Manager and CQA Officer. The Operator reserves the right to reject and request modification of any and all non-destructive seam continuity testing procedures submitted.

7.7.2.1 Vacuum Testing:

The equipment will consist of the following: 1) a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft gasket attached to the bottom, or valve assembly, and a vacuum gauge, 2) a vacuum pump assembly, and 3) a soapy solution.

Test Procedure is performed as follows: 1) apply soapy solution to the seam, 2) place vacuum box over the entire wetted seam area, 3) ensure that a leak-tight seal is created, 4) apply a vacuum of at least 5 psig, 5) examine the geomembrane through the viewing window for the presence of soap bubbles for not fewer than ten seconds, and 6) all areas where soap bubbles appear will be marked and repaired.

7.7.2.2 Air Pressure Testing (for double seam air channel):

The equipment will consist of the following: 1) an air pump or tank equipped with pressure gauge capable of generating and sustaining pressure over 30 psi, 2) a sharp, hollow needle, or other approved pressure feed device equipped with a pressure gauge, and 3) A hot air gun or other device to seal the ends of the air channel.

Test Procedure is performed as follows: **1)** seal both ends of seam to be tested, insert air needle into the air channel, and pressurize to at least 25 psi, **2)** the minimum pressure will be maintained for a two minute stabilization period, after which the air source will be disconnected from the air pressure gauge and the maximum pressure drop will be measured over a five-minute period, **3)** if pressure loss exceeds 4 psi or does not stabilize after five minutes, locate faulty area and repair. Puncture opposite end of seam to release air. If blockage is present, locate and test seam on both sides of blockage. A pressure gauge at both ends of the seam will also be acceptable. Remove needle or other approved pressure feed device and seal penetration holes by extrusion welding.

7.7.3 Installer Quality Control

The Installer will be responsible for providing quality control inspection staff and documentation for the equipment and testing performed. This will include, but will not be limited to, the following:

- Recent calibration of all gauges employed (vacuum and/or pressure). Proof of recent calibration, in the past six months will be submitted by the Installer for each gauge employed. This proof will be submitted no later than the first use of the apparatus. Negligence in producing this information will prohibit the Installer from using the apparatus.
- An individual who, as a permanent employee of the Installer, is experienced at and responsible for performing the non-destructive seam continuity test in accordance with the prescribed procedures and inspecting for areas of improperly welded geomembrane.
- Labeling directly on the geomembrane surface in the vicinity of the ends of each seam or tested section, the following:
    - Date and time of test;
    - Initials of the operator of the testing device;
    - Status or results of the outcome of non-destructive testing; and

- Start and finish time and pressure (pressure test method only).

7.8 DESTRUCTIVE SEAM TESTING

7.8.1 Testing Location and Frequency

Destructive seam samples will be obtained from factory and field seams at an average minimum frequency of one per 500 lineal feet of weld. The seam destructive test sampling frequency may be increased by the CQA Officer beyond the specified minimum based upon actual welding conditions and the results of other samples obtained. These additional locations may be based on suspicion of contamination by dirt or moisture, change in seaming materials, increase in failed non-destructive tests, and other causes that could result in unacceptable seams.

Test locations will be determined after welding. The sample locations will, in general, be randomly selected by the CQA Officer as welding progresses. However, selected sample locations may be prompted by suspicion of a poor quality weld.

The Installer will not be informed in advance of seam destructive test locations but will be required to physically obtain the samples from the geomembrane seam in the locations selected by the CQA Officer. The samples will be cut from the geomembrane by the Installer no later than three working days after the location has been selected.

The Installer will repair all holes in the geomembrane resulting from destructive testing. The repairs will be performed and tested in accordance with these Specifications.

7.8.2 Sample Size

The location for the destructive samples will be marked by the CQA Officer. The dimensions for the destructive samples will be, as a minimum, 12 inches wide by 34 inches long (minimum 40 inches long for dual tracked welds) with the seam centered lengthwise. The Installer will obtain a two-inch wide strip from each end of the marked seam destructive sample for preliminary field testing as described in the following section. If the preliminary field testing exceeds the pass/fail criteria, the sample will be cut and divided into two parts as described below:

- One portion of the sample, measuring 12 inches by 18 inches (24 inches for dual-tracked fusion welds), to the CQA Officer for laboratory testing.

- One portion of the sample, measuring 12 inches by 12 inches to the Operator for archiving.

The sample length will be increased to accommodate the additional length required by the Installer for laboratory testing or archiving.

Documentation of seam sampling will include sample location, date and time of sampling, operator and apparatus number used for the seam sampled, pass or fail description, and sample identification number. Each sample must be marked with its identification number.

7.8.3 Testing Procedure

7.8.3.1 Preliminary Field Testing

Two specimens, one from each end of the seam destructive sample, are to be removed from the geomembrane by the Installer while in the field. Each of these specimens is to be two inches in width. One specimen is to be tested in shear and the other in peel and neither is to fail in the seam.

If the laboratory destructive testing is to be performed on-site, the specification for preliminary field seam destructive testing may be waived.

7.8.3.2 Destructive Seam Testing

The destructive seam testing will be performed by the CQA Officer, or his duly appointed representative, in an on-site or off-site laboratory. This testing is to be completed within 72 hours of the time the samples are removed from the geomembrane installation.

The testing will be performed on a total of ten specimens (fifteen for dual-tracked fusion welds) obtained from the field sample. Five specimens will be tested in each of the shear and peel modes. For the dual-tracked fusion welds, five peel tests will be performed for each track of weld. These shear and peel specimens will be selected from the sample alternately so that no two immediately adjacent specimens are tested in the same mode.

The specimens will be of a size and shape in accordance with ASTM D638, Type I and will be tested at a cross-head rate of two inches per minute.

7.8.3.3 Seam Evaluation Criteria

Each seam sample must meet both the shear and peel criteria before being considered passing. The criteria for each is as follows.

7.8.3.3.1 Shear

Of the five specimens tested in the shear mode, each must have strength equal to or greater than 1,500 psi or 90 percent of the rated strength of the geomembrane sheet, whichever is greater. Additionally, as a minimum, four of the five specimens will not fail in the weld.

If, in the series of five specimens tested in shear, these criteria are not met, then the entire seam destructive sample is considered failing.

7.8.3.3.2 Peel

Of the five specimens tested in the peel mode, as a minimum, four will not fail in the weld. If more than one specimen fails to meet this criterion, then the entire seam destructive sample is considered failing.

In the instance of the dual-tracked fusion weld, both tracks of the weld will be tested in peel. If either peel test performed on specimens of this weld type fails, the entire specimen is considered failing.

7.8.3.4 Seam Destructive Test Failure Procedure

The Installer will submit a recommended procedure for the tracing and remediation of failed seam destructive tests. This procedure will be submitted as part of the Installer's Quality Control Manual and, as a minimum, will include the following:

- The Installer will reconstruct the failing seam bound by two passing seam destructive tests. The Installer will have the option of obtaining additional seam destructive tests at a minimum of ten-feet intervals in both directions along the failing seam from the failure location. The minimum interval may be increased by the CQA Officer and/or the Project Engineer if test failures become excessive.

- If both of these samples pass the laboratory seam destructive test, then the seam can be reconstructed between them. If one or both of these samples fail the laboratory seam

destructive test, then the procedure is repeated until passing laboratory results are obtained.

- If a seam is reconstructed to a length in excess of 125 feet, a seam destructive sample may be obtained from the reconstruction zone that must meet these specifications.

8. GEOTEXTILE

The geotextile materials will comply with the properties listed in Appendix B.

8.1 LABELING, PACKAGING, TRANSPORTATION AND STORAGE

Labeling - Upon initial delivery to the site, each geotextile roll will be labeled on the inside of the roll core and outside of the roll wrapping with the following, as a minimum:

- Manufacturer's Name;
- Product Identification;
- Batch or lot number;
- Roll Number;
- Roll length and width; and
- Material thickness.

Any roll delivered to the site without the proper labeling will, at the Project Manager's discretion, be rejected and subsequently removed from the site at the expense of the Manufacturer or Installer.

Packaging – New rolls of geotextile should be wrapped in a black wrap provided in UV radiation and abrasion protection.

Transportation - Deliver, store, and handle rolls in a manner to prevent damage.

Storage - Geotextile rolls should not be exposed to the elements for more than 30 days unless additional heavy-duty wrapping is provided.

Store rolls off the ground, protected from precipitation, UV radiation, strong chemicals, sparks and flames, temperatures in excess of 160 degrees F (71 degrees C), and other environmental conditions that could cause damage to the geotextile.

8.2 HANDLING AND PLACEMENT

The Installer will handle all geotextiles in such a manner as to ensure they are not damaged in any way, and will comply with the following. The surface to receive the geotextile will be of smooth condition. Fill deep or sharp-edged depressions, and remove large or sharp-edged rocks, debris and other obstructions that could damage the geotextile.

- In the presence of wind, all geotextiles will be weighted with sandbags or the equivalent. Such sandbags will be installed during placement and will remain until replaced with operations layer material. Sandbags will be made of material that will not degrade during the time they are in use. They will be filled with soil with a predominant grain size equivalent to sand or smaller.

- Geotextiles will be cut using a geotextile cutter approved by the CQA Officer. If in place, special care must be taken to protect other geosynthetic materials from damage that could be caused by the cutting or the geotextiles.

- During placement, care will be taken not to entrap stones, excessive dust, or moisture in the geotextile that could damage an underlying or overlying geomembrane, generate clogging of drains or filters, or hamper subsequent seaming.

- An examination of the geotextile over the entire surface, after installation, will be conducted to ensure that no potentially harmful foreign objects, such as large or sharp-edged rocks or needles (e.g., broken geotextile sewing needles), are present. Any foreign objects so encountered will be removed by the Installer, or the geotextile will be replaced.

8.3 CONFORMANCE TESTING

The CQA Officer will collect samples of geotextile from the materials delivered to the site, for conformance testing.

8.4 SEAMS AND OVERLAPS

All geotextiles will be continuously sewn (i.e., discontinuous or tact sewing is not allowed). Geotextiles will be overlapped a minimum of three inches prior to seaming. Any sewing will be done using polymeric thread with chemical and ultraviolet resistance properties equal to or exceeding those of the geotextile.

8.5 REPAIR

Any holes or tears in the geotextile will be repaired.

Should any tear exceed ten percent of the width of the roll, that roll will be removed from the slope and replaced.

A patch made from the same geotextile will be sewn in place with a minimum of six-inches overlap in all directions.

Care will be taken to remove any soil or other material that may have penetrated the geotextile.

9. LINER SYSTEM COMPONENT DESCRIPTIONS

9.1 BASE LINER SYSTEM COMPONENTS

The cross section of the bottom liner system is shown in Details 1, 2, and 3 of Drawing 006, and includes the following components listed sequentially from top to bottom.

- Operations layer
- Double-sided geocomposite LCRS drainage layer (includes 3.0-inch diameter perforated pipes)
- 80-mil HDPE flexible membrane liner (FML), textured on both sides
- Double-sided geocomposite LDS drainage layer
- 60-mil HDPE FML, textured on both sides
- Geosynthetic clay liner (GCL)
- 9.0-inch prepared subgrade (fine-grained soil)

The 2.5-feet thick operations layer will be clean soil and/or select waste, with the purpose of protecting the underlying liner components from damage due to heavy equipment or other operations activities. The layer must not contain large or angular elements which could damage the underlying liner system. The first foot of material placed should be of relatively small particle size material (e.g., sand and gravel) not exceeding one inch in diameter. The second foot of material can have larger particles (e.g., up to 6.0 inches in diameter) provided they are encompassed in a soil matrix.

The upper double-sided geocomposite is the drainage layer of the LCRS. The thee-inch diameter leachate collection pipes augment flow capacity to accommodate infiltration from the 25-year, 24-hour design storm event. Detail 1 of Drawing 008 shows the layout of these pipes and a typical section. The geocomposite drainage layer and pipes discharge into the LCRS sumps.

The 80-mil HDPE FML is the low-permeability component of the primary liner system. The 80-mil HDPE FML will be textured on both sides to provide additional interface strength.

The lower double-sided geocomposite is the drainage layer for the LDS. Its function is to facilitate detection, collection and drainage of leachate into the LDS sump.

The 60-mil HDPE FML is the upper low-permeability component of the secondary composite liner system. It is a lesser thickness than the primary FML since the secondary FML is located further below operations activities and is underlain by a GCL. Textured HDPE on both sides is selected for the reasons stated above for the primary FML.

The GCL is the lower low-permeability component of the secondary composite liner system.

The nine-inch prepared subgrade layer provides a smooth surface for installation of the geosynthetics materials providing protection of the overlying geosynthetic layers from puncture by angular materials in the subgrade. The nine-inch thick prepared subgrade layer (36.0 inches thick beneath sumps) also provides an additional low permeability layer with added adsorptive capacity.

9.2 SLOPE LINER SYSTEM COMPONENTS

A cross section of the liner system on the slopes of the trench is shown in Detail 2 of Drawing 006, and includes the following components listed sequentially from top to bottom:

- 2-feet thick operations layer (measured normal to the sidewall, placed as waste is deposited)
- 30-mil HDPE FML(protective layer, not a hydraulic liner component)
- Nonwoven geotextile filter fabric
- Geonet LCRS drainage layer
- 80-mil HDPE FML, smooth on the top side and textured on the bottom side
- Double-sided geocomposite LDS drainage layer
- 60-mil HDPE FML, textured on both sides
- GCL (placed over smooth or specially prepared subgrade)

A 10-feet wide, four-feet deep anchor trench is provided at the top of each slope as shown in Detail 3 on Drawing 008.

The 2-feet thick operations layer is installed incrementally along the slopes as the waste fill is placed. Since the slopes are steep (0.5:1.0) the operations layer will be advanced incrementally at a maximum height of a few feet above the waste fill height.

The sacrificial 30-mil HDPE FML is specified to provide UV exposure protection for underlying geosynthetic materials, especially the uppermost geotextile member. The sacrificial 30-mil HDPE FML also directs rainfall, during cell filling, onto the cell floor for infiltration into the waste and management by the LCRS of infiltration that reaches the LCRS collectors.

9.3 TRENCH BOTTOM/SIDEWALL TRANSITION LINER SYSTEM COMPONENTS

The cross section of the liner system at trench bottom/sidewall transition locations is depicted in Detail 3 of Drawing 006. This detail shows how overlaps will be made for each drainage layer to assure continuity of the LCRS and LDS from the side slope to the base of the landfill. The overlap extends from three feet above the floor to three feet onto the trench bottom.

10. LEACHATE COLLECTION SYSTEM

10.1 LEACHATE COLLECTION AND RECOVERY SYSTEM

The primary LCRS is located above the primary liner, and is designed to collect and allow removal of liquids within each cell. The secondary system, the LDS, is located between the two liners, and its main function is to provide detection and removal of any leakage through the top liner.

The LCRS is associated with the primary liner system. The function of the LCRS is to intercept leachate draining through the waste and to discharge it into the sumps for removal from the landfill. The typical sump configuration is shown in Detail 1 on Drawing 007. The LCRS sump is 12 inches deep. Liquid is removed from the sump through a riser that is shown in Sections A and B on Drawing 007. The components of the LCRS sump are sized to accommodate the maximum anticipated leachate flows while maintaining fluid head above the primary liner at or below one foot.

Trench 12 LCRS sump components are shown on the typical sump layout details on Drawing 007. The components include:

- Geocomposite. This is the principal LCRS drainage component (at cell bottom locations) that discharges directly to the drain rock at the edge of the sump.
- 8.0-ounce LCRS geotextile: This geotextile is used to separate the operations layer from the 1-inch diameter drain rock (described below). It is used over the entire sump area within the sump perimeter.
- 3.0-inch diameter perforated corrugated polyethylene pipes: These pipes are secondary flow components that assist the LCRS in handling the maximum anticipated flow resulting from a 25-year, 24-hour design storm event. The pipes discharge directly to a slip joint in the primary riser pipe (described below).
- 1.0-inch diameter (nominal) drain rock: This is a clean gravel conforming to the gradation included in the specifications (Exhibit B). The LCRS gravel fills the entire sump to the grade break.
- 16-ounce LCRS cushion geotextile: This is a nonwoven geotextile used to provide additional puncture protection to the liner system within the sump perimeter (see Sections A, B, and C on Drawing 008).

- Components of the LCRS riser system include the following (starting at the sump):

  - Flatstock/Riser Base: The riser system is extrusion welded to a 1.0-inch thick, 20-inch square HDPE flatstock base. The pipe is perforated with 1/2-inch diameter holes, 60 degrees apart on 3.0-inch centers (24 holes per foot). A 16-ounce geotextile sheet is wrapped around the perforated section with a double layer of geonet and secure with stainless steel clamps.

  - LCRS Riser Pipe: This is a 12-inch diameter, SDR 17 HDPE pipe. A 24-inch wide section of the 30-mil HDPE sacrificial liner directly beneath the riser pipe functions as a rubsheet to protect the slope liner system.

  - Riser Pipe Slip Cover: The function of this component is to minimize the transfer of friction and down-drag loads on the riser pipe due to settlement of the waste. The riser pipe slip cover will be fabricated from a 12-inch diameter corrugated polyethylene pipe that has been split longitudinally and placed over the riser as shown in Section A of Drawing 007. It is not necessary to join the individual pieces of the slip cover.

  - Riser Pipe Support: The riser pipe support consists of a concrete foundation block shown in Detail 2 on Drawing 007. The riser pipe support is intended to be precast 4,000 psi concrete, using Type V sulfate resistant cement. A 12-inch diameter, Schedule 80, Type 316 stainless steel welding stub will be cast in the concrete and secured with one-inch diameter by six-inch long expansion type anchor bolts.

  - Top of Slope Anchor: This is a concrete block with an adjustable U-bolt (shown in Detail 2 on Drawing 007). This component provides lateral restraint for the riser pipe while allowing vertical movement to accommodate settlement. When the starter berms and buttresses are constructed, the riser pipe will be extended and the top of slope anchor repositioned accordingly.

10.2 LEAK DETECTION SYSTEM

The LDS is associated with the secondary liner system. The functions of the LDS are to detect and remove liquid that may migrate through the primary liner system. Components used in the Trench 12 LDS sumps are shown in the typical sump layout on Detail 1 and Section B of Drawing 007. The components include:

- Geocomposite. This is the principal LDS drainage component (at the cell bottom locations) that discharges to the geonet at or near the sump perimeter (see Section C on Drawing 008).

- Geonet: The geonet is a high capacity synthetic drainage layer. It is used within the grade break at each sump to convey liquid to the 15-inch deep sump area (see Section B on Drawing 008). Geonet is used around all three sumps, 12A, 12B, and 12C.

- 16-ounce LDS cushion geotextile: This is a nonwoven geotextile used to provide additional puncture protection to the liner system within the sump perimeter (see Sections B and C on Drawing 008).

- 1.0-inch diameter (nominal) drain rock: A clean gravel conforming to the gradation included in the specifications (Appendix B). As shown in Section B on Drawing 008, the LDS gravel fills only the 15-inch deep sump area.

- LDS End Caps, Tee, Collection Pipes and Elbow: These pieces are all 12-inch diameter SDR 17 HDPE that is perforated to collect flow into the LDS sump. The pieces rest on a 1-inch thick piece of HDPE flatstock. The pieces also transfer the lateral load of the riser pipe to the sidewall of the LDS sump. A 1.0-inch thick piece of HDPE flatstock is used to evenly distribute the load from the HDPE tee and collection pipes to the sidewall (see Section B on Drawing 008). Additional lateral resistance is provided by the 4-feet thick operations layer placed directly over the sump.

- 16-ounce lower LDS cushion geotextile: This is a nonwoven geotextile that provides puncture protection to the secondary liner system in the 15-inch deep portion of the sump as shown in Section B on Drawing 008.

Components of the LDS riser system include the following (starting at the sump):

- LDS Riser: A 12-inch diameter SDR 17 HDPE pipe used for pump access.

- LDS Riser Recess Trench and Backfill: The LDS Riser (described above) is placed in a 24-inch wide by 18-inch deep recess cut into the sidewall during excavation. A 30-mil PVC rubsheet is used to separate the backfill material from the geocomposite and to provide additional cushion to the liner system. Backfill will consist of a lightweight concrete.

- Top of slope anchor: See the LCRS top of slope anchor description above since the units are identical.

11. LINER SYSTEM EXPOSURE PROTECTION

Exposure protection is necessary for the liner and leachate collection system components, both during construction as well as during disposal operations. Exposure issues include the following:

- Ultraviolet (UV) Radiation: Some geosynthetic materials (without UV resistance additives) degrade when exposed to sunlight. For Trench 12, the HDPE materials (e.g., FML and geonet) are UV-resistant; hence protection from exposure to UV radiation is not necessary for these materials. Polyester geotextile materials, however are sensitive to UV radiation and must be protected during storage, construction and disposal operations.

- Precipitation/Water: The bentonite within GCLs may expand if exposed to moisture and allowed to hydrate in an unconfined condition (e.g., during material staging or placement). Thus, GCLs must be protected during storage and construction.

- Dust and soil: Geonet materials can become partially filled with dust and soil if not protected from wind and rain during storage and construction. This geonet must be protected during storage and construction.

- Wind: High winds can lift geosynthetics that have not been properly anchored (e.g., during construction). This can result in damage (e.g., tears) or the material blowing away. Therefore, temporary anchorage and repair/replacement procedures are needed during construction. Protection from wind during disposal operations is also needed.

- Geosynthetic materials requiring exposure protection and/or special handling during construction include the following.

    - GCLs: Store on pallets in delivered plastic packaging and cover with tarps. Protect from rain after installation.

    - HDPE FMLs: Store on pallets to avoid damage. Provide temporary anchorage to facilitate installation and prevent wind uplift. Follow inspection, repair, and replacement procedures if wind damage has potentially occurred.

    - Geonets: Store on pallets and cover with tarps. Keep free of dust, soil and precipitation during installation.

    - Geotextiles: Store on pallets and cover with tarps. Place subsequent layer of liner systems within a reasonable period of time (e.g., within four to six weeks).

    - Geocomposites: Same as geotextiles.

- Geosynthetics on the cell bottom are likely to be covered by the operations layer within a reasonable period of time (e.g., four to six weeks) after installation. No further protective measures are required for those elements.

The side slope liner system incorporates a sacrificial 30-mil HDPE FML. The sacrificial liner protects the slope liner during filling and specifically eliminates UV exposure of the primary nonwoven geotextile filter-fabric. The layer also prevents infiltration into the slope LCRS during precipitation. Sand tubes and wind vents will be installed to secure the slope lining system and prevent uplift from wind.

Table C-1 - Soil Placement Inspection Schedule

Inspection Task	Inspection/Test Method Reference	Sample/Test Quantity/Frequency	Observation/Sample Locations		
			Excavation	Soil Stockpile	Fill Area
FIELD INSPECTION OF SOIL EXCAVATION AND PLACEMENT OPERATIONS					
General project observations	Visual observations, plus basic measurements and recordkeeping	Continuous observation, during trench construction (excavation, soil screening and amendment and soil placement)	Yes	Yes	Yes
Trench feature layout	Observation of survey staking	Continuous observation, during excavation	Yes	NA	Yes
Soil material observation	Observation of excavated and imported soil material	Continuous observation, during construction	Yes	Yes	Yes
SOIL TESTS TO BE DONE DURING TRENCH 12 CONSTRUCTION					
Particle-size analysis	ASTM C 136	3 tests per material type, reconfirmed as needed	Yes	Yes	Yes
Moisture/density curve	ASTM D1557, Modified proctor moisture-density relation	3 tests per material type, reconfirmed as needed	Yes	Yes	Yes
Lift thickness	Observation/measurement before and during compaction	Random locations	NA	No	Yes
In-place density and moisture content	ASTM D6938 (or approved alternative method)	As specified	No	No	Yes

Table C-1 - Soil Placement Inspection Schedule (continued)

Inspection Task	Inspection/Test Method Reference	Sample/Test Quantity/Frequency	Sample Location		Acceptance Criteria
			Soil Stockpile	Fill Area	
SURFACE SOIL LAYER RECOMPACTION					
Direct shear strength of compacted fill	TBD	3 tests per material type, reconfirmed as needed	Yes	No	cohesion ≥ 250 PSF
Particle-size analysis	ASTM C 136	3 tests per material type, reconfirmed as needed	Yes	No	95% <3.0" sieve >10% pass #200 sieve <20% pass #200 sieve
Moisture/density relation	ASTM D1557	3 tests per material type, reconfirmed as needed	Yes	No	NA
In-place density	ASTM D6938 (after compaction)	1 per lift minimum, or 1 per 2,000 yd^3 (placed), or as specified	No	Yes	95% MDD (min) by ASTM D 1557
Moisture content	ASTM D6938 (after compaction)	1 per lift minimum, or 1 per 2,000 yd^3 (placed), or as specified	No	Yes	OMC +2%
COMPACTED FILL STARTER BERM					
Moisture/density relation	ASTM D1557	3 tests per material type, reconfirmed as needed	Yes	No	NA

Table C-1 - Soil Placement Inspection Schedule (continued)

Inspection Task	Inspection/Test Method Reference	Sample/Test Quantity/Frequency	Sample Location		Acceptance Criteria
			Soil Stockpile	Fill Area	
In-place density	ASTM D6938 (after compaction)	1 per lift minimum, or 1 per 2,000 yd^3 (placed), or as specified	No	Yes	90% MDD (min) by ASTM D 1557
Moisture content	ASTM D6938 (after compaction)	1 per lift minimum, or 1 per 2,000 yd^3 (placed), or as specified	No	Yes	OMC +2%
TRENCH 12 BOTTOM AND SUMP SUBGRADE					
Hydraulic conductivity of compacted subgrade	TBD	3 tests per material type, reconfirmed as needed	Yes	No	$\leq 1 \times 10^{-5}$ cm/sec
Particle-size analysis	ASTM C136	3 tests per material type, reconfirmed as needed	Yes	No	≤10% >1.0" ≥10% pass #200 sieve
Moisture/density relation	ASTM D1557, Modified proctor moisture-density relation	3 tests per material type, reconfirmed as needed	Yes	No	NA
In-place density and moisture content, trench floor	ASTM D1557 (after compaction)	one test per each one test for every 10,000 square feet of subgrade placed (placed)	No	Yes	90% MDD OMC +2%
Thickness, after compaction, trench floor	Measurement after compaction	one test per each one test for every 10,000 square feet of subgrade placed (placed)	NA	No	Thickness ≥ 9.0"

Table C-1 - Soil Placement Inspection Schedule (continued)

Inspection Task	Inspection/Test Method Reference	Sample/Test Quantity/Frequency	Sample Location		Acceptance Criteria
			Soil Stockpile	Fill Area	
In-place density and moisture content, sump bottom	ASTM D6938 (after compaction)	1 test per lift, not less than 3 tests per sump	No	Yes	90% MDD OMC +2%
Lift thickness, sump bottom	Measurement after compaction	Not less than 3 measurements per lift in each sump	NA	No	Total compacted lift thickness at same location ≥36.0"
SUMP AND LCRS PIPING BEDDING GRAVEL					
Hydraulic conductivity of gravel	TBD	3 tests per material type, reconfirmed as needed	Yes	No	Minimum hydraulic conductivity = 1 cm/sec
Particle-size analysis	ASTM C136	3 tests per material type, reconfirmed as needed	Yes	No	100% <3.0" sieve ≥95% >1.0" sieve ≤5% passing #4 sieve

MDD = Standard Proctor (ASTM D1557) maximum dry density.
OMC = Standard Proctor (ASTM D1557) optimum moisture content
TBD = to be determined by soil testing laboratory
PSF = pounds per square foot