COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

Date Prepared/Revised **REV JUNE 2019**
DEP USE ONLY
Date Received

FORM 24
LINER SYSTEM - PHASE II

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form 24, reference the item number and identify the date prepared. The "date prepared/revised" on any attached sheets needs to match the "date prepared/revised" on this page.

General References: 273.161 and 273.251 to 273.260/277.161 and 277.251 to 277.260/285.123

SECTION A. SITE IDENTIFIER

Applicant/permittee **PA WASTE, LLC**

Site Name **CAMP HOPE RUN LANDFILL**

Facility ID (as issued by DEP) **TBD**

SECTION B. GENERAL ITEMS (Refer to Attachment 24-1)

Liner System is for:

- ☒ 1. Municipal Waste Landfill.
- ☐ 2. Construction/Demolition Waste Landfill.
- ☐ 3. Storage Impoundment.

SECTION C. LINER SYSTEM COMPONENTS (Refer to Attachment 24-1)

Liner System Components are:	Area (ft^2)	Is Equivalency Review Being Requested (Y/N)
☒ 1. Subbase.	9,453,000 (217 Ac.)	N
☒ 2. Secondary Liner.	9,453,000 (217 Ac.)	N
☒ 3. Leachate Detection Zone.	9,453,000 (217 Ac.)	Y
☒ 4. Primary Liner.	9,453,000 (217 Ac.)	N
☒ 5. Protective Cover.	9,453,000 (217 Ac.)	N
☒ 6. Leachate Collection System (within Protective Cover).	9,453,000 (217 Ac.)	N
☒ 7. Cap	9,453,000 (217 Ac.)	N
☐ 8. Natural Attenuation	NA	NA
☒ 9. Composite Liner Primary or Secondary (circle one)	Primary - 9,453,000 (217 Ac.)	N

SECTION D. SUPPORTING DATA

Supporting Data:

The following information must be submitted along with this form. For information not appended to this form, indicate below where in the specifications or drawings the required information is located.

	(Drawing)	(Specification)
1. Design of Liner System. (Refer to Part II.)	Drawing L1	Attachments 24-1, 24-4, 24-5, 24-6, and 24-8
2. Liner Installation Plan. (Refer to Part III.)	Drawings S3,S13, and L1	Attachment 24-2
3. Compatibility of Liner to Leachate. (Refer to Part IV)		Attachment 24-7
4. Physical, Chemical, Mechanical, and Thermal Properties of Liners. (Refer to Part V)		Attachments 24-1, 24-2, and 24-9
5. Quality Assurance Plan for Construction and Installation of Liners. (Refer to Part VI)		Attachment 24-3
6. Quality Control Plan for construction and installation of liners.		Attachment 24-3
7. Slope Stability Analysis		Attachment 24-8
8. If applicable, seismic impact analysis	NA	NA

PART II. DESIGN OF LINER SYSTEM

SECTION A. PROJECT SPECIFICATIONS (Refer to Attachment 24-2)

Project Specifications		Subbase	Secondary Liner	Leachate Detection Zone	Primary Liner	Leachate Collection Zone	Protective Cover	Cap
Thickness (inches or mils)		6”	60 mils	250 mils (geocomposite)	60 mils	18”	18”	40 mils
Maximum Particle Size (inches)		3/8” on surface	NA	3/8” (No. 8) 1.5” (No. 57)	NA	3/8” (No. 8) 1.5” (No. 57)	3/8” (No. 8) 1.5” (No. 57)	3”
Standard Proctor Density (percent)	FIELD	95%	NA	NA	NA	NA	NA	NA
	LAB	95%	NA	NA	NA	NA	NA	NA
Bearing Capacity (minimum) (lb/ft^2)		45,000	NA	NA	NA	NA	NA	NA
Total Applied Load (lb/ft^2)		18,750 (max) 15,000 (typ)	18,750 (max) 15,000 (typ)	18,750 (max) 15,000 (typ)	18,750 (max) 15,000 (typ)	18,750 (max) 15,000 (typ)	18,750 (max) 15,000 (typ)	240
Permeability (cm/s)	FIELD	1E-5	2E-13	3.1	2E-13	0.5 (No. 8)	0.5 (No. 8)	4E-13
	LAB	1E-5	2E-13	3.1	2E-13	0.5 (No. 8)	0.5 (No. 8)	4E-13
Slope (percent)	MINIMUM	2	2	2	2	2	2	2
	MAXIMUM	33	33	33	33	33	33	33

Geosynthetics: Where synthetic liners, geonets, geotextiles, or other geosynthetic materials are to be used, provided information as to the manufacturer, trade name, type, specifications and composition of each product.

Non-Synthetic Liners: Where clay or other soils will be used as the liner, provide information on the Atterberg Limits, soil density, moisture relationship moisture content, and sieve analysis to be maintained at the time of installation.

Drainage System: Where piping is installed as part of the leachate detection, leachate collection or gas disposal system submit plans and profile drawings of each level, cell or zone which clearly illustrates the: slope, spacing, diameter and schedule of all piping to be installed.

SECTION B. DESIGN BASIS

For each major element of the liner system outlined above, provide the following information which supports the basis for the design. Include copies of the results of all tests conducted at the site, assumptions, and calculations used in the design. The stability of the landfill site and design is to be determined at critical sections. This is to include any below grade excavations/embankments or berms that may be critical. Consideration must be given to long and short term stresses, equipment loadings, filling sequence, and the possibility of earthquakes. Where geosynthetics are used, a veneer stability analysis should be performed on the interfaces of the material and the soil or aggregates. A puncture analysis is to be included where a geosynthetic is used to protect a geomembrane. Include test results of all liner interfaces for friction angles. Following information is to be attached to this form and referenced to the appropriate section.

1. Subbase: **(Refer to Form 6, Form 7, and Attachments 24-4 and 24-8)**
   - i. Submit detailed information on how the subbase was sized and located, including the minimum and maximum depths to seasonal high water table and regional groundwater table. Be sure all elevations are tied to projects grid system and benchmarks. Explain this bases for the subbase size and materials selected.
   - ii. Describe how the subbase will bear the weight of the liners, leachate detection and collection systems, wastes, cover material, and operations equipment without causing or allowing any failure of the liner system. Explain what evaluations were conducted at the site and of the subgrade materials to ensure adequacy for the projected loads.
   - iii. Discuss the potential for subsidence and the liner systems ability to allow for settlement.
2. Secondary Liner: **(Refer to Attachments 24-2, 24-3, and 24-7)**
   - i. Describe the physical, chemical, and thermal properties taken into consideration in selecting the secondary liner.
   - ii. Submit and discuss the results of any testing conducted on the liner material which ensures it will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or leachate.

SECTION B. DESIGN BASIS (con't)

3. Leachate Detection Zone: **(Refer to Attachments 24-2, 24-3, and 24-5)**
   i. Describe the physical, chemical, and thermal properties taken into consideration in selecting materials.
   ii. Submit and discuss the results of any testing conducted on the detection zone materials which ensures they will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or its leachate.
   iii. Describe the methods for cleaning and maintaining pipes, including methods for testing installed pipes for leakage.
   iv. Describe how the leachate detection zone will support the primary liner without causing punctures in the event of subsidence.
4. Primary Liner: **(Refer to Attachments 24-2, 24-3, 24-4, and 24-7)**
   i. Describe the physical, chemical and thermal properties taken into consideration in selecting the primary liner.
   ii. Submit and discuss the results of any testing conducted on the liner material which ensures it will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or its leachate.
5. Protective Cover: **(Refer to Attachments 24-4, 24-5, and 24-8)**
   i. Provide a detailed description of the physical and structural aspects of the protective cover. Include information on the size, types, dimensions and depths of all materials used, slopes, calculations on anticipated stresses and loads from wastes and operating equipment. Describe how the cover material will protect the primary liner from physical damage from stresses and disturbances from overlying wastes, cover materials, and equipment operations.
   ii. Describe how the protective cover will allow the continuous and free flow of leachate. Describe the possibility and effects of subsidence should it occur.
6. Leachate Collection System within Protective Cover: **(Refer to Attachments 24-5 and 24-8)**
   i. Provide a detailed description of the physical and structural aspects of the proposed leachate detection system. Include information on the size, types, dimensions and depths of all materials used, slopes, calculations on anticipated bearing loads (wastes and equipment), and leachate detection capabilities. Indicate which drawings and sections of the specifications contain the information on layout and material requirements.
   ii. Provide a description of how the system will detect, collect, and transmit leachate. Briefly describe the leachate treatment facilities and approvals obtained.
   iii. Describe the methods for cleaning and maintaining pipes, including methods for testing installed pipes for leakage.
   iv. Provide an evaluation of geotextiles used as filters for filtration and clogging.
   v. Provide an evaluation for the transmissivity of geonets.
7. Cap: **(Refer to Attachments 24-2 and 24-6)**
   i. Provide a detailed description of the chemical and structural characteristics of the materials to be used for the final cover. Be sure to indicate the minimum and maximum size of materials allowed, sieve sizes, USDA Texture Class, and any other significant distinguishing characteristics.
   ii. Provide a description of how the materials are to be placed and compacted, with details on maximum slopes, minimum depths, and acceptable bearing loads.

PART III. LINER INSTALLATION PLAN

SECTION A. SUBBASE (Refer to Attachments 24-2 and 24-3)

1. Information on the maximum depth of earth moving activities and the site preparation procedures to be followed prior to the installation of any subbase materials.
2. Information on the selection of subbase materials, their grading and tests to be conducted to ensure uniformity.
3. Information on how the subbase materials are placed, graded, compacted, and tested for proper installation.

SECTION B. LINERS (Refer to Attachments 24-2 and 24-3)

1. For synthetic liners, provide all information supplied by the manufacturer as to required handling and installation procedures.
2. For non-synthetic liners, information on the minimum acceptable characteristics (i.e. moisture content, etc.) are to be provided.
3. For synthetic and non-synthetic liners, information as to the equipment required, pre and post installation testing is to be provided.

SECTION C. LEACHATE DETECTION AND COLLECTION ZONES (Refer to Attachments 24-2 and 24-3)

1. Provide details on how the detection and collection zones will be installed with specific information as to what materials and construction techniques will be used to construct each zone.
2. Describe the sequence of construction and equipment used.
3. Describe the sequence for installing the sump and all monitoring or gas venting facilities.

SECTION D. PROTECTIVE COVER (Refer to Attachments 24-2 and 24-3)

1. Describe where the cover materials will come from, and how they are transported and placed at the site.
2. Provide details on how the cover materials will be routinely tested for conformance with design specifications.

SECTION E. FINAL COVER AND GRADING (Refer to Attachments 24-2 and 24-3)

1. Provide a detailed description of how the final cover material is to be placed, compacted, and graded.
2. Describe the proposed final layout for the area with specific reference to any drainage facilities which will remain.

SECTION F. ATTENUATING SOIL BASE (C/D WASTE LANDFILLS) (N/A)

1. Explain how this proposal meets the requirements of Section 277.122 of the municipal waste regulations.
2. Describe the Class of soils to be used as classified by the United State Department of Agriculture.
3. Describe the proposed sequence for placement of waste and attenuating soils.

SECTION G. HIGHWALLS (N/A)

1. Describe how the liner or barrier materials will be installed to prevent the migration of leachate from the disposal area.
2. Provide information on each type of barrier material to be used and its minimum thickness. Include appropriate information on the physical and chemical characteristics of the material, and proof the material is not adversely affected by solid waste, leachate, or its constituents.
3. Provide detailed information on the different seams or outcrops at the proposed site and how they will be isolated from wastes.
4. Explain how groundwater and surface water drainage will be controlled and eliminated.
5. Submit a plan for controlling damage from subsidence or the collapse of highwalls.

SECTION H. LIMITATIONS (Refer to Attachment 24-1)

1. Provide appropriate information on any land use restrictions or limitations that should be followed during and after closure of the facility.

PART IV. COMPATIBILITY OF LINER TO LEACHATE (Refer to Attachment 24-7)

A sampling plan for each component of the liner system, including sample size, methods for determining sample locations, sampling frequency, acceptance and rejection criteria, and methods for ensuring that corrective measures are implemented is to be included with this form. **(Refer to Attachment 24-7)**

SECTION A.

Information must be submitted which demonstrates that leachate will not adversely affect the physical or chemical characteristics of the liner system, or inhibit the liner's ability to restrict the flow of solid waste, solid waste constituents, or leachate, based on EPA or ASTM guidelines approved by the Department. **(Refer to Attachment 24-7)**

SECTION B.

Attach a copy of the chemical analysis of the leachate used in determining the above results. **(Refer to Attachment 24-7)**

SECTION C.

Where appropriate, attach an analysis of the current leachate emanating from this landfill. **(N/A)**

PART V. PROPERTIES OF SYNTHETIC LINERS

Supply the following physical, chemical, mechanical, and thermal properties for liners, based on ASTM methods where appropriate. Additional information may be submitted. (Refer to Attachments 24-1, 24-2, and 24-9)

Geomembrane:

Agru America HDPE Microspike Liner	Results with Units of Measurement	ASTM Method
1. Thickness	60 mil (nominal)	**D5994***
2. Tensile Strength at Yield	132 lb/in width	**D6693, Type IV**
3. Elongation at Yield	13% (GL=1.3 in)	**D6693, Type IV**
4. Elongation at Break	350% (GL=2.0 in)	**D6693, Type IV**
5. Density	0.94 g/cc	**D792, Method B**
6. Tear Resistance	45 lbs	**D1004**
7. Carbon Black Content	2-3%	**D4218**
8. Puncture Resistance	120 lbs	**D4833**
9. Seam Strength (% of Liner Strength)	95% of Yield Strength in Shear	**D6392**
10. Ultraviolet Light Resistance	50% retained after 1600 hours	**D7238/D5885, 150 deg C, 500 psi Oxygen**
11. Carbon Black Dispersion	See note (1)	**D5596**
12. Permeability	2.0 x 10^-13 cm/sec	**HELP Model**
13. Liner Friction Angle in Degrees	26.6^{o} (150 PSF Normal Load); 20.0^{o} (2.5K - 10K PSF Normal Loads)	**D5321 / D6243**
14. Stress Crack Resistance	300 hours	**D5397, Appendix**
15. Oxidative Induction Time	≥140 min	**D3895, 200 deg C, 1 atm Oxygen**
16. Chemical Compatibility	Refer ATT. 24-7	**EPA 9090; D5747**
17. Percent Recycled Materials	≤10% Rework	**Per GRI GM13**

*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)
(1) Only near spherical agglomerates for 10 views: 9 views in Cat. 1 or 2, and 1 view in Cat. 3.

PART V. PROPERTIES OF SYNTHETIC LINERS

Supply the following physical, chemical, mechanical, and thermal properties for liners, based on ASTM methods where appropriate. Additional information may be submitted. **(Refer to Attachments 24-1, 24-2, and 24-9)**

Geomembrane:

Poly-Flex, Inc. Textured HDPE Geomembrane	Results with Units of Measurement	ASTM Method
1. Thickness	57 mil (min avg)	**D5994**
2. Tensile Strength at Yield	126 lb/in	**D6693**
3. Elongation at Yield	12%	**D6693**
4. Elongation at Break	100%	**D6693**
5. Density	0.94 g/cc	**D1505/D792**
6. Tear Resistance	42 lb	**D1004**
7. Carbon Black Content	2.0-3.0%	**D1603**
8. Puncture Resistance	90 lb	**D4833**
9. Seam Strength (% of Liner Strength)	95% of Yield Strength in Shear	**D6392**
10. Ultraviolet Light Resistance	50% after 90 days	**D7238/D5885**
11. Carbon Black Dispersion	See note (1)	**D5596**
12. Permeability	2.0 x 10^-13 cm/sec	**HELP Model**
13. Liner Friction Angle in Degrees	26.6^{o} (150 PSF Normal Load); 20.0^{o} (2.5K - 10K PSF Normal Loads)	**D5321 / D6243**
14. Stress Crack Resistance	300 hours	**D5397**
15. Oxidative Induction Time	100 mins	**D3895**
16. Chemical Compatibility	Ref. ATT. 24-7	**EPA 9090; D5747**
17. Percent Recycled Materials	≤10% Rework	**Per GRI GM13**

(1) Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be category 1 or 2. No more than 1 view from Category 3.

PART V. PROPERTIES OF SYNTHETIC LINERS

Supply the following physical, chemical, mechanical, and thermal properties for liners, based on ASTM methods where appropriate. Additional information may be submitted. **(Refer to Attachments 24-1, 24-2, and 24-9)**

Geomembrane:

Solmax Textured HDPE Geomembrane	Results with Units of Measurement	ASTM Method
1. Thickness	57 mil (min avg)	**D5994**
2. Tensile Strength at Yield	132 lb/in	**D6693**
3. Elongation at Yield	13%	**D6693**
4. Elongation at Break	150%	**D6693**
5. Density	0.94 g/cc	**D1505/D792**
6. Tear Resistance	45 lb	**D1004**
7. Carbon Black Content	2.0-3.0%	**D4218**
8. Puncture Resistance	120 lb	**D4833**
9. Seam Strength (% of Liner Strength)	95% of Yield Strength in Shear	**D6392**
10. Ultraviolet Light Resistance	50% after 1600 hr	**D7238/D5885**
11. Carbon Black Dispersion	See note (1)	**D5596**
12. Permeability	2.0 x 10^-13 cm/sec	**HELP Model**
13. Liner Friction Angle in Degrees	26.6^{o} (150 PSF Normal Load); 20.0^{o} (2.5K - 10K PSF Normal Loads)	**D5321 / D6243**
14. Stress Crack Resistance	500 hours	**D5397**
15. Oxidative Induction Time	100 mins	**D3895**
16. Chemical Compatibility	Ref. ATT. 24-7	**EPA 9090; D5747**
17. Percent Recycled Materials	≤10% Rework	**Per GRI GM13**

(1) Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be category 1 or 2. No more than 1 view from Category 3.

PART VI. QUALITY ASSURANCE PLAN FOR CONSTRUCTION AND FOR INSTALLATION OF LINERS

The following information shall be submitted on separate pages and referenced to the appropriate section. For each Section, a summary table is to be provided which explains the procedures, the frequency for each test, and the pass/fail criteria which must be met.

SECTION A. (Refer to Attachment 24-3)

Qualifications of independent QA personnel (describe experience and training).

SECTION B. SUBBASE (Refer to Attachment 24-3)

1. Provide design summary of procedures used to assure objectives are met:
   a. Outline tests and observations to ensure quality of compacted fill.
   b. Explain observations to ensure removal of objects or undesirable materials.
   c. Discuss observations and tests that ensure that the surface is compacted, smooth, uniform, and consistent with design grades.
   d. Summarize surveying to ensure that facility dimensions, side slopes, and bottom slopes are as specified in design.
   e. Summarize review of Quality Control information.

SECTION C. NON-SYNTHETIC LINERS N/A

1. Discuss inspection procedures of liner materials and test fill compaction. Properties to be tested should include: permeability, soil density/moisture content relationships, maximum clod size, particle size distribution, natural water content, Atterberg limits.
2. Outline procedures and methods for observing and testing liner materials before and after placement to ensure:
   a. Removal of roots, rocks, etc.
   b. Identification of changes in soil characteristics causing a change in construction specifications.
   c. Adequate spreading and incorporation of water to obtain full penetration through clods ad uniform distribution of the specified water content.
   d. Maintaining optimum water content throughout wet and dry periods and during construction.

SECTION D. SYNTHETIC AND GEOSYNTHETIC LINERS (Refer to Attachment 24-3)

Outline Procedures For:

1. Inspection of product quality, the review of manufacturers control procedures and any other observations related to transporting, storing, and handling.
2. Inspection of foundation preparation and equipment.
3. Observations of liner placement.
4. Need and availability of manufacturers representative.
5. Observations of weather conditions.
6. Observations and measurements of anchor trench to ensure that it is as specified in design drawings.
7. Observations and tests to confirm that all designed liner penetrations and liner connections are installed as specified.
8. Visual inspection for tears, punctures, or thin spots during placement.
9. Inspections during and after liner seaming.
10. Observations and tests to assure that seals around liner penetrations are of sufficient strength and are impermeable to leachate.

SECTION E. PROTECTIVE COVER (Refer to Attachment 24-3)

Outline Procedures For:

1. Tests to ensure that the cover material meets design specifications, including permeability and clogging potential.
2. Observations that the cover material is free from objects that could damage the liner.
3. Observation to ensure that equipment used to place cover does not damage liner.
4. Measurements to ensure that entire liner is covered with specified thickness of cover material.

SECTION F. LEACHATE DETECTION AND COLLECTION SYSTEM (Refer to Attachment 24-3)

Discuss how the following activities will be conducted.

1. Observations and measurements to ensure that materials are of specified size and strength, and that pipe perforations are sized and spaced as specified.
2. Observations and tests to ensure that soils to be used are of proper size and gradation.
3. Method of placing bedding and inspection to ensure the pipes are bedded correctly and not susceptible to movement.
4. Observations and measurements to ensure that pipes are placed at specified locations, at specified grades, and are joined together as specified.
5. Observations and tests to ensure that backfilling is completed as specified in design, in all areas, including areas where a liner connects to a structure.
6. Testing of pipe joints and testing of solid wall pipes to ensure that there is no leakage.
7. Observations and tests of the granular drainage layer to ensure that the material meets the specifications of design (including permeability and clogging potential of geosynthetics).
8. Synthetic drainage layers: Observations to ensure proper placement, correct seaming, and allowable weather conditions.
9. Geotextiles: Observations of placement to ensure that specifications are followed, adequate overlap or seaming, and that there is no damage.
10. Sumps: Observations to ensure that structures are of specified dimensions, material, and capacity.
11. Mechanical and electrical equipment installation: Observations to ensure that equipment is in accordance with design specifications and manufacturer's recommendations.

SECTION G. FINAL COVER SYSTEM (Refer to Attachment 24-3)

Discuss who and how following activities will be conducted:

1. Observations and tests to evaluate stability of cover system foundation.
2. Observations and testing as necessary to confirm that soil materials meet specified design.
3. Non-synthetic component: Monitor soil type, moisture content, density, compaction, lift thickness, clod size, uniformity of compaction, completeness of coverage, and permeability.
4. Tests for seals around penetrations such as gas vent pipes to ensure that they do not leak.
5. Inspections for perimeter of cover, where the soil component joins or overlies the liner system, to ensure that it is installed according to specifications.
6. Liners used in the capping system shall follow guidelines for synthetic liners.
7. Observations for a protective layer, such as a geotextile, which is placed above the liner as protection from drainage layer, to ensure proper placement to avoid damage to the liner.
8. Drainage and gas venting layer placement: The gas discharge layer is placed below the synthetic liner and the water drainage layer is placed above the synthetic liner. Guidelines for the leachate collection and detection zone will be followed. Inspections of the installation of the drainage layers around the perimeter of the cover system is important, for it is here that the system connects to the surface drainage facilities. Ensure that design specifications, particularly dimensions and slopes, are achieved. Controlled gas discharge or collection systems are checked for proper installation and function.
9. Filter layer used above or below drainage layer to stop migration or piping of fine materials should be tested for any clogging potential. During construction of filter layer, inspection will include monitoring of particle size (for soil materials) or geotextile type and certification, seaming or overlap for geotextiles, slope of surface, and coverage.
10. Topsoil layer placement: Monitor uniformity of application process, observations to ensure that soil is not overly compacted, and measurements of thickness and slope of topsoil layer.
11. Topsoil seeding: Inspection of seeding process, measurement of tilling depth, application rate of additives should be monitored for consistency with design specifications. Application equipment will be appropriate. Verify that all vents and standpipes or other penetrations through cover are not damaged by tilling and application process. Weather conditions are to be appropriate. Post-construction: Slopes will be surveyed and any unusual depressions noted and corrected.
12. Review of Quality Control information.

PHASE II APPLICATION
CAMP HOPE RUN LANDFILL
BOGGS TOWNSHIP, CLEARFIELD COUNTY, PENNSYLVANIA

FORM 24
ATTACHMENT 24-2
Technical Specifications

REVISED JUNE 2019

SECTION 02607

HIGH DENSITY POLYETHYLENE (HDPE) MANHOLES

HDPE Manholes: HDPE Manholes are used as collection points on the exterior of the landfill for leachate being transmitted to collection and/or treatment facilities. Thus, it is very important that all HDPE Manholes and appurtenances be installed leak and defect free to minimize the potential for groundwater contamination.

A. Description

1. General:

   The Contractor shall furnish all labor, material, and equipment to complete installation of HDPE Manholes in accordance with the Contract Drawings and these Specifications.

2. Related Work:

   Related Contract Work is described in the following sections of the Specifications:

Work	Section
Excavation	02222
Embankment	02223
HDPE Pipe	02614
CQA Manual	Attached

3. Quality Control:

   The Contractor shall perform leak testing of HDPE Manholes as described in this section.

4. Quality Assurance:

   Quality Assurance during placement of HDPE Manholes will be provided by the Owner as described in the accompanying Project CQA Manual.

B. Materials

1. HDPE Manholes shall be constructed from material which meets the requirements of Section 02614, HDPE Pipe, of these Specifications by an approved Polyethylene Fabricator as detailed on the Contract Drawings.

2. HDPE Pipe used in a manhole shall be of sufficient dimension ratio (DR) to maintain a minimum nominal thickness of 1 inch. HDPE sheets shall have a minimum thickness of 1 inch.

3. The cylinder and outlets shall be fabricated from pipe only, not sheet.

4. All HDPE Manholes shall be tested by the Polyethylene Fabricator for water tightness by filling with clean water and checking for weld leaks prior to shipment to the project site. Any and all leaks shall be repaired prior to shipment using approved manufacturer's techniques.

5. Each HDPE Manhole shall be furnished completely assembled with all accessories such that field work will involve only installation and connection of external equipment.

6. Manhole Covers:

   a. HDPE Manholes placed in non-traffic areas shall be fitted with concrete-filled polyethylene covers equipped with steel handles.

   b. HDPE Manholes placed in traffic areas shall be fitted with cast iron frames and covers (Vulcan Foundry, or equal) equipped with steel handles.

C. Submittals

1. The Contractor shall submit to the Engineer the qualifications of the Polyethylene Fabricator along with the Contractor's bid.

2. After the Polyethylene Fabricator has been approved by the Engineer, the Contractor shall submit shop drawings for the HDPE Manholes to the Engineer for approval at least 4 weeks prior to construction.

3. At shipment written certification shall be provided to the Engineer certifying the manholes are leak free.

D. Construction

1. The HDPE Manholes shall be installed at the locations and to the elevations indicated on the Contract Drawings. The Contractor shall give the CQA Engineer sufficient notice so he may observe the field location and installation activities.

2. The HDPE Manholes will be bedded and backfilled as indicated on the Contract Drawings.

3. Leak Testing:

   a. HDPE Manholes used in the leachate management system which will come into contact with the leachate shall be determined to be leak free prior to shipping.

   b. All welded connections of external pipes to stub-outs from the manhole shall be tested in accordance with Section 02614, HDPE Pipe.

END OF SECTION

SECTION 02710

DRAINAGE AGGREGATE (LEACHATE MANAGEMENT)

Drainage Aggregate: Drainage Aggregate includes leachate detection/protective cover media and coarse aggregate, which is placed on top of the geomembrane, around leachate collection pipes (gravel columns), and in the sump for the purpose of leachate collection and removal.

A. Description

1. General:

The Contractor shall furnish all labor, material, and equipment to complete the installation of Drainage Aggregate in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Geotextiles	02240
HDPE Pipe	02614
Drainage Geocomposite	02712
HDPE Geomembrane	02775
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Association of State Highway and Transportation Officials (AASHTO) American Society of Testing and Materials (ASTM) and the are hereby made a part of these specifications.

AASHTO	Stand Specifications for Transportation Materials and Methods of Sampling and Testing.
ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head).
ASTM D 3042	Standard Test Method for Insoluble Residue in Carbonate Aggregates.

4. Quality Assurance:

Quality Assurance during placement of Drainage Aggregate will be provided by the Owner as described in the accompanying Project CQA Manual.

B. Materials

1. Leachate Detection/Protective Cover (LD/PC) Media:

   a. A granular material (AASHTO No. 8 or alternate gradation if approved by the Engineer) from a non-carbonate source (≤ 15% carbonate content by ASTM D 3042) shall be used on the base and side slopes of the containment area (and around leachate detection piping), as shown on the Contract Drawings and shall be approved by the CQA Engineer at least four weeks prior to construction.

   b. The LD/PC media shall be sound, durable, and free from seams, cracks, or other structural defects. The material shall be free of shale, clay, friable materials, and debris. LD/PC media consisting of long, thin, and/or angular particles may be rejected at the sole discretion of the Engineer.

   c. The LD/PC media shall meet the following gradation criteria and have a coefficient of permeability of 0.5 cm/sec. (ASTM D 2434) or greater.

Sieve Size	Percent Passing
½ Inch	100
⅜ Inch	85-100
No. 4	10-30
No. 8	0-10
No. 16	0-5
No. 200 (In-Place)	0-5
No. 200 (Stockpile)	0-2

   The Engineer may approve an alternate gradation if the material meets permeability criteria.

2. Coarse Aggregate:

   a. Coarse aggregate (AASHTO No. 57 or alternate gradation if approved by the Engineer and the Department) from a non-carbonate source (≤ 15% carbonate content by ASTM D 3042) shall be placed around the collection pipes and within the sumps (excluding leachate detection sumps) where shown on the Contract Drawings and shall be approved by the CQA Engineer at least four weeks prior to construction.

   b. Coarse aggregate shall be sound, durable, and free from seams, cracks, or other structural defects. The material shall be free of shale, clay, friable materials, and debris. Coarse aggregate consisting of long, thin, and/or angular particles may be rejected at the sole discretion of the Engineer.

c. Coarse aggregate shall meet the following gradation criteria.

Sieve Size	Percent Passing
1½ Inch	100
1 Inch	95-100
½ Inch	25-60
No. 4	0-10
No. 8	0-5
No. 200 (In-Place)	0-5
No. 200 (Stockpile)	0-2

C. Submittals

The Contractor shall submit the following to the CQA Engineer:

1. Before approval is given to proceed, the Contractor shall submit descriptive information on equipment to be used for placement of the Drainage Aggregate.

2. The Contractor shall submit at least two bulk samples each of leachate LD/PC media and coarse aggregate from each material source for approval at least four weeks prior to beginning construction of the leachate collection system. Along with the bulk samples, the Contractor shall also submit a certification from each material source that the materials proposed meet the specified gradation requirements.

3. Survey Results:

   After completion of a segment of Drainage Aggregate, survey results shall be submitted for review prior to Drainage Aggregate acceptance.

D. Construction

1. Failing CQA Material Control Tests:

   Drainage Aggregate that is rejected upon testing shall be removed from the project site and replaced at Contractor's cost. Sampling and CQA testing of Drainage Aggregate supplied as replacement for rejected material shall be performed by the CQA Engineer at the Contractor's cost.

2. The Drainage Aggregate is placed directly over geosynthetics and piping; thus, extreme caution shall be exercised by the Contractor to prevent damage to these materials.

   Areas to evaluate potential damage due to equipment operations may be required by the Engineer to evaluate potential damage to underlying geosynthetics.

3. All placement of Drainage Aggregate shall be performed only when the CQA Engineer is informed by the Contractor of intent to perform such work.

4. The Contractor shall exercise care in maintaining a true line and grade for all piping during placement and spreading of Drainage Aggregate.

5. Drainage Aggregate shall be placed over geosynthetics and/or piping only after areas have been released by the Geosynthetics Installer and the CQA Engineer. Drainage Aggregate shall be placed as specified below:

   a. Drainage Aggregate shall be placed and spread using tracked equipment. On slopes of 6H:1V or steeper, low ground pressure (6 psi or less) tracked equipment shall be used. On slopes flatter than 6H:1V, tracked equipment shall have a ground pressure of 12 psi or less. The CQA Engineer shall approve the equipment used to place Drainage Aggregate. The Contractor shall place plastic traffic cones or other markers approved by the CQA Engineer on 100 foot centers to monitor thickness during placement.

   b. Tracked equipment used to place and spread Drainage Aggregate shall operate on at least 1 foot of material overlying geosynthetics and/or piping. Sharp turning of tracked equipment on the Drainage Aggregate will not be permitted.

   c. On slopes of 6H:1V or steeper, Drainage Aggregate shall be placed and spread from the bottom up unless otherwise approved by the Engineer. No material shall be dumped down a slope.

   d. Drainage Aggregate shall not be placed over standing water or ice.

   e. Drainage Aggregate shall not be compacted within the limits of the containment area.

   f. Drainage Aggregate shall be placed to the lines and grades as shown on the Contract Drawings except that a 0.15 foot overbuild at the Contractor's expense is allowed. Drainage Aggregate placed beyond these limits shall be removed at the Contractor's sole expense if required by the Engineer.

6. The Drainage Aggregate shall be spread in a manner that minimizes development of wrinkles or tension in the underlying geosynthetics. Any portion of the underlying geosynthetics that develops excessive wrinkles or crimp or is otherwise damaged shall be repaired by the Geosynthetics Installer at no expense to the Owner.

   a. Drainage Aggregate shall not be placed when conditions are warm enough to produce excessive wrinkles in the underlying geosynthetics. Likewise, Drainage Aggregate shall not be placed when conditions are cold enough to produce tension in the underlying geosynthetics.

   b. If during spreading, excessive wrinkles develop, the Contractor shall adjust placement and spreading methods, or cease until the underlying geosynthetics cool and wrinkles decrease in size.

   c. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and spreading methods or underlying geosynthetics that become crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

7. Stockpiling of Drainage Aggregate within the limits of the containment area shall be subject to advance approval by the Engineer. Any hauling equipment (dump trucks, etc.) operating within the containment area shall have a minimum of 3 feet of separation between the vehicle wheels and the Geomembrane.

   The Contractor shall minimize equipment operations directly over coarse aggregate.

8. The CQA Engineer may require removal of Drainage Aggregate and/or other underlying layers at the Contractor's sole expense to allow examination of the underlying geosynthetics and/or piping. Any damage to the underlying layers or excessive wrinkling or crimping during placement of Drainage Aggregate shall be repaired in accordance with the applicable section of these Specifications at the Contractor's sole expense.

9. Surveying:

After completion of a segment of Drainage Aggregate, the Drainage Aggregate shall be surveyed on 100 foot centers and at slope breaks (including all tops and toes of slope, points of grade change, etc.) (Note that the tops of gravel columns may be surveyed along with the Protective Cover) to ensure:

a. The specified thickness has been achieved.

b. The top of the Drainage Aggregate slopes at grades specified on the Contract Drawings; and

c. Drainage Aggregate placed more than 0.15 feet beyond the limits of the lines and grades as shown on the Contract Drawings will not be accepted and must be removed at the Contractor's sole expense if required by the Engineer.

This work shall be performed at the Contractor's cost by a registered surveyor.

END OF SECTION

SECTION 02775

HDPE GEOMEMBRANE

HDPE Geomembrane (HDPE-GM): The HDPE Geomembrane serves as the primary hydraulic containment barrier for the leachate to be developed in the landfill. Thus, it is of great importance that the HDPE-GM be free from defects and installed free from damage.

A. Description

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of HDPE-GM including all necessary and incidental items as detailed or required to complete the installation in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Excavation	02222
Embankment	02223
Geotextiles	02240
Subbase	02253
Drainage Aggregate (Leachate Management)	02710
Drainage Geocomposite	02712
Geosynthetic Clay Liner	02776
CQA Manual	Attached

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the Geosynthetic Research Institute (GRI) are hereby made a part of these Specifications.

ASTM D 792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
ASTM D 1004	Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.
ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5321	Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

ASTM D 5397	Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test.
ASTM D 5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
ASTM D 5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
ASTM D 6243	Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.
ASTM D 6365	Standard Practice for Nondestructive Testing of Geomembrane Seams Using the Spark Test
ASTM D 6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
ASTM D 6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Flexible Polyethylene and Nonreinforced Polypropylene Geomembranes.
ASTM D 7466	Standard Test Method for Measuring the Asperity Height of Textured Geomembrane.
GRI GM9	Cold Weather Seaming of Geomembranes.
GRI GM13	Standard Specification for Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.
GRI GM19	Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

4. Quality Control:

   a. The Contractor shall perform Quality Control tests in accordance with Table 2 of this section.

   b. The Geomembrane Installer shall follow the procedures and requirements described in the accompanying Project CQA Manual during installation of HDPE-GM including performing and documenting trial seams, nondestructive and destructive Quality Control tests, and repairs.

5. Quality Assurance:

   Quality Assurance during installation of HDPE-GM will be provided by the Owner as described in the accompanying Project CQA Manual.

6. Manufacturers Qualifications:

The Manufacturer shall have previously demonstrated his ability to produce the required HDPE-GM by having successfully manufactured a minimum of 10,000,000 ft^2 of HDPE-GM for hydraulic containment purposes.

7. Installer Qualifications:

   a. Installation of the HDPE-GM shall be performed by an Installer that has installed a minimum of 5,000,000 ft^2 of the material within the past five (5) years in similar landfill installations.

   b. All Installation Supervisors assigned to the Project shall have previously managed the installation of at least 2,000,000 ft^2 of HDPE-GM using the same techniques to be used on site.

   c. All seaming equipment operators shall have demonstrated performance on previous geomembrane installations and/or documented training.

8. Warranties:

   a. General: Should a defect occur, which is covered under warranty, the Warrantor shall bear all costs for repair and/or relocation and replacement of the HDPE-GM.

   b. Workmanship: The Contractor shall furnish the Owner a warranty from the Installer of the HDPE-GM which warrants their workmanship to be free of defects on a prorata basis for five (5) years after the final acceptance of the Work. This warranty shall include but not be limited to all field seams, anchor trenches, and penetration seals, as applicable.

   c. Manufacturer's Warranty: The Contractor shall furnish the Owner a warranty from the HDPE-GM Manufacturer for the materials used. The material warranty shall be for defects or failures related to manufacture on a prorata basis for five (5) years after the date of shipment.

B. Materials

1. General:

   The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes. The HDPE-GM and HDPE-GM Manufacturer shall be approved by the Engineer.

   The HDPE-GM shall be supplied in rolls which shall have a minimum width of 22 feet. The roll length shall be maximized to provide the largest manageable sheet for the fewest seams. However, no factory seaming of HDPE-GM panels shall be accepted. Labels on the roll shall identify the thickness, length, width, lot and roll numbers, and name of Manufacturer.

2. HDPE-GM Materials:

   Textured HDPE-GM shall be 60 mils thick. Resin and sheet properties of HDPE-GM shall meet or exceed the requirements of GRI GM13 and Table 1 of this section.

3. Extrusion Resin/Typical Extrudate:

   Extrusion resin/typical extrudate used for extrusion seaming of HDPE-GM shall be high density polyethylene (HDPE). Physical properties shall be the same as the HDPE-GM sheet.

The extrudate's additives shall be thoroughly dispersed throughout the rod or bead. The extrudate shall be free of contamination by moisture or foreign matter and shall be recommended for use with the associated sheet material.

4. Texturing:

Textured HDPE-GM, where required, shall be fabricated using coextrusion or structuring methods. Texturing shall not be created by lamination or impingement. All texturing shall be uniform in appearance and coverage on the finished sheet. Textured HDPE-GM shall be textured on both sides of the sheet.

C. Submittals

The Contractor shall submit the following to the CQA Engineer:

1. Pre-Installation Requirements:

Prior to HDPE-GM installation, the Contractor shall submit the following:

a. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the HDPE-GM attesting that the HDPE-GM meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample of the HDPE-GM to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

b. Qualifications:

(1) Submit list of equipment and personnel proposed for the Project. Include equipment type and quantities. Include personnel experience on similar projects.

(2) Submit resume and references of Installation Supervisor to be assigned to the Project, including data and duration of employment and pertinent experience information.

(3) Submit resumes and references of installation personnel who will perform seaming operations, including dates and durations of employment and pertinent experience information.

c. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

d. Delivery Date: Submit notification of the scheduled delivery dates for the materials.

e. Installation Procedures and Drawings:

Submit installation procedures and (shop) drawings for carrying out the work.

(1) Installation procedures to be addressed shall include but not be limited to material installation, repair, and protection to be provided in the event of rain or strong winds.

(2) Shop drawings shall have HDPE-GM sheet layout with proposed size, number, position, and sequence of placing all panels, and indicating the location of all field seams. Shop drawings shall also show complete details and/or methods for anchoring the HDPE-GM, making field seams, and

making seals around pipes and structures penetrating the HDPE-GM (if applicable).

Following review, these procedures and drawings shall be used for installation of the HDPE-GM. Any deviations from these procedures and drawings must be approved by the Engineer and CQA Engineer.

f. Quality Control Certificates: For HDPE-GM delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided which represent every roll of HDPE-GM. Each certificate shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall meet or exceed the requirements of GRI GM13.

g. Contractor Quality Control Test Results: The Contractor shall provide the results of required testing.

h. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

i. A proposed procedure for hydrostatically testing the primary sump areas.

2. Post-Installation Requirements:

Upon completion of the HDPE-GM installation, the Contractor shall submit the following:

a. Certificate stating that the HDPE-GM has been installed in accordance with the Drawings, Specifications, and the Manufacturer's recommendations.

b. Completed Manufacturer's and workmanship warranties.

c. Record Information: Record information shall include but not be limited to:

(1) CQC Documentation: Includes trial seam logs, panel placement logs, panel seaming logs, non-destructive seam testing report forms, field destructive seam testing report forms, and repair logs.

(2) As-Built Drawing: Includes the requirements listed in Paragraph D.8 (Surveying) of this Specification.

Finalization of payment for HDPE-GM installation shall not be made until the above submittals have been reviewed by the CQA Engineer.

D. Construction

1. Shipping, Handling, and Storage:

The HDPE-GM shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Failing CQA Material Control Tests:

HDPE-GM that is rejected upon testing shall be removed from the project site and replaced at Contractor's cost. Sampling and CQA testing of HDPE-GM supplied as replacement for rejected material shall be performed by the CQA Engineer at Contractor's cost.

3. Subbase Preparation:

a. The surface of the Subbase shall be smooth, uniform, free from sudden changes in grade (such as vehicular ruts), rocks or stones greater than 3/8 inch in size, debris, and deleterious materials. Rocks, stones, and other material embedded in the surface of the Subbase shall be removed and the surface of the Subbase shall be amended with sodium bentonite, compacted and hydrated in the holes. During actual placing and seaming of the HDPE-GM, the Subbase shall be kept free of all standing water. If the Subbase below the HDPE-GM becomes excessively wet and unstable as determined by the CQA Engineer, it shall be dried and recompacted, and replaced if needed. Likewise, GCL which becomes hydrated shall be removed and replaced at Contractor expense.

b. Before an individual panel of HDPE-GM is installed; the Contractor and Installer shall verify in writing and submit to the CQA Engineer:

(1) Lines and grades are in conformance with the Contract Drawings and Specifications.

(2) The surface area to be lined has been rolled and compacted, free of irregularities and abrupt changes in grade.

c. The Contractor shall not proceed with HDPE-GM installation until a complete report on all Subbase and GCL CQA testing has been submitted and approved by the CQA Engineer. If the Contractor proceeds with HDPE-GM installation prior to completion of these tests, the Contractor will do so at his own risk. If any tests fail, the Contractor shall be required to remove HDPE-GM and reconstruct the underlying components to specification requirements. All costs associated with such actions (including the costs of additional testing) shall be paid for entirely by the Contractor.

4. HDPE-GM Placement:

a. Weather Conditions:

HDPE-GM placement shall not proceed at an ambient temperature below 32° F or above 100° F unless otherwise authorized, in writing, by the Engineer. Installation of HDPE-GM at temperatures below 32° F, if authorized by the Engineer, shall follow GRI GM9. HDPE-GM placement shall not be performed during precipitation, excessive moisture, in an area of ponded water, or in excessive winds. Any portion of HDPE-GM or subsurface damaged due to weather conditions shall be repaired at the Contractor's cost.

b. Method of Placement:

(1) Each panel of the HDPE-GM shall be installed in accordance with the approved shop drawings prepared by the Contractor. The layout shall be designed to keep field seaming of the HDPE-GM to a minimum, shall avoid seams parallel to and under leachate collection piping, and shall be consistent with proper methods of HDPE-GM installation.

(2) Panels shall be oriented perpendicular to the line of the slope crest (i.e., down and not across slope).

(3) The HDPE-GM shall be placed smooth and free of excessive wrinkles.

(4) HDPE-GM rolls shall be placed using proper spreader and rolling bars with cloth slings. If a sheet must be displaced a distance greater than its width, a slip sheet shall be used.

(5) The CQA Engineer shall inspect each panel, after placement and prior to seaming, for damage and/or defects. Defective or damaged panels shall be replaced or repaired, as approved by the CQA Engineer and as described in this section.

(6) The Installer shall avoid dragging the HDPE-GM on rough soil.

(7) All HDPE-GM shall be anchored as shown on the Contract Drawings and consistent with Manufacturer's recommendations.

(8) Personnel working on the HDPE-GM shall not smoke, wear damaging shoes, or involve themselves in any activity that may damage the HDPE-GM, in the opinion of the CQA Engineer.

(9) The HDPE-GM shall be properly weighted to avoid uplift due to wind.

(10) Vehicular traffic across the HDPE-GM shall not be allowed, except that four-wheel (or greater) all-terrain vehicles (ATVs) with low ground pressure may be allowed if approved in advance by the Engineer. The Contractor shall submit proposed equipment and procedures for use of ATVs to the CQA Engineer as part of his submittals. If ATVs are allowed by the Engineer, each ATV shall be operated such that no sudden stops, starts, or turns are made.

(11) All damage shall be recorded and located on the record drawings.

(12) When tying into existing HDPE-GM, excavation of previously installed geosynthetics shall be performed in a manner that minimizes damage to the existing geosynthetics and as approved by the Engineer. All damage to the existing geosynthetics shall be repaired by the Geosynthetics Installer at the Contractor’s sole expense.

(13) The HDPE-GM shall be kept free of debris, unnecessary tools, and materials. In general, the HDPE-GM area shall remain neat in appearance.

c. Pipe Penetrations:

All pipe penetrations through the HDPE-GM shall be as shown in the Contract Drawings. Alternative penetration details may be approved by the Engineer and CQA Engineer.

5. Field Seams:

a. Individual panels of HDPE-GM shall be laid out and overlapped by a minimum of 4 inches prior to seaming. The area to be seamed shall be cleaned and prepared in accordance with the Manufacturer's recommendations.

b. Dual or single track hot wedge methods shall be used for straight seams.

c. Extrusion fillet methods shall be used to seam cross seam tees, patches, repairs, and penetration boots. All extrudate shall be free of dirt, dry, and protected from damage. No overgrinding shall be left exposed after an extrusion seam is completed.

d. The seaming equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the HDPE-GM so as to ensure that changes in environmental conditions will not affect the integrity of the seam.

e. All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be seamed together.

f. Where horizontal seams are required on sloped surfaces, the panels shall be placed such that the "upstream" panel forms the upper panel and overlaps the "downstream" panel in order to minimize infiltration potential. All seams constructed on slopes of 6H:1V or steeper shall be vertical seams, except where slope lengths exceed standard roll lengths and elsewhere as approved in advance by the Engineer. Where approved, end seams on slopes of 6H:1V or steeper shall be staggered a minimum of 5 feet and shall be made at an angle of approximately 45 degrees.

g. All panels placed on slopes of 6H:1V or steeper shall extend a minimum of 5 feet beyond the grade break with a slope flatter than 6H:1V.

h. All seams shall extend to the full extent of the anchor trench.

i. Unless otherwise approved by the Engineer, all “T” seams (i.e., the result of three panels placed together) shall be staggered a minimum of 3 feet along either seam and shall be covered with a patch.

j. No junctions of four or more panels shall be allowed unless approved by the Engineer.

k. If extrusion seaming equipment is stopped for longer than one minute, it shall be purged to remove heat-degraded extrudate. All purged extrudate shall be placed on a sacrificial sheet and disposed of.

l. To prevent moisture buildup during seaming, it may be necessary to place a movable protective layer of plastic directly below each overlap of HDPE-GM that is to be seamed.

m. If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

n. Excessive wrinkles along geomembrane seams shall be minimized. Fish-mouths or large wrinkles shall be cut along the ridge of the wrinkle to allow a flat overlap, which shall be re-seamed. All cuts shall be repaired with a patch.

o. All seams (including repairs) shall meet or exceed the requirements of GRI GM19 and Table 3 of this section.

p. No overlying material (i.e., leachate collection layer) shall be placed over the HDPE-GM until approved by the CQA Engineer.

6. Anchor Trench:

a. The anchor trench shall be constructed as shown on the Contract Drawings and as specified herein. The anchor trench shall be maintained by the Contractor.

b. Slightly rounded corners shall be provided in the trench to avoid sharp bends in the HDPE-GM.

c. The anchor trench shall be adequately drained to prevent water ponding and softening to adjacent soils. The anchor trench shall be backfilled with Subbase material and compacted in 12 inch (max.) as-compacted lifts to 95% standard Proctor dry density (ASTM D 698) and ± 4% of the optimum moisture content.

d. If the anchor trench is located in a clay susceptible to desiccation, the amount of trench open at any time shall be limited to one day of HDPE-GM installation capacity.

7. Repair Procedures:

a. Any portion of the HDPE-GM exhibiting signs of defect or failing a nondestructive or a destructive test, shall be repaired by the Geomembrane Installer. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be made by the CQA Engineer. The procedures available include:

(1) Patching - Apply a new piece of HDPE-GM sheet over, and at least 6-inches beyond the limits of a defect. The patch shall be extrusion seamed to the underlying HDPE-GM. This method should be used to repair holes, tears, destructive test locations, undispersed raw materials, contamination by foreign matter, dents, pinholes, and pressure test holes.

(2) Capping - Apply a new strip of HDPE-GM along the length of a delineated faulty seam. The cap strip shall extend at least 6-inches beyond the limit of the seam and the edges shall be extrusion seamed to the underlying HDPE-GM. This method should be used to repair lengths of extrusion or hot wedge seams.

(3) Replacement - The faulty seam is removed and replaced.

b. In addition, the following provisions shall be satisfied:

(1) Surfaces of the HDPE-GM which are to be repaired shall be abraded no more than one hour prior to the repair;

(2) All surfaces must be clean and dry at the time of the repair;

(3) All seaming equipment used in repairing procedures must be approved;

(4) The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA Engineer;

(5) Extrusion seaming of flaps of dual track hot wedge seams is not acceptable. A patch or cap strip shall be used; and

(6) Patches or caps shall extend at least 6-inches beyond the edge of the defect, and all patch corners shall be rounded.

8. Surveying:

a. After completion of a segment of HDPE-GM, the Contractor shall survey HDPE-GM to obtain the following information:

(1) Location and numbering of all panels/seams.
(2) Location of all repairs/patches;

(3) Location of all destructive test locations; and

(4) Location of all pipe penetrations (if applicable).

b. No overlying materials shall be placed before survey information is obtained.

c. The Contractor shall provide the CQA Engineer with updated survey information when requested by the CQA Engineer to verify that the required information is being obtained.

9. Testing of Sumps:

The sump(s) of landfill cells will be tested to determine the integrity of the sump areas prior to certification or start of waste disposal operations in that cell or subcell. These methods may include electric leak location (ASTM D7877-14 or D7703-15), or other equivalent methods, as approved by the Engineer and Department.

10. Testing of Boots:

The boots in landfill cells shall be tested to determine the integrity of construction prior to placement of overlying materials. These methods may include spark testing (ASTM D6365), or other equivalent methods, as approved by the Engineer and Department.

11. Cover Placement:

Placement of materials over HDPE-GM shall be performed in a manner as to ensure that HDPE-GM and the underlying geosynthetics are not damaged; minimal slippage of HDPE-GM on the underlying geosynthetics occurs; no excess tensile stresses occur in the HDPE-GM; and that no portion of the HDPE-GM develops excessive wrinkles or crimp. Wrinkles that exceed approximately 6 inches in height and cannot be eliminated by amended placement and covering methods or HDPE-GM that becomes crimped shall be cut and repaired by the Geosynthetics Installer in a method approved by the Engineer.

Table 1: Required HDPE-GM Properties

Property	Test Method	Units	Value
Thickness mils (min. ave.)	ASTM D 5994	mil	60
Asperity Height mils (min. ave.)	ASTM D 7466	mil	16
Formulated Density (min. ave.)	ASTM D 1505 ASTM D 792	g/cc	0.940
Tensile Properties (min. ave.)[1] • yield strength • break strength • yield elongation • break elongation	ASTM D 6693 Type IV	 lb/in lb/in % %	 126 90 12 100
Tear Resistance (min. ave.)	ASTM D 1004	lb	42
Puncture Resistance (min ave.)	ASTM D 4833	lb	90
Stress Crack Resistance[2]	ASTM D 5397 (App.)	hr	500
Carbon Black Content (range)	ASTM D 4218[3]	%	2.0-3.0
Carbon Black Dispersion	ASTM D 5596	-	Note [4]
Oxidative Induction Time (OIT) (min.ave.) (a) Standard OIT --or-- (b) High Pressure OIT	 ASTM D 3895 ASTM D 5885	 min	 100 400
Oven Aging at 85°C [5,6] (a) Standard OIT (min.ave.) - % retained after 90 days ---or--- (b) High Pressure OIT (min.ave) - % retained after 90 days	 ASTM D 5721 ASTM D 3895 ASTM D5885	 %	 55 80
UV Resistance [7] (a) Standard OIT (min.ave.) ---or--- (b) High Pressure OIT (min.ave.) - % retained after 1600 hrs[9]	 ASTM D 7238 ASTM D 3895 ASTM D 5885	 %	 N.R.[8] 50
Interface Shear Strength (Peak)[10, 11, 12]	ASTM D 5321 ASTM D 6243 (GCL)	psf	75 psf (150 psf Load) 910 psf (2,500 psf) 1,820 psf (5,000 psf) 3,640 psf (10,000 psf)

Notes:

1. Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
   - Yield elongation is calculated using a gage length of 1.3 inches
   - Break elongation is calculated using a gage length of 2.0 inches
2. SP-NCTL per ASTM D5397 Appendix, is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
   The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
3. Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
4. Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3
5. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
6. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
7. The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
8. Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
9. UV resistance is based on percent retained value regardless of the original HP-OIT value.
10. Textured HDPE-GM shall have adequate adhesion against adjacent materials under low normal loads to achieve the successful installation of overlying components without slippage.
11. Note that the required values for textured HDPE-GM may require an aggressively textured sheet.
12 If there are material differences in the surface of any of the geosynthetic materials from one side to the other, then all possible combinations of interfaces shall be tested. This testing shall be performed at Contractor cost by an independent GAI accredited laboratory and submitted to the Engineer for review prior to shipping. Upon review of the test results, the Engineer may allow exceptions to the above criteria. Approval from PADEP is required before any exceptions may be made by the Engineer.

Table 2: Required Contractor Quality Control Tests

Property	Test Method	Minimum Test Frequency
Interface Shear Strength	ASTM D 5321 ASTM D 6243 (GCL)	(See Note 1)

Notes:

1. Test each interface to be used on this project using representative samples of materials to be supplied under normal loads indicated and using test parameters as specified by the Engineer. For this project, interfaces to be tested are:

   A. Textured HDPE-GM (60 mil) against Subbase:
   B. Drainage Geocomposite against Textured HDPE-GM (60 mil);
   C. Geosynthetic Clay Liner against Drainage Geocomposite;
   D. Textured HDPE-GM (60 mil) against Geosynthetic Clay Liner; and
   E. Type GT-C Geotextile against Textured HDPE-GM (60 mil).

If there are material differences in the surface of any of the geosynthetic materials from one side to the other, then all possible combinations of interfaces shall be tested. This testing shall be performed at Contractor cost by an independent GAI accredited laboratory and submitted to the Engineer for review prior to shipping. Upon review of test results, the Engineer may allow exceptions to the above criteria. Approval from PADEP is required before any exceptions may be made by the Engineer.

For tests involving textured geomembranes, the laboratory shall also report the asperity height (ASTM D 7466) for the material samples used in the actual direct shear tests.

Table 3: Required Seam Strength Properties

Property	Test Method	Value	
		Hot Wedge Seams	**Extrusion Fillet Seams**
Shear Strength[1]	ASTM D 6392	120 lbs/inch	
Shear Elongation at Break[2]		50%	
Peel Strength[1]		91 lbs/inch	78 lbs/inch
Peel Separation (Incursion)		≤ 25%	
Locus-of-Break		See Note 3	

Notes:
1. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values.
2. Omit elongation measurements when performing field tests.
3. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392 (in this regard, SIP is an acceptable break code):

   Hot Wedge: AD and AD-BRK with > 25% Separation
   Extrusion Fillet: AD1, AD2, and AD-WLD (unless strength is achieved).

END OF SECTION

PHASE II APPLICATION
CAMP HOPE RUN LANDFILL
BOGGS TOWNSHIP, CLEARFIELD COUNTY, PENNSYLVANIA

FORM 24
ATTACHMENT 24-3
CQA Manual

REVISED JUNE 2019

Construction Quality Assurance Manual

Camp Hope Run Landfill
Boggs Township
Clearfield County, Pennsylvania

Prepared for:

PA Waste, LLC

Revised June 2019

Prepared by:

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Camp Hope Run Landfill
Boggs Township, Clearfield County, Pennsylvania

Construction Quality Assurance Manual

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APPENDIX

1.0 GENERAL

This Construction Quality Assurance (CQA) Manual has been prepared to provide the Owner, Design Engineer (Engineer), and CQA Engineer the means to govern the construction quality and to satisfy landfill certification requirements under current solid waste management regulations.

More specifically, this CQA Manual addresses the soils and geosynthetics components of the liner system, the leachate management system, and the final cover system. The liner system, as referenced herein, consists of a soil subgrade and a composite liner (consisting of a soil subbase and an overlying primary and secondary liner systems). The leachate management system consists of a leachate detection and leachate collection systems (LDS/LCS) and a leachate transmission and storage system. The final cover system consists of a landfill gas (LFG) system, LLDPE geomembrane, overlying geosynthetic drainage composite and vegetative soil layer with stormwater collection piping.

The CQA Manual is divided into the following sections:

- Section 1.0 General
- Section 2.0 CQA Documentation
- Section 3.0 Earthwork CQA
- Section 4.0 Subbase CQA
- Section 5.0 Geomembrane CQA
- Section 6.0 Leachate Management System CQA
- Section 7.0 Geotextile CQA
- Section 8.0 Drainage Geocomposite CQA
- Section 9.0 Geosynthetic Clay Liner CQA
- Section 10.0 Final Cover System CQA

1.1 Definitions Relating to Construction Quality

1.1.1 Construction Quality Assurance (CQA)

In the context of this Manual, Construction Quality Assurance is defined as a planned and systematic program employed by the Owner to assure conformity of the liner, leachate management, and final cover systems installation with the project drawings and the project specifications. CQA is provided by the CQA Engineer as a representative of the Owner and is independent from the Contractor, and all manufacturers. The CQA program is designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

1.1.2 Construction Quality Control (CQC)

Construction Quality Control refers to actions taken by manufacturers, fabricators, installers, and/or the Contractor to ensure that the materials and the workmanship meet the requirements of the project drawings and the project specifications. The manufacturer's specifications and quality control (QC) requirements are included in this CQA Manual by reference only. A complete

updated version of each geosynthetic component manufacturer's QC Plan shall be incorporated as part of the Contractor's CQC Plan.

1.1.3 CQA Certification Document

At the completion of construction, a certification document will be prepared by the CQA Engineer and submitted to Pennsylvania Department of Environmental Protection (PA DEP). The certification report will include documentation of all QC testing performed by the Geosynthetics Manufacturers, all CQC testing performed by the Geosynthetic Installers, and all CQA testing performed by the CQA Engineer.

1.1.4 Discrepancies Between Documents

The Contractor is instructed to bring discrepancies to the attention of the CQA Engineer who shall then notify the Engineer for resolution. The Engineer has the sole authority to determine resolution of discrepancies existing within the Contract Documents (this may also require the approval of PA DEP). Unless otherwise determined by the Engineer, the more stringent requirement shall be the controlling resolution.

1.2 Parties to Construction Quality Assurance

1.2.1 Description of the Parties

The parties to Construction Quality Assurance and Quality Control include the Owner, Engineer, Contractor, Geosynthetics Manufacturer, Geosynthetics Installer, CQA Engineer, Geosynthetics CQA Laboratory, and Soils CQA Laboratory.

1.2.1.1 Owner

The Owner is PA Waste, LLC, who owns and/or is responsible for the facility.

1.2.1.2 Engineer

The Engineer is responsible for the engineering design, drawings, and project specifications for the liner, leachate management, and final cover systems. The Engineer is an official representative of the Owner. The Engineer serves as communications coordinator for the project, initiating the meetings outlined in **Section 1.6**. The Engineer will also be responsible for proper resolution of all quality issues that arise during construction. The Engineer is Smith Gardner, Inc.

1.2.1.3 Contractor

The Contractor is responsible for the construction of the subgrade, earthwork, and for placement of the composite liner, leachate management, and/or final cover systems. The Contractor is responsible for the overall CQC on the project and coordination of submittals to the

CQA Engineer. Additional responsibilities of the Contractor are defined by the project specifications.

1.2.1.4 Geosynthetics Manufacturer

The Geosynthetics Manufacturer(s) is (are) responsible for the production of the geosynthetic components used in landfill construction. The Manufacturer(s) is (are) responsible for Quality Control (QC) during manufacture of the geosynthetic components, certification of the properties of the geosynthetic components, and field installation criteria.

1.2.1.5 Geosynthetics Installer

The Geosynthetics Installer(s) is (are) routinely a subcontractor of the Contractor and is (are) responsible for field handling, storing, placing, seaming, protection of (against wind, etc.), and other aspects of the geosynthetics installations. The Installer may also be responsible for transportation of these materials to the site, and for the preparation and completion of anchor trenches.

1.2.1.6 CQA Engineer

The CQA Engineer is a representative of the Owner, is independent from the Contractor, and is responsible for observing, testing, and documenting activities related to the CQA of the earthworks at the site, and the installation of the soil and geosynthetic components of the liner, leachate management, and final cover systems. The CQA Engineer may make field observations and review submittals for the Engineer and is responsible for notifying the Owner and Engineer of all quality issues that arise during construction. The CQA Engineer is also responsible for issuing a facility certification report, sealed by a Professional Engineer registered in The State of Pennsylvania.

1.2.1.7 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory is a party, independent from the Owner, that is responsible for conducting tests on conformance samples of geosynthetics used in the liner, leachate management, and final cover systems. The Geosynthetics CQA Laboratory service cannot be provided by any party involved with the manufacture, fabrication, or installation of any of the geosynthetic components. The services of the Geosynthetics CQA Laboratory are coordinated by the CQA Engineer and are paid for by the Owner.

1.2.1.8 Soils CQA Laboratory

The Soils CQA Laboratory is a party, independent from the Owner, that is responsible for conducting geotechnical tests on conformance samples of soils and aggregates used in structural fills and the liner, leachate management, and final cover systems. The services of the Soils CQA

Laboratory are coordinated by the CQA Engineer and are paid for by the Owner.

1.2.2 Qualifications of the Parties

The following qualifications are required of all parties involved with the manufacture, fabrication, installation, transportation, and CQA of all materials for the liner, leachate management, and final cover systems. Where applicable, these qualifications must be submitted by the Contractor to the Owner and Engineer for review and approval.

1.2.2.1 Contractor

Qualifications of the Contractor are specific to the construction contract and independent of this CQA Manual.

1.2.2.2 Geosynthetics Manufacturers

Each Geosynthetics Manufacturer must satisfy the qualifications presented in the project specifications.

1.2.2.3 Geosynthetic Installer(s)

The Geosynthetic Installer(s) will be trained and qualified to install the geosynthetics components of the liner, leachate management, and final cover systems. Each Geosynthetics Installer must meet the requirements of the project specifications and be approved by the Engineer.

1.2.2.4 CQA Engineer

The CQA Engineer will act as the Owner's Quality Assurance Representative. The CQA Engineer will perform CQA testing to satisfy the requirements of this CQA Manual and will prepare the CQA certification document. The CQA Engineer will have experience in the CQA aspects of the construction and testing of landfill liner, leachate management, and final cover systems, and be familiar with ASTM and other related industry standards. The activities of the CQA Engineer will be performed under the supervision of a Registered Professional Engineer.

1.2.2.5 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory should be certified by the Geosynthetics Accreditation Institute, will have experience in testing geosynthetics, and be familiar with ASTM, GRI, and other applicable test standards. The Geosynthetics CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples depending on the test(s) to be conducted, as agreed to at the outset of the project by affected parties, and will maintain that standard throughout the installation.

1.2.2.6 Soils CQA Laboratory

The Soils CQA Laboratory will have experience in testing structural fills, subbase, and aggregates, and be familiar with ASTM and other applicable test standards. The Soils CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples depending on the test(s) to be conducted, as agreed to at the outset of the project by affected parties, and will maintain that standard throughout the installation.

1.3 Scope of Construction Quality Assurance Manual

The scope of this CQA Manual includes the CQA of the soils and geosynthetic components of the liner, leachate management, and final cover systems for the subject facility. The CQA for the selection, evaluation, and placement of the soils is included in the scope.

1.4 Units

In this CQA Manual, all properties and dimensions are expressed in U.S. units.

1.5 References

The CQA Manual includes references to the most recent version of the test procedures of the American Society of Testing and Materials (ASTM) and/or the Geosynthetic Research Institute (GRI). **Appendix A** contains a list of these procedures.

1.6 CQA Meetings

To facilitate the specified degree of quality during installation, clear, open channels of communication are essential. To that end, meetings are critical.

1.6.1 Subbase CQA Meeting

Prior to the start of the subbase system construction a CQA Meeting will be held. This meeting will include all parties then involved, including the Engineer, the CQA Engineer, and the Contractor.

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

This meeting should include all of the activities referenced in the project specifications.

The meeting will be documented by the Engineer and minutes will be transmitted to all parties. The Subbase CQA Meeting and the Geosynthetics CQA Meeting may be held as one meeting or separate meetings, depending on the direction of the Engineer.

1.6.2 Geosynthetics CQA Meeting

A CQA Meeting will be held at the site prior to placement of the geosynthetics. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and the Geosynthetic Installation Superintendent(s).

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

This meeting should include all of the activities referenced in the project specifications.

The meeting will be documented by the Engineer and minutes will be transmitted to all parties. The Subbase CQA Meeting and the Geosynthetics CQA Meeting may be held as one meeting or separate meetings, depending on the direction of the Engineer.

1.6.3 CQA Progress Meetings

Progress meetings will be held between the Engineer, the CQA Engineer, the Contractor, the Geosynthetic Installation Superintendent(s), and representatives from any other involved parties at the frequency dictated in the project specifications or, at a minimum, once per month during active construction. These meetings will discuss current progress, planned activities for the next week, and any new business or revisions to the work. The CQA Engineer will log any problems, decisions, or questions arising at this meeting in the CQA Engineer's daily or periodic reports. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties. These meetings will be documented by the Engineer and minutes will be transmitted to affected parties.

1.6.4 Problem or Work Deficiency Meetings

A special meeting will be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and representatives from any other involved parties. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions; and
- implement an action plan to resolve the problem or deficiency.

The meeting will be documented by the Engineer and minutes will be transmitted to affected parties.

1.7 Control Versus Record Testing

1.7.1 Control Testing

In the context of this CQA Manual, Control Tests are those tests performed on a material prior to its actual use in construction to demonstrate that it can meet the requirements of the project plans and specifications. Control Test data may be used by the Engineer as the basis for approving alternative material sources.

1.7.2 Record Testing

Record Tests are those tests performed during the actual placement of a material to demonstrate that its in-place properties meet or exceed the requirements of the project drawings and specifications

2.0 CQA DOCUMENTATION

An effective CQA plan depends largely on recognition of construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Engineer will document that quality assurance requirements have been addressed and satisfied.

The CQA Engineer will provide the Owner and Engineer with daily and progress reports including signed descriptive remarks, data sheets, and logs to verify that required CQA activities have been carried out. These reports will also identify potential quality assurance problems. The CQA Engineer will also maintain at the job site a complete file of project drawings, reports, project specifications, a CQA Manual, checklists, test procedures, daily logs, and other pertinent documents.

2.1 Daily CQA Report

The CQA Engineer's reporting procedures will include preparation of a daily report which, at a minimum, will include the following information, where applicable:

- a unique identifying sheet number for cross referencing and document control;
- date, project name, location, and other identification;
- data on weather conditions;
- a reduced scale Site Plan showing all proposed work areas and test locations;
- descriptions and location of ongoing construction;
- descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- locations where tests and samples were taken;
- a summary of test results;
- calibrations or recalibrations of test equipment, and actions taken as a result of recalibration;
- off-site materials received, including quality verification documentation;
- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality;
- summaries of pertinent discussions with the Contractor and/or Geosynthetic Installers; and
- the CQA Engineer’s signature.

The daily report must be completed at the end of each day. This information will be submitted to the Engineer for review on a routine basis and to the Owner upon request.

2.2 CQA Progress Reports

The CQA Engineer will prepare summary progress reports at time intervals as requested by the Engineer or Owner or upon a total project shutdown. As a minimum, this report will include the following information for the reporting period, where applicable:

- a summary of work activities performed;
- a summary of construction situations, deficiencies, and/or defects;
- a summary of all test results, failures, and retests;
- a compilation of daily CQA reports; and
- the CQA Engineer's signature.

Critical problems that occur will be communicated verbally to the Engineer immediately as well as being included in the progress reports.

2.3 CQA Photographic Reporting

Photographs will be taken by the CQA Engineer at regular intervals during the construction process and in all areas deemed critical by the CQA Engineer. These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. Videotaping may be used to supplement photographs in the documentation of work progress, problems, and/or mitigation activities. These records will be presented to the Engineer upon completion of the project.

2.4 Deficiencies

The Owner and Engineer will be made aware of any significant recurring non-conformance with the project specifications. The Engineer will then determine the cause of the non-conformance and recommend appropriate changes in procedures or specification. When this type of evaluation is made, the results will be documented, and any revision to procedures or project specifications will be approved by the Owner and Engineer.

2.5 Design and/or Project Technical Specification Changes

Design and/or project specification changes may be required during construction. In such cases, the CQA Engineer will notify the Engineer. The Engineer will then notify PA DEP. All changes that are necessary during the construction of the facility must be submitted, reviewed, and approved in writing by the PA DEP prior to the change being made at the site.

Design and/or project specification changes will be made only with the written agreement of the Engineer, and will take the form of an addendum to the project

specifications. All design changes will include a detail (if necessary) and state which detail it replaces in the plans.

2.6 Final CQA Report

At the completion of each major construction activity at the landfill unit, the CQA Engineer will certify all required forms, observation logs, field and laboratory testing data sheets including sample location plans, etc. The CQA Engineer will also provide a final report which will certify that the work has been performed in compliance with the plans and project technical specifications, and that the supporting documents provide the necessary information.

The CQA Engineer will also provide summaries of all the data listed above with the report. The Record Drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). All surveying and base maps required for development of the Record Drawings will be done by the Contractor's Construction Surveyor. These documents will be certified by the Contractor and delivered to the CQA Engineer and included as part of the final CQA (Certification) report.

It may be necessary to prepare interim certifications, as allowed by the regulatory agency, to expedite completion and review.

At a minimum, the items shown in **Table 2.1** will be included in the Final CQA Report. Note that some items may not be applicable to all projects.

2.7 Storage of Records

All handwritten data sheet originals, especially those containing signatures, will be stored by the CQA Engineer in a safe repository on site. Other reports may be stored by any standard method which will allow for easy access. All written documents will become property of the Owner.

Table 2.1A Final CQA Report General Outline (Liner System)

1. Introduction
2. Project Description
3. CQA Program
    a. Scope of Services
    b. Personnel
4. Earthwork CQA
5. Subbase CQA
6. GCL CQA
7. Geomembrane CQA
8. Leachate Management System CQA
9. Geotextile CQA
10. Drainage Geocomposite CQA
11. Summary and Conclusions
12. Project Certification

Table 2.1A (Continued):

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- Appendix A Design Clarifications and Modifications
- Appendix B Piezometer Abandonment (if applicable)
- Appendix C Rock Blasting (if applicable)
  - C1. Approved Rock Blasting Plan
  - C2. Results of Rock Blasting
- Appendix D Photographic Documentation
- Appendix E CQA Reporting
  - E1. CQA Reports
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- Appendix I GCL CQA Data
  - I1. Manufacturer's Product Data Submittals and Quality Control Certificates
  - I2. Geosynthetics Inventory - GCL
  - I3. CQA Test Results - Material Control Tests
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- Appendix J Geomembrane CQA Data
  - J1. Manufacturer's Product Data Submittals and Quality Control Certificates
  - J2. Geosynthetics Inventory - Geomembrane(s)
  - J3. CQA Test Results - Material Control Tests
  - J4. Subbase Acceptance Certificates
  - J5. Trial Seam Logs
  - J6. Panel Placement Logs
  - J7. Panel Seaming Logs
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  - J9. CQC Test Results - Destructive Seam Testing Report Forms (Field)
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  - J12. Geomembrane Installation Certification
- Appendix K Leachate Management System CQA Data
  - K1. Manufacturer's Product Data Submittals and Quality Control Certificates
  - K2. CQA Test Results - Drainage Aggregate
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  - K5. CQC Test Results - Leak Testing of Precast Concrete Structures
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  - M1. Manufacturer's Product Data Submittals and Quality Control Certificates
  - M2. Geosynthetics Inventory - Drainage Geocomposite

Table 2.1A (Continued):

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N2. Subbase As-Built
N3. Geomembrane As-Built(s)
N4. Leachate Collection Media As-Built
N5. HDPE Pipe As-Built
N6. Protective Cover As-Built

Table 2.1B Final CQA Report General Outline (Final Cover System)

1. Introduction
2. Project Description
3. CQA Program
    a. Scope of Services
    b. Personnel
4. Earthwork CQA
5. Final Cover System CQA
6. Geomembrane CQA
7. Geotextile CQA
8. Drainage Geocomposite CQA
9. Summary and Conclusions
10. Project Certification

Appendices
Appendix A Design Clarifications/Modifications
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G5. Trial Seam Logs
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G8. CQC Test Results - Nondestructive Seam Testing Report Forms
G9. CQC Test Results - Destructive Seam Testing Report Forms (Field)

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G12.	Geomembrane Installation Certification
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J3.	HDPE Pipe As-Built
J4.	Vegetative Soil Layer As-Built

3.0 EARTHWORK CQA

This section of the CQA Manual addresses earthwork (excavation and embankment) and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, field control and record tests, and resolution of problems.

3.1 Embankment Material Approval

All material to be used as compacted embankment (a.k.a. "structural fill") shall be approved in advance by the CQA Engineer. Approval is based upon successful completion of CQA control testing outlined below. Such testing can be performed either during excavation and stockpiling or from existing stockpiles prior to use.

3.1.1 Control Tests

The procedure for CQA testing during excavation and stockpiling (including existing stockpiles) is outlined below.

Each load of soil will be examined either at the borrow source or the stockpile area. Any unsuitable material will be rejected or routed to separate stockpiles consistent with its end use. Appropriate entries will be made in the daily log.

During stockpiling operations, control tests, as shown on **Table 3.1**, will be performed by the CQA Engineer prior to placement of any compacted embankment.

3.2 Subgrade Approval

The CQA Engineer will verify that the subgrade for placement of compacted embankment is constructed in accordance with the project specifications.

3.3 Test Fill Construction

A test fill meeting the requirements of the project specifications will be constructed using the same construction methods, equipment, and material to be used for the embankment component. The test fill construction will be conducted prior to the beginning embankment construction where the Contractor plans to construct Embankment using compacted lifts in excess of eight (8) inches.

Construction equipment and methods will be reviewed by the CQA Engineer prior to test fill placement.

3.3.1 Control Tests

The control tests, as shown on **Table 3.2**, will be performed by the CQA Engineer prior to placement of embankment material in the test fill.

3.3.2 Record Tests

The record tests, as shown on **Table 3.2**, will be performed by the CQA Engineer during placement of embankment material in the test fill.

3.3.3 Test Fill Completion

The test fill program will be used to determine the maximum allowable (compacted) lift thickness that can meet the project specifications. The test fill be completed when the Contractor has shown that the embankment constructed to a specified maximum thickness using the same construction methods, equipment, and material to be used in construction of the embankment will satisfy project specifications. No embankment can be placed until the test fill program is completed. Changes in equipment, material or lift thickness will require completion of a new test fill program, prior to continuing embankment construction.

3.4 Earthwork Construction

3.4.1 Construction Monitoring

A. Earthwork shall be performed as described in the project specifications.

B. Only soil previously approved by the CQA Engineer (see **Section 3.1**) shall be used in construction of the compacted embankment. Unsuitable material will be removed prior to acceptance by the CQA Engineer.

C. All required field density and moisture content tests shall be completed before the overlying lift of soil is placed. The surface preparation (e.g. wetting, drying, scarification, etc.) shall be completed before the CQA Engineer will allow placement of subsequent lifts.

D. The CQA Engineer will monitor protection of the earthwork during and after construction.

3.4.2 Control Tests

The control tests, as shown on **Table 3.3**, will be performed by the CQA Engineer prior to placement of compacted embankment.

3.4.3 Record Tests

The record tests, as shown on **Table 3.3**, will be performed by the CQA Engineer during placement of compacted embankment.

3.4.3.1 Record Test Failure

Recompaction of the failed area shall be performed and retested until the area meets or exceeds requirements outlined in the specifications.

3.4.4 Judgmental Testing

During construction, the frequency of control and/or record testing may be increased at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- the rollers slip during rolling operation;
- the lift thickness is greater than specified;
- the fill material is at an improper moisture content;
- fewer than the specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- the rollers may not have used optimum ballast;
- the fill materials differ substantially from those specified; or
- the degree of compaction is doubtful.

3.5 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 3.1 CQA Testing Program for Embankment Material Approval

Property	Test Method	Minimum Test Frequency
Control Tests:		
Visual Classification	ASTM D 2488	Each Soil
Moisture-Density Relationship	ASTM D 698	5,000 CY per Each Soil

Table 3.2 CQA Testing Program for Compacted Embankment Test Fill

Property	Test Method	Minimum Test Frequency
Control Tests:		
Visual Classification	ASTM D 2488	1 per Lift
Moisture-Density Relationship	ASTM D 698	1 per Lift
Record Tests:		
Lift Thickness	-----	1 per Lift
In-Place Density	ASTM D 6938[1]	3 per Lift
Moisture Content	ASTM D 6938[2]	

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.

2. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every 10 nuclear moisture tests perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.

3. These tests performed on the test fill may count toward the minimum frequencies established in **Table 3.1**.

Table 3.3 CQA Testing Program for Compacted Embankment

Property	Test Method	Minimum Test Frequency
Control Tests: (See **Table 3.1**)		
Record Tests:		
Lift Thickness	-----	Each Soil
In-Place Density	ASTM D 6938[1]	10,000 ft^2 per Lift & 1 per 500 LF/Lift of Berms (< 200 ft. Base Width)
Moisture Content	ASTM D 6938[2]	

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.

2. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every 10 nuclear moisture tests perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.

4.0 SUBBASE CQA

This section of the CQA Manual addresses the subbase component of the liner system and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, test fill construction, field and laboratory control and record tests, and resolution of problems.

4.1 Subbase Material Approval

All material to be used as subbase shall be approved in advance by the CQA Engineer. Approval is based upon successful completion of CQA control testing outlined below. Such testing can be performed either during excavation and stockpiling or from existing stockpiles prior to use.

4.1.1 Control Tests

The procedure for CQA testing during excavation and stockpiling (including existing stockpiles) is outlined below.

Each load of soil will be examined either at the borrow source or the stockpile area. Any unsuitable material will be rejected or routed to separate stockpiles consistent with its end use. Appropriate entries will be made in the daily log.

During stockpiling operations, control tests, as shown on **Table 4.1**, will be performed by the CQA Engineer prior to placement of any subbase material.

4.2 Subgrade Approval

The CQA Engineer will verify that the subgrade is constructed in accordance with the project specifications.

4.3 Test Fill Construction

A test fill meeting the requirements of the project specifications will be constructed using the same construction methods, equipment, and material to be used for the subbase component. The test fill construction will be conducted prior to the beginning of construction of the subbase component.

Construction equipment and methods will be reviewed by the CQA Engineer prior to test fill placement.

4.3.2 Control Tests

The control tests, as shown on **Table 4.2**, will be performed by the CQA Engineer prior to placement of subbase material in the test fill.

4.3.3 Record Tests

The record tests, as shown on **Table 4.2**, will be performed by the CQA Engineer during placement of subbase material in the test fill.

4.3.4 Test Fill Completion

The test fill program is completed when the Contractor has shown that the subbase constructed using the same construction methods, equipment, and material to be used in construction of the subbase will satisfy project specifications. No subbase can be placed until the test fill program is completed.

4.4 Subbase Construction

4.4.1 Construction Monitoring

A. Subbase shall be placed as described in the applicable section(s) of the project specifications using the construction methods, equipment, and material demonstrated in the test fill construction.

B. Only soil previously approved by the CQA Engineer (see **Section 4.1**) shall be used in construction of the subbase. Unsuitable material will be removed prior to acceptance by the CQA Engineer.

C. All required field density and moisture content tests shall be completed before the overlying lift of soil is placed. The surface preparation (e.g. wetting, drying, scarification, etc.) shall be completed before the CQA Engineer will allow placement of subsequent lifts.

D. The CQA Engineer will monitor protection of the subbase during and after construction.

E. The liner surface shall be sprinkled with water as needed to prevent desiccation. Should desiccation occur, the last lift shall be reconstructed in accordance with the project specifications. Standing water should not be present on the subbase.

F. Frost heave or other damage due to freezing shall require lift reconstruction in accordance with the project specifications.

G. The CQA Engineer will inspect the subbase and certify that it is in accordance with the project specifications and approved plans prior to the Contractor beginning installation of overlying geosynthetics.

H. The finished subbase shall be free of all protrusions. For minor surface cracking (1/4-inch or less), the Contractor may add water to the surface of the Subbase and roll the surface with a smooth-drum roller where the thickness of the subbase has been shown to be in excess of 6.25-inches. For more significant cracking (greater than ¼-inch), the Subbase shall be scarified and reworked. Any testing performed prior to reworking shall be repeated at the Contractor's sole expense. No rubber tired vehicles are permitted on the final dressed surface unless authorized by the CQA Engineer.

I. The surface on which the overlying geosynthetics are to be placed shall be maintained in a firm, clean, and smooth condition and shall be within the acceptable moisture range before and during the geosynthetics installation.

J. The subbase shall be hard, uniform, smooth, and free of debris, rock, plant materials, and other foreign materials.

4.4.2 Control Tests

The control tests, as shown on **Table 4.3**, will be performed by the CQA Engineer prior to placement of subbase material.

4.4.3 Record Tests

The record tests, as shown on **Table 4.3** and as described below, will be performed by the CQA Engineer during placement of subbase material.

A. Each lift will be checked visually for soil clods, rocks, debris, plant materials and other foreign material. Any such material which does not meet specified requirements shall be identified and removed prior to and during the compaction process, see **Section 4.4.1.H**.

B. The thickness of the loose lift will be measured at random locations after spreading and leveling is completed. Loose lift thickness should not exceed the depth of penetration of the compaction feet.

C. Moisture content will be monitored by the CQA Engineer prior to compaction. If the soil is drier than the specified minimum moisture content, water will be added and the lift will be disced to distribute the moisture evenly.

Results of testing will be certified within 7 days of subbase placement.

4.4.3.1 Record Test Failure

The following procedures shall be used in the event of density or hydraulic conductivity test failure:

A. Failed Density Test: Recompaction of the failed area shall be performed and retested until the area meets or exceeds requirements outlined in the specifications. In order to delineate the extent of a failing area, the CQA will test adjacent locations in a minimum of four (4) directions from the initial failing test. A passing test must be achieve in each direction.

B. Failed Hydraulic Conductivity Test: The area of failure shall be localized and reconstructed in accordance with the project specifications. This area will be retested as outlined within the plan by the CQA Engineer. Optionally, at least five (5) replicate samples shall be obtained and tested by the Contractor in the immediate vicinity of the failed test. If all five samples pass, then the initial failing test will be discounted. However, should the replicate samples confirm the failure of the subbase to meet specifications, the area of failure shall be localized, reconstructed, and retested as described in **Section 4.4.3.1.A**.

4.4.4 Judgmental Testing

During construction, the frequency of control and/or record testing may be increased at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- the rollers slip during rolling operation;
- the lift thickness is greater than specified;
- the fill material is at an improper moisture content;
- fewer than the specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- the rollers may not have used optimum ballast;
- the fill materials differ substantially from those specified; or
- the degree of compaction is doubtful.

4.4.5 Perforations In Subbase

Locations of control stakes, in-place density tests, or other samples in the Subbase shall be patched with sodium bentonite, compacted and hydrated in the holes. Any other repairs shall be performed in accordance with **Section 4.4.1.H**.

4.5 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 4.1 CQA Testing Program for Subbase Material Approval

Property	Test Method	Minimum Test Frequency
Control Tests:		
Visual Classification	ASTM D 2488	Each Soil
Moisture Content	ASTM D 2216	2,000 CY per Each Soil
Grain Size Analysis	ASTM D 6913	2,000 CY per Each Soil
Atterberg Limits	ASTM D 4318	2,000 CY per Each Soil
Moisture-Density Relationship	ASTM D 698	5,000 CY per Each Soil
Hydraulic Conductivity - Lab Remolded	ASTM D 5084[1]	10,000 CY per Each Soil

Note:

1. Maximum effective confining pressure and hydraulic gradient as required by the project specifications. Backpressure as recommended by ASTM D 5084.

Table 4.2 CQA Testing Program for Subbase Test Fill

Property	Test Method	Minimum Test Frequency
Control Tests: (See **Table 4.1**)**:**		
Moisture-Density Relationship	ASTM D 698[4]	1 per Lift
Hydraulic Conductivity - Lab Remolded	ASTM D 5084[3,4]	1 per Lift
Record Tests:		
Lift Thickness	-----	Each Lift
Atterberg Limits	ASTM D 4318	1 per Lift
Grain Size Analysis	ASTM D 6913	1 per Lift
In-Place Density	ASTM D 6938[1]	3 per Lift
Moisture Content	ASTM D 6938[2]	3 per Lift
Hydraulic Conductivity - Undisturbed (Shelby Tube)	ASTM D 5084[3]	1 per Lift

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.

2. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every 10 nuclear moisture tests perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.

3. Maximum effective confining pressure and hydraulic gradient as required by the project specifications. Backpressure as recommended by ASTM D 5084.

4. These tests performed on the test fill may count toward the minimum frequencies established in **Table 4.1**.

Table 4.3 CQA Testing Program for Subbase

Property	Test Method	Minimum Test Frequency
Control Tests: (See **Table 4.1**)**:**		
Record Tests:		
Lift Thickness	-----	1 depth check per acre
In-Place Density	ASTM D 6938[1,4]	10,000 ft^2 per Lift
Moisture Content	ASTM D 6938[2,4]	10,000 ft^2 per Lift
Hydraulic Conductivity - Undisturbed (Shelby Tube)	ASTM D 5084[3,4]	40,000 ft^2 per Lift

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.

2. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every 10 nuclear moisture tests perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.

3. Maximum effective confining pressure and hydraulic gradient as required by the project specifications. Backpressure as recommended by ASTM D 5084.

4. A 100’ x 100’ grid will be used by the CQA Engineer to help ensure the uniformity of coverage of in-place testing.

5.0 GEOMEMBRANE CQA

This section of the CQA Manual addresses the geomembrane components of the liner and final cover systems and outlines the CQA program to be implemented with regard to manufacturer and installer approval, material approval, Subbase or Intermediate Cover approval, field and laboratory control and record tests, repairs, and resolution of problems.

5.1 Geomembrane Manufacturer and Installer Approval

The Contractor shall submit the qualifications of the Geomembrane Manufacturer and the Geomembrane Installer, as described in the specifications, to the CQA Engineer for approval.

5.2 Geomembrane Material Approval

5.2.1 Geomembrane Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

5.2.2 Shipment And Storage

During shipment and storage, all geomembrane will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

5.2.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls or sheets related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications

5.2.4 Material Control Tests

Samples for material control tests, as shown on **Table 5.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the geomembrane. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be three (3) feet long by the roll or sheet width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All control test results must be available at the site prior to the deployment of all geomembrane. The CQA Engineer will examine all results from laboratory conformance testing.

5.2.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geomembrane Installer will replace the roll or sheet of geomembrane that is in nonconformance with the project specifications with a roll or sheet that meets project specifications.

B. The Geomembrane Installer will remove conformance samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll or sheet on both sides of the failed roll or sheet. These two samples must both conform to project specifications. If either of these samples fails, then the next numerical roll or sheet will be tested until a passing roll or sheet is found. This additional conformance testing will be at the expense of the Geomembrane Installer. If either of the two closest rolls or sheets fails, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

5.3 Geomembrane Installation

5.3.1 Handling

The Geosynthetic Installer will handle all geomembrane in such a manner as required by the project specifications.

5.3.2 Earthwork

5.3.2.1 Surface Preparation

The Geomembrane Installer will certify in writing that the surface on which the geomembrane will be installed meets line and grade, and the surface preparation requirements of the project specifications. The certificate of acceptance will be given to the CQA Engineer prior to commencement of geomembrane installation in the area under consideration. The CQA Engineer will give a copy of this certificate to the Engineer.

To ensure a timely covering of the subbase or intermediate cover surface, the Engineer may allow acceptance of these surfaces in areas as small as one (1) acre. After the supporting soil has been accepted by the Geomembrane Installer, it will be the Geomembrane Installer's responsibility to indicate to the Engineer and CQA Engineer any change in the supporting soil condition that may require repair work. If the CQA

Engineer concurs with the Geomembrane Installer, then the Engineer will ensure that the supporting soil is repaired.

5.3.2.2 Anchorage System

The CQA Engineer will verify that anchor trenches have been constructed and backfilled according to project specifications and design drawings.

5.3.3 Geomembrane Placement

5.3.3.1 Field Panel Identification

The CQA Engineer will document that the Geomembrane Installer labels each field panel with an "identification code" (number or letter-number consistent with the layout plan) agreed upon by the Geomembrane Installer and CQA Engineer at the Geosynthetics CQA Meeting (see **Section 1.6.2**).

The Geomembrane Installer will establish a table or chart showing correspondence between roll or sheet numbers and field panel identification codes. This documentation shall be submitted to the CQA Engineer weekly for review and verification. The field panel identification code will be used for all quality control and quality assurance records.

5.3.3.2 Field Panel Placement

Location: The CQA Engineer will verify that field panels are installed at the location indicated in the Geomembrane Installer's layout plan, as approved or modified in **Section 5.3.3.1**.

Installation Schedule: The CQA Engineer will evaluate every change in the schedule proposed by the Geomembrane Installer and advise the Engineer on the acceptability of that change.

The CQA Engineer will record the identification code, location, and date of installation of each field panel.

Placement of Geomembrane: The CQA Engineer will verify that project specification related restrictions on placement of geomembrane are fulfilled. Additionally, the CQA Engineer will verify that the supporting soil has not been damaged by weather conditions.

Damage: The CQA Engineer will visually observe each panel, after placement and prior to seaming, for damage. The CQA Engineer will advise the Engineer which panels, or portion of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected will be marked and their removal from the work area recorded by the CQA Engineer. Repairs will be made according to procedures described in this section.

As a minimum, the CQA Engineer will document that:

- the panel is placed in such a manner that it is unlikely to be damaged; and

- any tears, punctures, holes, thin spots, etc. are either marked by the Geomembrane Installer for repair or the panel is rejected.

5.3.4 Field Seaming

5.3.4.1 Seam Layout

The Geomembrane Installer will provide the CQA Engineer with a seam layout drawing, i.e., a drawing of the area to be lined showing all expected seams. The CQA Engineer and Engineer will review the seam layout drawing and verify that it is consistent with the accepted state of practice and this CQA Manual.

A seam numbering system compatible with the panel numbering system will be agreed upon at the Geosynthetics CQA Meeting (see **Section 1.6.2**). An on-going written record of the seams and repair areas shall be maintained by the Geomembrane Installer with weekly review by the CQA Engineer.

5.3.4.2 Requirements of Personnel

The Geomembrane Installer will provide the CQA Engineer with a list of proposed seaming personnel and their experience records. This document will be reviewed by the CQA Engineer for compliance with project specifications.

5.3.4.3 Seaming Equipment and Products

Field seaming processes must comply with project specifications. Proposed alternate processes will be documented and submitted to the Engineer and CQA Engineer for their approval. Only seaming apparatus which have been specifically approved by make and model will be used. The CQA Engineer will submit all documentation to the Engineer for the Engineer's concurrence.

5.3.5 Field Seam Control Tests

5.3.5.1 Trial Seams

A. Prior to production seaming, after four (4) hours of continuous seaming, and/or when significant changes in geomembrane or ambient temperature occurs, the Geomembrane Installer shall perform trial seams to verify that seaming conditions and procedures are adequate. Trial seams shall be performed by each operator of extrusion welders and by the primary operator of each wedge welder using seaming equipment to be used in production seaming.

B. Trial seams shall be made on appropriate sized pieces of identical or equivalent geomembrane material.

C. Hot wedge trial seams shall be approximately 72" x 12" with the seam centered lengthwise. Extrusion fillet trial seams shall be approximately 36" x 12" with the seam centered lengthwise. A minimum of four coupons shall be tested in peel and shear (two each) (ASTM D 6392) by the Geomembrane Installer using a field tensiometer. All coupons shall meet the minimum seam strength requirements as shown in the project specifications.

D. Each trial seam shall be assigned a number and the test results recorded in the appropriate log by the Geomembrane Installer. The CQA Engineer will observe all trial seams and compile all trial seam logs.

5.3.6 Field Seam Record Tests

5.3.6.1 Nondestructive Seam Continuity Testing

The Geomembrane Installer shall test and document all seams continuously over their full length using one of the following nondestructive seam tests. This testing shall be performed simultaneously with geomembrane deployment as the work progresses and not at the completion of all field seaming.

A. Vacuum Testing shall conform to ASTM D 5641 requirements.

B. Air Pressure Testing (for double seam with an enclosed space) shall conform to ASTM D 5820 requirements and the requirements listed in **Table 5.2**.

C. Electric leak location (for sump areas) shall conform to ASTM D787 or ASTM D7703 requirements.

D. Spark testing shall conform to ASTM D6365 requirements.

The CQA Engineer will observe the nondestructive testing on a full time basis to ensure conformance with this CQA Manual and the project specifications.

5.3.6.2 Field Destructive Seam Testing

A. The Geomembrane Installer shall obtain 12” x 30” (or longer as needed) samples of field seams with the seam centered lengthwise, suitable for testing, at a minimum frequency of one sample per 500 linear feet of seam (or one sample per seam on shorter seams (i.e., when there is a change in welding machine and/or welder)). The sample shall be cut into two equal-length pieces, one for field destructive seam testing by the Geosynthetics Installer and one given to the CQA Engineer as an archive sample. The date, time,

equipment, seam number, and seaming parameters will be marked on each sample and recorded by the CQA Engineer.

B. The Geomembrane Installer shall perform and document field destructive seam testing using a field tensiometer which has been calibrated within the prior six (6) months (calibration information shall be provided to the CQA Engineer). A minimum of five (5) coupons each will be tested in peel and shear (ASTM D 6392). Coupons shall meet the minimum seam strength requirements as shown in the project specifications.

C. The CQA Engineer or the Owner may require additional random samples to be taken for testing in areas which visually appear defective and not in accordance with the project requirements.

D. All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in **Section 5.3.7**.

5.3.6.3 Geosynthetics CQA Laboratory Destructive Testing

A. The Geomembrane Installer shall obtain 12" x 30" (or longer as needed) samples of field seams with the seam centered lengthwise, suitable for testing, at an average frequency of one sample per day to confirm field destructive seam tests. The sample shall be cut into two equal-length pieces, both to be given to the CQA Engineer for laboratory destructive seam testing and as an archive sample. The date, time, equipment, seam number, and seaming parameters will be marked on each sample and recorded by the CQA Engineer.

B. Laboratory destructive test samples will be packaged and shipped to the Geosynthetics CQA Laboratory by the CQA Engineer in a manner that will not damage the test sample.

C. A minimum of five (5) coupons each will be tested in peel and shear (ASTM D 6392) by the Geosynthetics CQA Laboratory. Coupons shall meet the minimum seam strength requirements as shown in the project specifications.

D. All geomembrane destructive test samples that fail to meet project specifications will be saved and sent to the CQA Engineer for observation.

E. The CQA Engineer will review laboratory test results as soon as they become available.

5.3.6.4 Field Seam Record Test Failure

For noncomplying tests, the CQA Engineer will:

- observe continuity testing of the repaired areas performed by the Geomembrane Installer;

- confirm the record location, date, test unit number, name of tester, and compile the record of testing provided by the Geomembrane Installer;

- provide a walk-through inspection of all impacted seam areas and verify that the areas have been tested in accordance with the CQA Manual and project specifications; and

- verify that the Geomembrane Installer has marked repair areas with the appropriate color-coded marking pencil.

5.3.6.5 Defining Extent of Field Seam Record Test Failure

All defective seam test failures must be bounded by acceptable destructive tests. The CQA Engineer will document repair actions taken in conjunction with all seam test failures.

5.3.7 Repairs & Verification

5.3.7.1 Repair Procedures

A. All repair procedures shall be in accordance with the project specifications. The CQA Engineer will observe all repair procedures.

B. All surfaces shall be clean and dry at the time of the repair.

C. After an extrusion seam is made, no overgrinding shall be left exposed after an extrusion seam is completed.

5.3.7.2 Repair Verification

A. Each repair shall be numbered and logged by the Geomembrane Installer.

B. Each repair shall be non-destructively tested by the Geomembrane Installer using the methods described above. Repairs which pass non-destructive testing shall be taken as an indication of an adequate repair.

C. Repairs more than 150 feet long may be of sufficient length to require destructive test sampling, at the discretion of the CQA Engineer. A failed test indicates that the repair shall be redone and retested until passing test results are achieved.

5.4 Liner System Acceptance

The geomembrane component of the liner system will be accepted by the Owner when:

- the installation is finished;

- verification of the adequacy of all seams and repairs, including associated testing, is complete;

- CQA Engineer provides the Engineer with a final copy of the nondestructive test documentation, repair information, and as-built drawings, as submitted by the Geomembrane Installer;

- CQA Engineer provides the Engineer with a certification, submitted by the Geomembrane Installer that the geomembrane was installed in accordance with the Geomembrane Manufacturer's recommendations as well as the project drawings and project specifications; and

- all documentation of the installation is completed including the CQA Engineer's final report.

5.5 Materials in Contact with Geomembranes

The quality assurance procedures indicated in this subsection are only intended to assure that the installation of these materials does not damage the geomembrane. All reasonable measures to protect the geomembrane and provide additional quality assurance procedures are necessary to assure that systems built with these materials will be constructed to ensure proper performance.

5.5.1 Soils

Prior to placement, the CQA Engineer will visually confirm that all soil materials to be placed against the geomembrane comply with project specifications. The Geomembrane Installer will provide the CQA Engineer a written surface acceptance certificate in accordance with **Section 5.3.2**. All soil materials shall be placed and compacted in accordance with project specifications.

5.5.2 Sumps and Boots

The CQA Engineer will verify that:

- installation of the geomembrane in sump areas, and connection of the geomembrane to boots have been made according to the project specifications; and

- the geomembrane or boots have not been visibly damaged while making connections.

5.6 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 5.1 CQA Testing Program for Geomembrane Material Approval

Property	Test Method	Minimum Test Frequency
Control Tests:		
Thickness	ASTM D 5199/D 5994	100,000 ft^2 or 1 per Lot[1]
Density	ASTM D 1505/D 792	100,000 ft^2 or 1 per Lot[1]
Carbon Black Content	ASTM D 1603	100,000 ft^2 or 1 per Lot[1]
Carbon Black Dispersion	ASTM D 5596	100,000 ft^2 or 1 per Lot[1]
Tensile Properties: Tensile Strength at Yield Tensile Strength at Break Elongation at Yield Elongation at Break	ASTM D 6693 (Type IV)	100,000 ft^2 or 1 per Lot[1]
Tear Resistance	ASTM D 1004	100,000 ft^2 or 1 per Lot[1]
Asperity Height	ASTM D 7466	100,000 ft^2 or 1 per Lot[1]
Puncture Resistance	ASTM D 4833	100,000 ft^2 or 1 per Lot[1]
Oxidative Induction Time	ASTM D 1004	1 per Lot

Notes:

1. Whichever provides the larger number of tests.

Table 5.2 Air Pressure Test Requirements

Material	Minimum Pressure (PSI)	Maximum Pressure Drop (PSI) After 5 Minutes
40 Mil LLDPE ≥ 60 Mil HDPE	25	3

6.0 LEACHATE MANAGEMENT SYSTEM CQA

This section of the CQA Manual addresses the components of the leachate management system including components of the leachate detection and collection systems (LDS/LCS) (drainage aggregate, collection pipe, protective cover, and geosynthetic rain cover) and the leachate transmission and storage system (sumps, transmission piping, manholes, valves, and storage tanks). By reference to **Sections 7.0 and 8.0** of this CQA Manual, this section also addresses the geotextiles and drainage geocomposite that are components of the LDS/LCS. This section outlines the CQA program to be implemented with regard to material approval, construction monitoring, and resolution of problems.

6.1 Leachate Management System Material Approval

The CQA Engineer will verify that the following are provided and installed in accordance with the project drawings, specifications, and this CQA Manual.

6.1.1 Coarse Aggregate (Drainage Aggregate)

A. Receipt of Contractor's submittals on coarse aggregate.

B. Review of submittals for coarse aggregate for conformity to the project specifications.

C. Verify that coarse aggregate in stockpiles or at borrow sources conforms to the project specifications.

D. Conduct material control tests in accordance with **Table 6.1**.

6.1.2 Leachate Detection/Protective Cover Media (Drainage Aggregate)

A. Receipt of Contractor's submittals on leachate collection media.

B. Review of submittals for leachate collection media for conformity to the project specifications.

C. Verify that collection media in stockpiles or at borrow sources conforms to the project specifications.

D. Conduct material control tests in accordance with **Table 6.1**.

6.1.3 High Density Polyethylene (HDPE) Pipe

A. Receipt of Contractor's submittals on HDPE pipe.

B. Review of submittals for HDPE pipe for conformity to the project specifications.

6.1.4 Geotextiles (Verify for each type of Geotextile)

The CQA program for geotextiles is presented in **Section 7.0** of this CQA Manual.

6.1.5 Drainage Geocomposite

The CQA program for drainage geocomposite is presented in **Section 8.0** of this CQA Manual.

6.1.6 Geosynthetic Rain Cover

A. Receipt of Contractor's submittals on Geosynthetic Rain Cover.

B. Review of submittals for Geosynthetic Rain Cover for conformity to the project specifications.

6.1.7 Sumps/Manholes/Tanks

A. Receipt of Contractor's submittals on sumps/manholes/tanks.

B. Review of submittals for sumps/manholes/tanks for conformity to the project specifications.

6.1.8 Valves

A. Receipt of Contractor's submittals on valves.

B. Review of submittals for valves for conformity to the project specifications.

6.2 Leachate Management System Installation

6.2.1 Leachate Detection and Collection Systems (LDS/LCS)

The CQA Engineer will allow installation of the LDS/LCS to proceed only after he has been provided certification of the installed HDPE geomembrane.

The CQA Engineer will monitor and document the construction of all LDS/LCS components for compliance with the project specifications. Monitoring the construction work includes the following:

- monitoring the minimum vertical buffer maintained between field equipment and the geomembrane;
- monitoring that the placement of the LDS/LCS components does not fold or damage the geomembrane or other underlying layers; and
- witness and verify the installation of collection piping and gravel columns.

6.2.2 Leachate Transmission and Storage System

The CQA Engineer will monitor and document the construction of all leachate transmission and storage system components for compliance with the project specifications. Monitoring the construction work includes the following:

- witness and verify the installation of transmission piping;

- witness and verify the leak testing of transmission piping; and
- witness and verify the leak testing of manholes and storage tanks (where applicable).

6.3 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 6.1 CQA Testing Program for Leachate Management System

Component	Property	Test Method	Minimum Test Frequency
Control Tests:			
Coarse Aggregate:	Gradation	ASTM C 136	5,000 CY
	Carbonate Content	ASTM D 3042	2 per source
Leachate Detection Media/ Protective Cover Media:	Gradation	ASTM C 136	5,000 CY
	Permeability	ASTM D 2434	2 per Source
	Carbonate Content	ASTM D 3042	2 per Source

7.0 GEOTEXTILE CQA

This section of the CQA Manual addresses geotextiles and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

7.1 Geotextile Material Approval

7.1.1 Geotextile Product Data

For each type of geotextile to be used, the CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

7.1.2 Shipment And Storage

During shipment and storage, all geotextiles will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

7.1.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

7.1.4 Geotextile Material Control Tests

Samples for material control tests, as shown on **Table 7.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the geotextiles. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be three (3) feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all geotextiles. The CQA Engineer will examine all results from laboratory testing.

7.1.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of geotextile that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fails, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fails, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

7.2 Geotextile Installation

7.2.1 Handling And Placement

The Geosynthetic Installer will handle and place all geotextiles in such a manner as required by the project specifications.

7.2.2 Seams And Overlaps

All geotextiles will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer. The CQA Engineer will conduct a visual inspection of all geotextile seams to verify bonding.

7.2.3 Repairs

Any holes or tears in the geotextile will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

7.2.4 Placement Of Overlying Materials

All soil materials located on top of a geotextile shall be placed in accordance with the project specifications.

7.3 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 7.1 CQA Testing Program for Geotextile Material Approval

Property	Test Method	Minimum Test Frequency
Control Tests:		
Tensile Properties	ASTM D 4632	100,000 ft^2 or 1 per Lot[1]
Puncture Resistance	ASTM D 6241	100,000 ft^2 or 1 per Lot[1]
Trapezoidal Tear Strength	ASTM D 4533	100,000 ft^2 or 1 per Lot[1]
Mass Per Unit Area (Type GT- C Geotextile Only)	ASTM D 5261	100,000 ft^2 or 1 per Lot[1]
Apparent Opening Size (AOS) (Type GT-S Geotextile Only)	ASTM D 4751	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.
2. CQA testing is not required for geotextiles placed outside of the containment area.

8.0 DRAINAGE GEOCOMPOSITE CQA

This section of the CQA Manual addresses drainage geocomposite (DGC) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

8.1 DGC Material Approval

8.1.1 DGC Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

8.1.2 Shipment And Storage

During shipment and storage, all DGC will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

8.1.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

8.1.4 DGC Material Control Tests

Samples for material control tests, as shown on **Table 8.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the DGC. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be three (3) feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all DGC. The CQA Engineer will examine all results from laboratory testing.

8.1.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of DGC that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fails, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fails, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

8.2 DGC Installation

8.2.1 Handling And Placement

The Geosynthetic Installer will handle and place all DGC in such a manner as required by the project specifications.

8.2.2 Stacking And Joining

When several layers of DGC are stacked, care should be taken to ensure that stacked DGC are placed in the same direction. Stacked DGC will never be laid in perpendicular directions to the underlying DGC (unless otherwise specified by the Engineer). The CQA Engineer will observe the stacking of DGC.

Adjacent rolls of DGC will be joined according to construction drawings and project specifications. The CQA Engineer will conduct a visual inspection of all drainage geocomposite seams to verify bonding.

8.2.3 Repairs

Any holes or tears in the DGC will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

8.2.4 Placement Of Overlying Materials

All soil materials located on top of DGC shall be placed in accordance with the project specifications.

8.3 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 8.1 CQA Testing Program for Drainage Geocomposite Material Approval

Property	Test Method	Minimum Test Frequency
Control Tests:		
Thickness (geonet only)	ASTM D 5199	100,000 ft^2 or 1 per Lot[1]
Density (geonet only)	ASTM D 1505	100,000 ft^2 or 1 per Lot[1]
Ply Adhesion	ASTM D 7005	100,000 ft^2 or 1 per Lot[1]
Transmissivity	ASTM D 4716[2]	1 per Resin Lot

Notes:

1. Whichever provides the larger number of tests.

2. Conduct tests for transmissivity in accordance with the conditions given in the project specifications.

9.0 GEOSYNTHETIC CLAY LINER (GCL) CQA

This section of the CQA Manual addresses geosynthetic clay liner (GCL) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

9.1 GCL Manufacturer and Installer Approval

The Contractor shall submit the qualifications of the GCL Manufacturer and the GCL Installer, as described in the specifications, to the CQA Engineer for approval.

9.2 GCL Material Approval

9.2.1 GCL Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

9.2.2 Shipment And Storage

During shipment and storage, GCL will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

9.2.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

9.2.4 GCL Material Control Tests

Samples for material control tests, as shown on **Table 9.1**, will be obtained by the CQA Engineer at the indicated frequencies upon delivery of the GCL. Alternatively, samples may be randomly obtained at the manufacturing site by the CQA Engineer or representatives of the Geosynthetics CQA Laboratory.

Unless otherwise specified, samples will be three (3) feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all GCL. The CQA Engineer will examine all results from laboratory testing.

9.2.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of GCL that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fails, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fails, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

9.3 GCL Installation

9.3.1 Surface Preparation

The Geosynthetics Installer will certify in writing that the surface on which the GCL will be installed meets line and grade, and the surface preparation requirements of the project specifications. The certificate of acceptance will be given to the CQA Engineer prior to commencement of GCL installation in the area under consideration. The CQA Engineer will give a copy of this certificate to the Engineer.

To ensure a timely covering of the drainage geocomposite, the Engineer may allow acceptance of the installed drainage composite in areas as small as one acre. After acceptance by the Geosynthetics Installer, it will be the Geosynthetics Installer's responsibility to indicate to the Engineer and CQA Engineer any change in the supporting surface conditions that may require repair work. If the CQA Engineer concurs with the Geosynthetics Installer, then the Engineer will ensure that the supporting surface is repaired.

9.3.2 Handling And Placement

The Geosynthetic Installer will handle and place all GCL in such a manner as required by the project specifications.

9.3.3 Seams And Overlaps

All GCL will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer.

9.3.4 Repairs

Any holes or tears in the GCL will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

9.3.5 Placement Of Overlying Materials

HPDE Geomembrane materials located on top of the GCL shall be placed in accordance with the project technical specifications.

9.4 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 9.1 CQA Testing Program for GCL Material Approval

Property	Test Method	Minimum Test Frequency
Control Tests:		
Hydraulic Conductivity	ASTM D 5084/D 5887	100,000 ft^2 or 1 per Lot[1]
Bentonite Content	ASTM D 5993 (@ 0% moisture)	100,000 ft^2 or 1 per Lot[1]
Peel Strength	ASTM D 6496	100,000 ft^2 or 1 per Lot[1]

Notes:

1. Whichever provides the larger number of tests.

10.0 FINAL COVER SYSTEM CQA

This section of the CQA Manual addresses the landfill gas (LFG) system, drainage aggregate and piping, and the vegetative soil layer of the final cover system. By reference to **Sections 5.0, 7.0, and 8.0** of this CQA Manual, this section also addresses the geomembrane, geotextiles, and drainage geocomposite that are included in the final cover system. This section outlines the CQA program to be implemented with regard to material approval, construction monitoring, and resolution of problems.

10.1 Final Cover System Material Approval

The CQA Engineer shall verify that the following are provided and installed in accordance with the project drawings, specifications, and this CQA Manual.

10.1.1 High Density Polyethylene (HDPE) Pipe

A. Receipt of Contractor's submittals on HDPE pipe.

B. Review of submittals for HDPE pipe for conformity to the project specifications.

10.1.2 Polyvinyl Chloride (PVC) Pipe

A. Receipt of Contractor's submittals on PVC pipe.

B. Review of submittals for PVC pipe for conformity to the project specifications.

10.1.3 Corrugated Polyethylene (CPE) Pipe

A. Receipt of Contractor's submittals on CPE pipe.

B. Review of submittals for CPE pipe for conformity to the project specifications.

10.1.4 LFG System Components

A. Receipt of Contractor's submittals on LFG system components.

B. Review of submittals for LFG system components for conformity to the project specifications.

10.1.5 Aggregates (Verify for each type of aggregate)

A. Receipt of Contractor's submittals on aggregates.

B. Review of submittals for aggregates for conformity to the project specifications.

C. Verify that aggregates in stockpiles or at borrow sources conform to the project specifications.

D. Conduct material control tests in accordance with **Table 10.1**.

10.1.6 Geomembrane

The CQA program for geomembranes is presented in **Section 5.0** of this CQA Manual.

10.1.7 Geotextiles

The CQA program for geotextiles is presented in **Section 7.0** of this CQA Manual.

10.1.8 Drainage Geocomposite

The CQA program for drainage geocomposite is presented in **Section 8.0** of this CQA Manual.

10.1.9 Vegetative Soil Layer

A. Review the proposed source of vegetative soil layer for conformance with the project specifications.

B. Conduct material control tests in accordance with **Table 10.1**.

10.2 Final Cover System Installation

The CQA Engineer will monitor and document the construction of all final cover system components for compliance with the project specifications. Monitoring the construction work for the components of the final cover system includes the following:

- verify location and depth of LFG wells;
- verify location of all piping;
- monitoring the minimum vertical buffer maintained between field equipment and geosynthetics/piping; and
- monitoring that the placement of the final cover system components does not fold or damage the geosynthetics or other underlying layers.

10.3 Deficiencies

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies will be documented by the CQA Engineer. The Contractor shall correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer will observe all retests on repaired defects.

Table 10.1 CQA Testing Program for Final Cover System

Component	Property	Test Method	Minimum Test Frequency
Control Tests:			
Coarse Aggregate:	Gradation	ASTM C 136	5,000 CY
Vegetative Soil Layer:	Visual Classification	ASTM D 2488	Each Load
	Grain Size Analysis	ASTM D 6913	5,000 CY
	Atterberg Limits	ASTM D 4318	5,000 CY

Appendix A

Reference List of Test Methods

Construction Quality Assurance Manual
Camp Hope Run Landfill
Boggs Township, Clearfield County, Pennsylvania

Construction Quality Assurance Manual
Appendix A: Reference List of Test Methods

American Society American Society of Testing and Materials (ASTM):

ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM D 698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
ASTM D 792	Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
ASTM D 1004	Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
ASTM D 1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique.
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.
ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head).
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.
ASTM D 3042	Standard Test Method for Insoluble Residue in Carbonate Aggregates.
ASTM D 3895	Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry.
ASTM D 4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

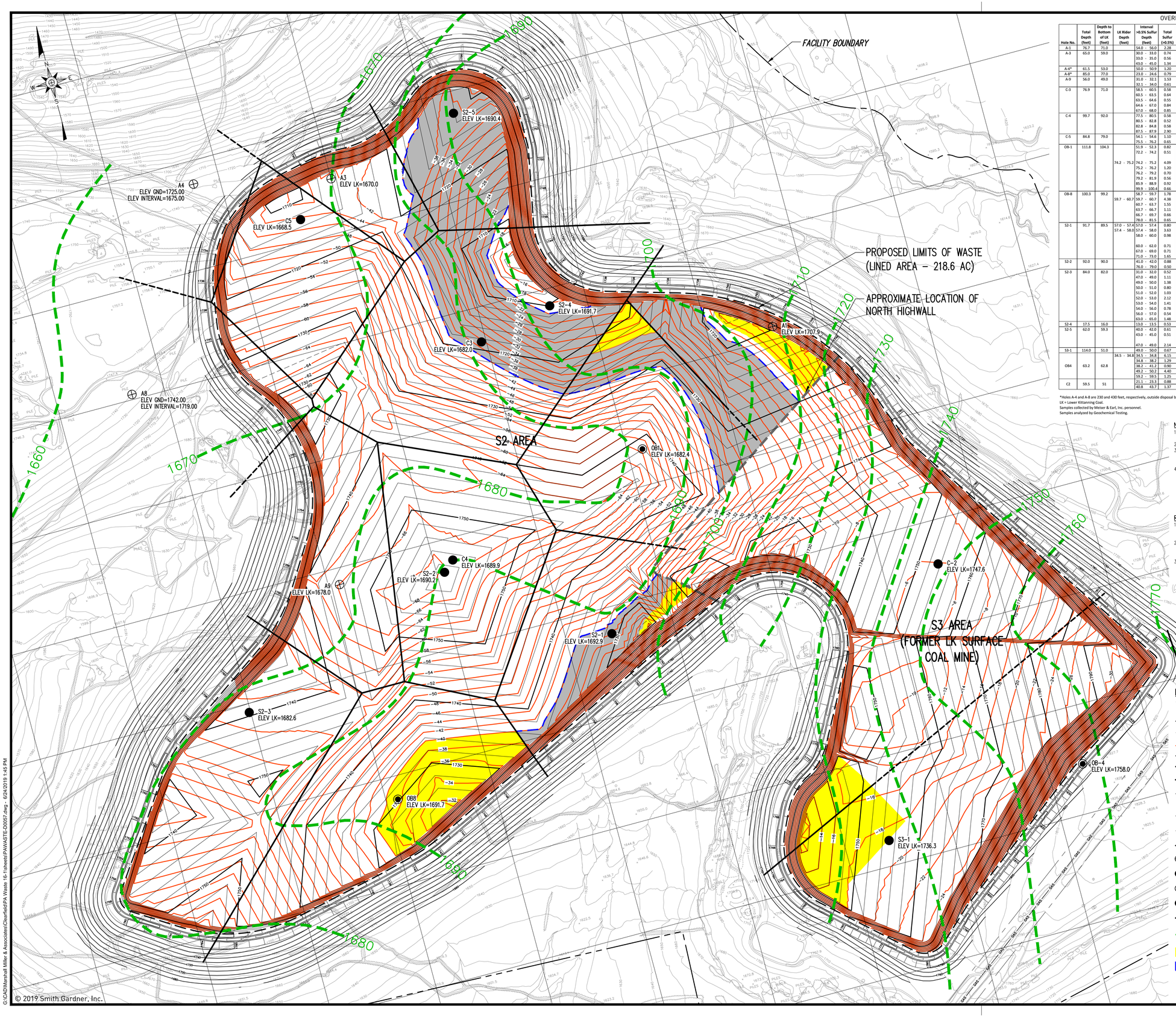
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
ASTM D 4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
ASTM D 4716	Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4959	Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.
ASTM D 5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
ASTM D 5199	Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
ASTM D 5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
ASTM D 5641	Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
ASTM D 5820	Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
ASTM D 5887	Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.
ASTM D 5993	Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners.
ASTM D 5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
ASTM D 6241	Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile Related Products Using a 50 mm Probe.

ASTM D 6391	Standard Test Method for Field Measurement of Hydraulic Conductivity Limits of Porous Materials Using Two Stages of Infiltration from a Borehole.
ASTM D 6392	Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
ASTM D 6496	Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.
ASTM D 6693	Standard Test Method for Determining Tensile Properties of Nonreinforced Flexible Polyethylene and Nonreinforced Polypropylene Geomembranes.
ASTM D 6913	Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
ASTM D 7005	Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites.
ASTM D 7466	Standard Method for Measuring the Asperity Height of Textured Geomembrane.
ASTM D 7928	Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis.

PHASE II APPLICATION
CAMP HOPE RUN LANDFILL
BOGGS TOWNSHIP, CLEARFIELD COUNTY, PENNSYLVANIA

FORM 24
EXHIBIT 24-4.3
Overburden Analyses Areas of Influence for S2 Area

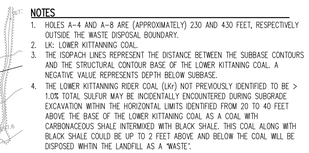
REVISED JUNE 2019



OVERBURDEN ANALYSIS SUMMARY

Hole No.	Total Depth (feet)	Depth to Bottom of LK (feet)	LK Rider Depth (feet)	Interval >0.5% Sulfur Depth (feet)	Total Sulfur (>0.5%)	Height Above Bottom of LK (feet)	LK Rider Height Above Bottom of LK (feet)	Description
A-1	76.7	71.0		54.0 - 56.0	2.28	17.0 - 15.0		Dark gray shale
A-3	65.0	59.0		30.0 - 33.0	0.74	29.0 - 26.0		Dark gray , coarse-grained sandstone, many binders
				33.0 - 35.0	0.56	26.0 - 24.0		Dark gray , coarse-grained sandstone, many binders
				43.0 - 45.0	1.34	16.0 - 14.0		Dark gray shale
A-4*	61.5	53.0		50.0 - 50.9	1.20	9.0 - 8.1		Coal and dark gray shale
A-8*	85.0	77.0		23.0 - 24.6	0.79	54.0 - 52.4		Dark gray sandy shale
A-9	56.0	49.0		31.0 - 32.1	1.53	18.0 - 16.9		Dark sandstone with coal
				32.1 - 34.0	0.61	16.9 - 15.0		Dark gray shale with black layers
C-3	76.9	71.0		58.5 - 60.5	0.58	12.5 - 10.5		Light gray sandstone laminae
				60.5 - 63.5	0.64	10.5 - 7.5		Medium-dark to medium-light gray siltstone
				63.5 - 64.6	0.55	7.5 - 6.4		Light gray, very fine-grained sandstone
				64.6 - 67.0	0.84	6.4 - 4.0		Medium gray, very fine-grained sandstone to claystone
				67.0 - 68.0	0.85	4.0 - 3.0		Dark gray claystone (on coal)
C-4	99.7	92.0		77.5 - 80.5	0.58	14.5 - 11.5		Grayish black siltstone, decreasing organic with depth
				80.5 - 82.8	0.52	11.5 - 9.2		Grayish black siltstone, decreasing organic with depth
				82.8 - 84.8	0.58	9.2 - 7.2		Grayish black siltstone, decreasing organic with depth
				87.5 - 87.9	2.90	4.5 - 4.1		Medium black to dark gray siltstone (on coal)
C-5	84.8	79.0		54.1 - 54.6	1.10	24.9 - 24.4		Fine sandstone 50%-70% coal stringers
				75.5 - 76.2	0.65	3.5 - 2.8		Medium gray, fine sandstone (on coal)
OB-1	111.8	104.3		51.9 - 52.3	0.82	52.4 - 52.0		Black carbonaceous shale intermixed with coal
				72.2 - 74.2	0.51	32.1 - 30.1		Dark gray carbonaceous sandstone, black carbonaceous shale, intermixed with coal
			74.2 - 75.2	74.2 - 75.2	4.09	30.1 - 29.1	30.1 - 29.1	Coal **LK rider**
				75.2 - 76.2	1.20	29.1 - 28.1		Dark gray carbonaceous shale intermixed with coal
				76.2 - 79.2	0.70	28.1 - 25.1		Dark gray shale
				79.2 - 81.9	0.56	25.1 - 22.4		Dark gray shale
				85.9 - 88.9	0.92	18.4 - 15.4		Dark gray shale
				99.9 - 100.4	0.66	4.4 - 3.9		Dark gray shale and coal
OB-8	100.3	99.2		58.7 - 59.7	1.78	40.5 - 39.5		Gray-black shale
			59.7 - 60.7	59.7 - 60.7	4.38	39.5 - 38.5	39.5 - 38.5	**LK rider coal** and black shale
				60.7 - 63.7	1.55	38.5 - 35.5		Dark gray clay shale
				63.7 - 66.7	1.11	35.5 - 32.5		Dark gray shale
				66.7 - 69.7	0.66	32.5 - 29.5		Dark gray shale
				78.0 - 81.5	0.65	21.2 - 17.7		Dark gray clay shale
S2-1	91.7	89.5	57.0 - 57.4	57.0 - 57.4	0.80	32.5 - 32.1	32.5 - 32.1	Coal and black shale, **LK rider**
			57.4 - 58.0	57.4 - 58.0	3.63	32.1 - 31.5	32.1 - 31.5	Coal and siltstone, **LK rider**
				58.0 - 60.0	0.98	31.5 - 29.5		Gray and yellowish brown, fine-grained to very fine-grained sandstone
				60.0 - 62.0	0.71	29.5 - 27.5		Gray very fine-grained sandstone
				67.0 - 69.0	0.71	22.5 - 20.5		Gray very fine-grained sandstone
				71.0 - 73.0	1.65	18.5 - 16.5		Gray silty shale,
S2-2	92.0	90.0		41.0 - 42.0	0.88	49.0 - 48.0		Gray claystone, thin coal
				76.0 - 79.0	0.50	13.1 - 10.1		Medium–dark gray very fine-grained sandstone
S2-3	84.0	82.0		31.0 - 32.0	0.52	51.0 - 50.0		Black shale and gray siltstone
				47.0 - 49.0	1.11	35.0 - 33.0		Gray siltstone
				49.0 - 50.0	1.38	33.0 - 32.0		Medium-dark gray shale
				50.0 - 51.0	0.80	32.0 - 31.0		Medium-dark gray shale
				51.0 - 52.0	1.03	31.0 - 30.0		Medium-dark gray shale
				52.0 - 53.0	2.12	30.0 - 29.0		Medium-dark gray shale
				53.0 - 54.0	1.41	29.0 - 28.0		Gray siltstone very fine-grained sandstone
				54.0 - 56.0	0.78	28.0 - 26.0		Gray siltstone
				56.0 - 57.0	0.54	26.0 - 25.0		Gray siltstone
				63.0 - 65.0	1.48	19.0 - 17.0		Gray shale
S2-4	17.5	16.0		13.0 - 13.5	0.53	3.0 - 2.5		Yellow clay on coal
S2-5	62.0	59.3		40.0 - 42.0	0.61	19.3 - 17.3		Gray very fine-grained sandstone
				43.0 - 45.0	0.51	16.3 - 14.3		Gray very fine-grained sandstone, shale siltstone interbed
				47.0 - 49.0	2.14	12.3 - 10.3		Gray shale
S3-1	114.0	51.0		49.0 - 50.0	0.67	1.0 - 2.0	-	Medium brown shale
			34.5 - 34.8	34.5 - 34.8	6.15	28.3 - 28.0	28.3 - 28.0	LK Rider - coal
OB4	63.2	62.8		34.8 - 38.2	1.29	28.0 - 24.6	-	Medium gray shale
				38.2 - 41.2	0.90	24.6 - 21.6	-	Medium gray sandy shale
				49.2 - 50.2	4.40	13.6 - 12.6	-	Dark gray/black shale
				59.2 - 59.5	1.25	3.6 - 3.3	-	Dark gray shale and coal
C2	59.5	51		21.1 - 23.3	0.88	29.9 - 27.7	-	Light gray sandstone
				40.8 - 43.7	1.37	10.2 - 7.3	-	Dark gray siltstone - lingula

*Holes A-4 and A-8 are 230 and 430 feet, respectively, outside disposal boundary.
LK = Lower Kittanning Coal.
Samples collected by Meiser & Earl, Inc. personnel.
Samples analyzed by Geochemical Testing.

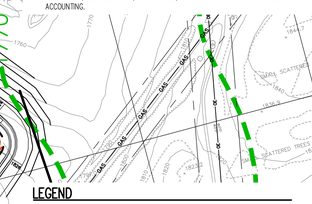


NOTES

1. HOLES A–4 AND A–8 ARE (APPROXIMATELY) 230 AND 430 FEET, RESPECTIVELY OUTSIDE THE WASTE DISPOSAL BOUNDARY.
2. LK: LOWER KITTANNING COAL.
3. THE ISOPACH LINES REPRESENT THE DISTANCE BETWEEN THE SUBBASE CONTOURS AND THE STRUCTURAL CONTOUR BASE OF THE LOWER KITTANNING COAL. A NEGATIVE VALUE REPRESENTS DEPTH BELOW SUBBASE.
4. THE LOWER KITTANNING RIDER COAL (LK) NOT PREVIOUSLY IDENTIFIED TO BE > 1.0% TOTAL SULFUR MAY BE INCIDENTALLY ENCOUNTERED DURING SUBGRADE EXCAVATION WITHIN THE HORIZONTAL LIMITS IDENTIFIED FROM 20 TO 40 FEET ABOVE THE BASE OF THE LOWER KITTANNING COAL AS A COAL WITH CARBONACEOUS SHALE INTERMIXED WITH BLACK SHALE. THIS COAL ALONG WITH BLACK SHALE COULD BE UP TO 2 FEET ABOVE AND BELOW THE COAL WILL BE DISPOSED WHTIN THE LANDFILL AS A "WASTE".

REFERENCES

1. DIGITAL TOPOGRAPHY FOR THE SITE WAS COMPILED FROM AERIAL PHOTOGRAPHY OBTAINED ON DECEMBER 20, 2004, BY MAPMAKER PHOTOGRAMMETRIC SERVICES, ST. ALBANS, VERMONT.
2. TOPOGRAPHY AUGMENTED WITH TOPOGRAPHIC AND CULTURAL INFORMATION FROM U.S.G.S. 7.5 MINUTE GLEN RICHEY (1993) AND WALLACETON (1993) PA TOPOGRAPHIC QUADRANGLE MAPS.
3. PUBLICATION TITLED, "COAL MINE DRAINAGE PREDICTION AND POLLUTION PREVENTION IN PENNSYLVANIA", PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION, OCTOBER 1998, CHAPTER 11, INTERPRETATION OF ACID–BASE ACCOUNTING.



LEGEND

- EXISTING GROUND CONTOUR (10' INTERVAL)
- 1832 — SUBBASE CONTOUR (10' INTERVAL)
- SUBBASE CONTOUR (2' INTERVAL)
- 30 — ISOPACH LINES (2' INTERVAL) (SEE NOTE 3)
- PROPERTY LINE
- FACILITY BOUNDARY
- FACILITY LIMIT COINCIDENT WITH PROPERTY LINE
- OE OE — EXISTING OVERHEAD POWER TRANSMISSION LINE
- GAS GAS GAS — EXISTING GAS LINE
- RIGHT OF WAY
- PROPOSED LIMIT OF WASTE (LINED AREA)
- A4, TH–1 — GEOLOGIC WELL
- C1, CH–1 — COREHOLE
- OB3 — OVERBURDEN ANALYSIS BOREHOLE
- S2, S3 — INVESTIGATIVE WELLS (2014 MEISER & EARL)
- THIESSEN POLYGON CONSTRUCTION LINE (SEE REFERENCE 3)
- 1680 — STRUCTURAL CONTOUR BASE OF LOWER KITTANNING COAL
- TOTAL SULFUR >1.0%
- POTENTIAL LK LIMITS (SEE NOTE 4)

0 200' 400' 600'

PREPARED FOR:

PA WASTE, LLC
CLEARFIELD COUNTY, PA

PREPARED BY:

SMITH+ GARDNER
ENGINEERS
14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577
1526 Richland St., Columbia SC 29201

SEAL

SEAL

REV.	DATE	DESCRIPTION
1	3/19	RESPONSE TO 11/26/18
		PADEP COMMENTS
2	6/19	RESPONSE TO 6/4/19
		PADEP COMMENTS

PROJECT TITLE:

PA WASTE, LLC
CAMP HOPE RUN LANDFILL
CLEARFIELD COUNTY, PA

DRAWING TITLE:

OVERBURDEN ANALYSES
AREAS OF INFLUENCE
FOR S2 AREA

DESIGNED: J.M.G.	PROJECT NO: PAWASTE 16-1
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED:	DATE: FEB. 2018
FILENAME: PAWASTE-D0057	
SHEET NUMBER:	DRAWING NUMBER: FIG. 24-4.3

G:\CAD\Marshall Miller & Associates\Clearfield\PA Waste 16-1\sheets\PAWASTE-D0057.dwg - 6/24/2019 1:45 PM

PHASE II APPLICATION
CAMP HOPE RUN LANDFILL
BOGGS TOWNSHIP, CLEARFIELD COUNTY, PENNSYLVANIA

FORM 24
ATTACHMENT 24-9
Geosynthetic Specification Sheets

REVISED JUNE 2019

FORM 24 - LINER SYSTEM - PHASE II

The geosynthetic specification sheets tabulated below are provided as **Exhibits 24-9.1 through 24-9.5**.

Geosynthetic Clay Liners (GCLs) (Exhibit 24-9.1):**

Manufacturer:	Product:
CETCO	Bentomat DN Resistex DN**
Solmax (GSE)	BentoLiner NWL BentoLiner NWL35 BentoLiner NWL60

HDPE Geomembranes (Exhibit 24-9.2):

Manufacturer:	Product:
Agru America	HDPE Microspike Liner
Poly-Flex, Inc.	Textured Geomembrane
Solmax	Textured Geomembrane

LLDPE Geomembranes (Exhibit 24-9.3):

Manufacturer:	Product:
Agru America	LLDPE Microspike Liner
Solmax	LLDPE Textured Liner

Drainage Geocomposites (Exhibit 24-9.4):

Manufacturer:	Product:
Agru America	6-250-6 6-275-6 6-300-6
Solmax (GSE)l	Fabrinet HF (6 oz/sy geotextiles)* Fabrinet HS (6 oz/sy geotextiles)* Fabrinet UF (6 oz/sy geotextiles)*
SKAPS Industries	Transnet 250 (6 oz/sy geotextiles) Transnet 270 (6 oz/sy geotextiles) Transnet 330 (6 oz/sy geotextiles)

Geotextiles (Exhibit 24-9.5):

Manufacturer:	Product:
Agru America	Agrutex 061 (6 oz/sy geotextile) Agrutex 161 (16 oz/sy geotextile)
Solmax (GSE)	NW6 (6 oz/sy geotextile) NW16 (16 oz/sy geotextile)
SKAPS Industries	GE 160 (6 oz/sy geotextile) GE 116 (16 oz/sy geotextile)

*Material not represented by leachate compatibility test information. Use proposed for final cover system only.

** Note that due to the concern of a lower pH leachate due to disposal of AMD material in the landfill, Resistex DN will be utilized in the liner system until actual leachate values are available and can be used to support the application and approval of the other GCL products included herein.

PHASE II APPLICATION
CAMP HOPE RUN LANDFILL
BOGGS TOWNSHIP, CLEARFIELD COUNTY, PENNSYLVANIA

FORM 24
EXHIBIT 24-9.1
Geosynthetic Clay Liners (GCLs)

FEBRUARY 2018

BENTOMAT® DN

GEOSYNTHETIC CLAY LINER

BENTOMAT DN CERTIFIED PROPERTIES			
MATERIAL PROPERTY	**TEST METHOD**	**TEST FREQUENCY ft²(m²)**	**REQUIRED VALUES**
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft² (4,000 m²)	0.75 lb/ft² (3.6 kg/m²) min
GCL Grab Strength[3]	ASTM D 6768	200,000 ft² (20,000 m²)	50 lbs/in (88 N/cm) MARV
GCL Peel Strength[3]	ASTM D 6496	40,000 ft² (4,000 m²)	3.5 lbs/in (6.1 N/cm) min
GCL Index Flux[4]	ASTM D 5887	Weekly	1 x 10^{-8} m³/m²/sec max
GCL Hydraulic Conductivity[4]	ASTM D 5887	Weekly	5 x 10^{-9} cm/sec max
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321 ASTM D 6243	Periodic	500 psf (24 kPa) typ @ 200 psf

Bentomat DN is a reinforced GCL consisting of a layer of sodium bentonite between two nonwoven geotextiles, which are needlepunched together.

Notes

[1] Bentonite property tests performed at a bentonite processing facility before shipment to CETCO's GCL production facilities.

[2] Bentonite mass/area reported at 0 percent moisture content.

[3] All tensile strength testing is performed in the machine direction using ASTM D 6768. All peel strength testing is performed using ASTM D 6496. Upon request, tensile and peel results can be reported per modified ASTM D 4632 using 4 inch grips.

[4] Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of 5x10^{-9} cm/sec for typical GCL thickness. Actual flux values vary with field condition pressures. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.

[5] Peak values measured at 200 psf (10 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

CETCO has developed an edge enhancement system that eliminates the need to use additional granular sodium bentonite within the overlap area of the seams. We call this edge enhancement, SuperGroove™, and it comes standard on both longitudinal edges of Bentomat® DN. It should be noted that SuperGroove™ does not appear on the end-of-roll overlaps and recommend the continued use of supplemental bentonite for all end-of-roll seams.

TR 401-BMDN 05/07

North America: 847.851.1800 | 800.527.9948 | www.CETCO.com

TDS_BENTOMATDN_AM_EN_201402_v1

CETCO®

OUR STANDARDS. YOUR PEACE OF MIND.

A Minerals Technologies Company

RESISTEX® DN CERTIFIED PROPERTIES

Resistex is designed to provide GCL chemical compatibility in moderately aggressive leachate environments such as some coal combustion product storage facilities, mining operations, and industrial waste storage facilities. Site-specific compatibility testing is strongly recommended.

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY FT^2 (M^2)	REQUIRED VALUES
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2) min
Fann Viscosity	API 13A mod[3]	200,000 ft^2 (20,000 m^2)	11 min to 15 max, cps
Loss on Ignition	ASTM D7626	200,000 ft^2 (20,000 m^2)	2.5% min to 5.0% max
GCL Tensile Strength[3]	ASTM D 6768	200,000 ft^2 (20,000 m^2)	50 lbs/in (88 N/cm) MARV
GCL Peel Strength[3]	ASTM D 6496	40,000 ft^2 (4,000 m^2)	3.5 lbs/in (6.1 N/cm) min
GCL Hydraulic Conductivity[4]	ASTM D 6766	Annually	< 3 x 10^{-9} cm/sec
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321 ASTM D 6243	Periodic	500 psf (24 kPa) typ @ 200 psf

Resistex DN is a reinforced GCL consisting of a layer of granular sodium bentonite between two nonwoven geotextiles, which are needle punched together. The sodium bentonite in Resistex DN is modified with a proprietary polymer to improve chemical resistance against selected contaminants. Site-specific compatibility testing is recommended.

Notes:

[1] Bentonite property tests performed at a bentonite processing facility before shipment to CETCO's GCL production facilities.

[2] Bentonite mass/area reported at 0 percent moisture content.

[3] All tensile strength testing is performed in the machine direction using ASTM D 6768. All peel strength testing is performed using ASTM D 6496. Upon request, tensile and peel results can be reported per modified ASTM D 4632 using 4 inch grips.

[4] Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tail water pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of $5x10^{-9}$ cm/sec for typical GCL thickness. Actual flux values vary with field condition pressures. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.

[5] Peak values measured at 200 psf (10 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

MINERALS TECHNOLOGIES CETCO®

PRODUCT DATA SHEET

GSE BentoLiner NWL Geosynthetic Clay Liner

GSE BentoLiner "NWL" is a needle-punched reinforced composite geosynthetic clay liner (GCL) comprised of a uniform layer of granular sodium bentonite encapsulated between a nonwoven and a scrim-nonwoven geotextile for dimensional stability. The product is intended for moderate to steep slopes and moderate to high load applications where increased internal shear strength is required.

[*]

AT THE CORE:

This composite clay liner is composed of a uniform layer of granular sodium bentonite between a nonwoven and scrim-nonwoven textile for dimensional stability.

Product Specifications

Tested Property	Test Method	Frequency	Value
Geotextile Property			
Cap Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft²	6.0 oz/yd² MARV(1)
Carrier Scrim Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft²	6.0 oz/yd² MARV
Bentonite Property			
Swell Index	ASTM D 5890	1/100,000 lb	24 ml/2 g min
Moisture Content	ASTM D 4643	1/100,000 lb	12% max
Fluid Loss	ASTM D 5891	1/100,000 lb	18 ml max
Finished GCL Property			
Bentonite, Mass/Unit Area(2)	ASTM D 5993	1/40,000 ft²	0.75 lb/ft² MARV
Tensile Strength(3)	ASTM D 6768	1/40,000 ft²	45 lb/in MARV
Peel Strength	ASTM D 6496 ASTM D 4632(4)	1/40,000 ft²	3.5 lb/in MARV 21 lb MARV
Hydraulic Conductivity(5)	ASTM D 5887	1/Week	5 x 10^{-9} cm/sec max
Index Flux(5)	ASTM D 5887	1/Week	1 x 10^{-8} m³/m²/sec max
Internal Shear Strength(6)	ASTM D 6243	Periodically	500 psf Typical
TYPICAL ROLL DIMENSIONS			
Width x Length(7)	Typical	Every Roll	15.5 ft x 150 ft
Area per Roll	Typical	Every Roll	2,325 ft²
Packaged Weight	Typical	Every Roll	2,600 lb

NOTES:

- (1)Minimum Average Roll Value.
- (2)At 0% moisture content.
- (3)Tested in machine direction.
- (4)Modified ASTM D 4632 to use a 4 in wide grip. The maximum peak of five specimens averaged in machine direction.
- (5)Deaired, deionized water @ 5 psi maximum effective confining stress and 2 psi head pressure.
- (6)Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf normal stress.
- (7)Roll widths and lengths have a tolerance of ±1%.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

[DURABILITY RUNS DEEP]

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

PRODUCT DATA SHEET

GSE BentoLiner NWL-35 Geosynthetic Clay Liner

GSE BentoLiner "NWL-35" is a needlepunched reinforced composite geosynthetic clay liner (GCL) comprised of a uniform layer of granular sodium bentonite encapsulated between a nonwoven and a scrim-nonwoven geotextile for dimensional stability. The product is intended for moderate to steep slopes and moderate to high load applications where increased internal shear strength is required.

AT THE CORE:

This composite clay liner is composed of a uniform layer of granular sodium bentonite between a nonwoven and scrim-nonwoven textile for dimensional stability.

Product Specifications

Tested Property	Test Method	Frequency	Value
Geotextile Property			
Cap Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft²	6.0 oz/yd² MARV(1)
Carrier Scrim Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft²	6.0 oz/yd² MARV
Bentonite Property			
Swell Index	ASTM D 5890	1/100,000 lb	24 ml/2 g min
Moisture Content	ASTM D 4643	1/100,000 lb	12% max
Fluid Loss	ASTM D 5891	1/100,000 lb	18 ml max
Finished GCL Property			
Bentonite, Mass/Unit Area(2)	ASTM D 5993	1/40,000 ft²	0.75 lb/ft² MARV
Tensile Strength(3)	ASTM D 6768	1/40,000 ft²	45 lb/in MARV
Peel Strength	ASTM D 6496 ASTM D 4632(4)	1/40,000 ft²	5.3 lb/in MARV 35 lb MARV
Hydraulic Conductivity(5)	ASTM D 5887	1/Week	5 x 10^{-9} cm/sec max
Index Flux(5)	ASTM D 5887	1/Week	1 x 10^{-8} m³/m²/sec max
Internal Shear Strength(6)	ASTM D 6243	Periodically	500 psf Typical
TYPICAL ROLL DIMENSIONS			
Width x Length(7)	Typical	Every Roll	15.5 ft x 150 ft
Area per Roll	Typical	Every Roll	2,325 ft²
Packaged Weight	Typical	Every Roll	2,600 lb

NOTES:

- (1)Minimum Average Roll Value.
- (2)At 0% moisture content.
- (3)Tested in machine direction.
- (4)Modified ASTM D 4632 to use a 4 in wide grip. The maximum peak of five specimens averaged in machine direction.
- (5)Deaired, deionized water @ 5 psi maximum effective confining stress and 2 psi head pressure.
- (6)Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf normal stress.
- (7)Roll widths and lengths have a tolerance of ±1%.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

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For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

PRODUCT DATA SHEET

GSE BentoLiner NWL-60 Geosynthetic Clay Liner

GSE BentoLiner "NWL-60" is a heavily needlepunched reinforced composite geosynthetic clay liner (GCL) comprised of a uniform layer of granular sodium bentonite encapsulated between a nonwoven and a scrim-nonwoven geotextile for dimensional stability. The product is intended for steep slopes and high load applications where increased internal shear strength is required.

AT THE CORE:

This composite clay liner is intended for steep slopes and high load applications where increased internal shear strength is required.

Product Specifications

Tested Property	Test Method	Frequency	VALUE
Geotextile Property			
Cap Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft^2	6.0 oz/yd^2 MARV(1)
Carrier Scrim Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft^2	6.0 oz/yd^2 MARV
Bentonite Property			
Swell Index	ASTM D 5890	1/100,000 lb	24 ml/2 g min
Moisture Content	ASTM D 4643	1/100,000 lb	12% max
Fluid Loss	ASTM D 5891	1/100,000 lb	18 ml max
Finished GCL Property			
Bentonite, Mass/Unit Area(2)	ASTM D 5993	1/40,000 ft^2	0.75 lb/ft^2 MARV
Tensile Strength(3)	ASTM D 6768	1/40,000 ft^2	50 lb/in MARV
Peel Strength	ASTM D 6496 ASTM D 4632(4)	1/40,000 ft^2	12 lb/in MARV 60 lb MARV
Hydraulic Conductivity(5)	ASTM D 5887	1/Week	5 x 10^{-9} cm/sec max
Index Flux(5)	ASTM D 5887	1/Week	1 x 10^{-8} m^3/m^2/sec max
Internal Shear Strength(6)	ASTM D 6243	Periodically	500 psf Typical
TYPICAL ROLL DIMENSIONS			
Width x Length(7)	Typical	Every Roll	15.5 ft x 150 ft
Area per Roll	Typical	Every Roll	2,325 ft^2
Packaged Weight	Typical	Every Roll	2,600 lb

NOTES:

- (1)Minimum Average Roll Value.
- (2)At 0% moisture content.
- (3)Tested in machine direction.
- (4)Modified ASTM D 4632 to use a 4 in wide grip. The maximum peak of five specimens averaged in machine direction.
- (5)Deaired, deionized water @ 5 psi maximum effective confining stress and 2 psi head pressure.
- (6)Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf normal stress.
- (7)Roll widths and lengths have a tolerance of ±1%.

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PHASE II APPLICATION
CAMP HOPE RUN LANDFILL
BOGGS TOWNSHIP, CLEARFIELD COUNTY, PENNSYLVANIA

FORM 24
EXHIBIT 24-9.2
HDPE Geomembranes

REVISED JUNE 2019

High Density Polyethylene MicroSpike® Liner

Product Data

Property	Test Method	Values				
Thickness, nominal (mm)		30 (.75)	40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)
Thickness (min. ave.), mil (mm)	ASTM D5994*	29 (.71)	38 (.95)	57 (1.43)	76 (1.90)	95 (2.38)
Thickness (lowest indiv. for 8 of 10 spec.), mil (mm)	ASTM D5994*	27 (.68)	36 (.90)	54 (1.35)	72 (1.80)	90 (2.25)
Thickness (lowest indiv. for 1 of 10 spec.), mil (mm)	ASTM D5994*	26 (.64)	34 (.85)	51 (1.28)	68 (1.70)	85 (2.13)
*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)						
Asperity Height (min. ave.), mil (mm)	ASTM D7466	16 (.41)	16 (.41)	16 (.41)	16 (.41)	16 (.41)
Density, g/cc, minimum	ASTM D792, Method B	0.94	0.94	0.94	0.94	0.94
Tensile Properties (ave. both directions)	ASTM D6693, Type IV					
Strength @ Yield (min. ave.), lb/in width (N/mm)	2 in/minute	66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Yield (min. ave.), % (GL=1.3in)	5 specimens in each direction	13	13	13	13	13
Strength @ Break (min. ave.), lb/in width (N/mm)		66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Break (min. ave.), % (GL=2.0in)		350	350	350	350	350
Tear Resistance (min. ave.), lbs. (N)	ASTM D1004	23 (102)	30 (133)	45 (200)	60 (267)	72 (320)
Puncture Resistance (min. ave.), lbs. (N)	ASTM D4833	60 (267)	90 (400)	120 (534)	150 (667)	180 (801
Carbon Black Content (range in %)	ASTM D4218	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3
Carbon Black Dispersion (Category)	ASTM D5596	Only near spherical agglomerates for 10 views: 9 views in Cat. 1 or 2, and 1 view in Cat. 3				
Stress Crack Resistance (Single Point NCTL), hours	ASTM D5397, Appendix	300	300	300	300	300
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O_2	≥140	≥140	≥140	≥140	≥140
Melt Flow Index, g/10 minutes	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Oven Aging with HP OIT, (% retained after 90 days)	ASTM D5721 ASTM D5885, 150°C, 500psi O_2	80	80	80	80	80
UV Resistance with HP OIT, (% retained after 1600 hours)	ASTM D7238 ASTM D5885, 150°C, 500psi O_2	20hr. Cycle @ 75°C/4 hr. dark condensation @ 60°C 50	50	50	50	50

Agru America's geomembranes are certified to pass Low Temp. Brittleness via ASTM D746 (-80°C), and Dimensional Stability via ASTM D1204 (±2% @ 100°C).

These product specifications meet or exceed GRI's GM13

Supply Information (Standard Roll Dimensions)

Thickness		Width		Length		Area (approx.)		Weight (average)*	
mil	mm	ft	m	ft	m	ft^2	m^2	lbs	kg
30	.75	23	7	930	283.117	21,390	1,984	3,900	1,770
40	1.0	23	7	710	216.41	16,330	1,514.87	3,900	1,770
60	1.5	23	7	505	153.53	11,615	1,078	3,900	1,770
80	2.0	23	7	385	117.35	8,855	821	3,900	1,770
100	2.5	23	7	310	94.49	7,130	661	3,900	1,770

Notes:

All rolls are supplied with two slings. All rolls are wound on a 6 inch core. Special lengths are available on request. All roll lengths and widths have a tolerance of ±1%
**The weight values may change due to project specifications (i.e. absolute minimum thickness or special roll lengths) or shipping requirements (i.e. international containerized shipments).*

500 Garrison Road, Georgetown, South Carolina 29440 843-546-0600 800-373-2478 Fax: 843-527-2738
email: salesmkg@agruamerica.com www.AgruAmerica.com

TEXTURED HDPE GEOMEMBRANE
ENGLISH UNITS

Property	Test Method	Minimum Average Values 40 mil	60 mil	80 mil	100 mil
Thickness, mils	ASTM D 5994				
minimum average		38	57	76	95
lowest individual of 8 of 10 readings		36	54	72	90
lowest individual of 10 readings		34	51	68	85
Asperity Height[1], mils	ASTM D 7466	10	10	10	10
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940
Tensile Properties[2]	ASTM D 6693				
1. Yield Strength, lb/in		84	126	168	210
2. Break Strength, lb/in		60	90	120	150
3. Yield Elongation, %		12	12	12	12
4. Break Elongation, %		100	100	100	100
Tear Resistance, lb	ASTM D 1004	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	60	90	120	150
Stress Crack Resistance[3], hrs	ASTM D 5397 (App.)	300	300	300	300
Carbon Black Content[4], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	--Note 5--			
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C	ASTM D 5721				
High Pressure OIT - % retained after 90 days	ASTM D 5885	80	80	80	80
UV Resistance[6]	ASTM D 7238				
High Pressure OIT[7] - % retained after 1600 hrs	ASTM D 5885	50	50	50	50
Roll Dimensions					
1. Width (feet):		23	23	23	23
2. Length (feet)		750	500	375	300
3. Area (square feet):		17,250	11,500	8,625	6,900
4. Gross weight (pounds, approx.)		3,500	3,500	3,470	3,470

1 Of 10 readings; 8 must be ≥ 7 mils and lowest individual reading must be ≥ 5 mils.
2 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 1.3 inches; Break elongation is calculated using a gauge length of 2.0 inches.
3 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
4 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
5 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
6 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
7 UV resistance is based on percent retained value regardless of the original HP-OIT value.

This data is provided for informational purposes only and is not intended as a warranty or guarantee. Poly-Flex, Inc. assumes no responsibility in connection with the use of this data. These values are subject to change without notice. REV.04/11

These data are provided for informational purposes only and are not intended as a warranty or guarantee. Poly-Flex, Inc. assumes no responsibility in connection with the use of these data. Suitablility for a particular use shall be determined by and is the sole responsibility of the end user. These values are subject to change without notice. REV. 08/11

TECHNICAL DATA SHEET

HDPE Series, 60 mils

Black, Textured

2801 Boul. Marie-Victorin Varennes, Quebec Canada J3X 1P7
Tel: (450) 929-1234 Sales: (450) 929-2544 Toll free in North America:1-800-571-3904 www.Solmax.com www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	1042790
SPECIFICATIONS				
Nominal Thickness		-	mils	60
Thickness (min. avg.)	ASTM D5994	Every roll	mils	57.0
Lowest ind. for 8 out of 10 values			mils	54.0
Lowest ind. for 10 out of 10 values			mils	51.0
Asperity Height (min. avg.) (3)	ASTM D7466	Every roll	mils	16
Resin Density	ASTM D1505	1/Batch	g/cc	> 0.932
Sheet Density (8)	ASTM D792	Every 10 rolls	g/cc	≥ 0.940
Carbon Black Content (9)	ASTM D4218	Every 2 rolls	%	2.0 - 3.0
Carbon Black Dispersion	ASTM D5596	Every 10 rolls	Category	Cat. 1 & Cat. 2
OIT - standard (avg.)	ASTM D3895	1/Batch	min	100
Tensile Properties (min. avg) (2)	ASTM D6693	Every 2 rolls		
Strength at Yield			ppi	132
Elongation at Yield			%	13
Strength at Break			ppi	132
Elongation at Break			%	150
Tear Resistance (min. avg.)	ASTM D1004	Every 5 rolls	lbf	45
Puncture Resistance (min. avg.)	ASTM D4833	Every 5 rolls	lbf	120
Dimensional Stability	ASTM D1204	Certified	%	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D5397	1/Batch	hr	500
Oven Aging - % retained after 90 days	ASTM D5721	Per formulation		
HP OIT (min. avg.)	ASTM D5885		%	80
UV Res. - % retained after 1600 hr	ASTM D7238	Per formulation		
HP-OIT (min. avg.)	ASTM D5885		%	50
Low Temperature Brittleness	ASTM D746	Certified	°F	- 106
SUPPLY SPECIFICATIONS (Roll dimensions may vary ±1%)				
Roll Dimension - Width			ft	22.3
Roll Dimension - Length			ft	540
Area (Surface/Roll)			sf	12042

NOTES

1. Testing frequency based on standard roll dimension and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
3. Lowest individual and 8 out of 10 readings as per GRI-GM13 / 17, latest version.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
9. Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.

* All values are nominal test results, except when specified as minimum or maximum.
* The information contained herein is provided for reference purposes only and is not intended as a warranty of guarantee. Final determination of suitability for use contemplated is the sole responsability of the user. SOLMAX assumes no liability in connection with the use of this information.

Solmax is not a design professional and has not performed any design services to determine if Solmax's goods comply with any project plans or specifications, or with the application or use of Solmax's goods to any particular system, project, purpose, installation or specification.

PHASE II APPLICATION
CAMP HOPE RUN LANDFILL
BOGGS TOWNSHIP, CLEARFIELD COUNTY, PENNSYLVANIA

FORM 24
EXHIBIT 24-9.3
LLDPE Geomembranes

REVISED JUNE 2019

Linear Low Density Polyethylene MicroSpike® Liner

Product Data

Property	Test Method	Values			
Thickness, nominal, (mm)		40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)
Thickness (min. ave.), mil (mm)	ASTM D5994*	38 (.95)	57 (1.43)	76 (1.90)	95 (2.38)
Thickness (lowest indiv. for 8 of 10 spec.), mil (mm)	ASTM D5994*	36 (.90)	54 (1.35)	72 (1.80)	90 (2.25)
Thickness (lowest indiv. for 1 of 10 spec.), mil (mm)	ASTM D5994*	34 (.85)	51 (1.28)	68 (1.70)	85 (2.13)
*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)					
Asperity Height (min. ave.), mil (mm)	ASTM D7466	16 (.41)	16 (.41)	16 (.41)	16 (.41)
Density, g/cc, maximum	ASTM D792, Method B	0.939	0.939	0.939	0.939
Tensile Properties (ave. both directions)	ASTM D6693, Type IV				
Strength @ Break (min. ave.), lb/in width (N/mm)	2 in/minute	112 (19.6)	168 (29.4)	224 (392)	280 (49.0)
Elongation @ Break (min. ave.), % (GL=2.0in)	5 specimens in each direction	400	400	400	400
Tear Resistance (min. ave.), lbs. (N)	ASTM D1004	25 (111)	36 (160)	50 (222)	60 (267)
Puncture Resistance (min. ave.), lbs. (N)	ASTM D4833	50 (222)	70 (310)	90 (400)	115 (512)
Carbon Black Content (range in %)	ASTM D4218	2 - 3	2 - 3	2 - 3	2 - 3
Carbon Black Dispersion (Category)	ASTM D5596	Only near spherical agglomerates			
		for 10 views: 9 views in Cat. 1 or 2, and 1 view in Cat. 3			
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O_2	≥140	≥140	≥140	≥140
Melt Flow Index, g/10 minutes	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0	≤1.0	≤1.0
Oven Aging	ASTM D5721	60	60	60	60
with HP OIT, (% retained after 90 days)	ASTM D5885, 150°C, 500psi O_2				
UV Resistance	ASTM D7238	20hr. Cycle @ 75°C/4 hr. dark condensation @ 60°C			
with HP OIT, (% retained after 1600 hours)	ASTM D5885, 150°C, 500psi O_2	35	35	35	35
2% Secant Modulus (max.), lb/in. (N/mm)	ASTM D5323	2400 (420)	3600 (630)	4800 (840)	6000 (1050)
Axi-Symmetric Break Resistance Strain, % (min.)	ASTM D5617	30	30	30	30

Agru America's geomembranes are certified to pass Low Temp. Brittleness via ASTM D746 (-80°C), and Dimensional Stability via ASTM D1204 (±2% @ 100°C).

These product specifications meet or exceed GRI's GM17

Supply Information (Standard Roll Dimensions)

Thickness		Width		Length		Area (approx.)		Weight (average)*	
mil	mm	ft	m	ft	m	ft^2	m^2	lbs	kg
40	1.0	23	7	710	283.47	16,330	1,514.87	3,900	1,770
60	1.5	23	7	505	216.41	11,615	1,078	3,900	1,770
80	2.0	23	7	385	117.35	8,855	821	3,900	1,770
100	2.5	23	7	310	94.49	7,130	661	3,900	1,770

Notes:

All rolls are supplied with two slings. All rolls are wound on a 6 inch core. Special lengths are available on request. All roll lengths and widths have a tolerance of ±1%

**The weight values may change due to project specifications (i.e. absolute minimum thickness or special roll lengths) or shipping requirements (i.e. international containerized shipments).*

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TECHNICAL DATA SHEET

LLDPE Series, 40 mils

Black, Textured

2801 Boul. Marie-Victorin Varennes, Quebec Canada J3X 1P7
Tel: (450) 929-1234 Sales: (450) 929-2544 Toll free in North America:1-800-571-3904 www.Solmax.com www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY[1]	UNIT Imperial	1009613
SPECIFICATIONS				
Nominal Thickness		-	mils	40
Thickness (min. avg.)	ASTM D5994	Every roll	mils	38.0
Lowest ind. for 8 out of 10 values			mils	36.0
Lowest ind. for 10 out of 10 values			mils	34.0
Asperity Height (min. avg.) (3)	ASTM D7466	Every roll	mils	16
Resin Density	ASTM D1505	1/Batch	g/cc	
Sheet Density (8)	ASTM D792	Every 10 rolls	g/cc	≤ 0.939
Carbon Black Content (9)	ASTM D4218	Every 2 rolls	%	2.0 - 3.0
Carbon Black Dispersion	ASTM D5596	Every 10 rolls	Category	Cat. 1 & Cat. 2
OIT - standard (avg.)	ASTM D3895	1/Batch	min	100
Tensile Properties (min. avg) (2)	ASTM D6693	Every 2 rolls		
Strength at Break			ppi	100
Elongation at Break			%	250
2% Modulus (max.)	ASTM D5323	Per formulation	ppi	2400
Tear Resistance (min. avg.)	ASTM D1004	Every 5 rolls	lbf	25
Puncture Resistance (min. avg.)	ASTM D4833	Every 5 rolls	lbf	56
Dimensional Stability	ASTM D1204	Certified	%	± 2
Multi-Axial Tensile (min.)	ASTM D5617	Per formulation	%	30
Oven Aging - % retained after 90 days	ASTM D5721	Per formulation		
STD OIT (min. avg.)	ASTM D3895		%	35
HP OIT (min. avg.)	ASTM D5885		%	60
UV Res. - % retained after 1600 hr	ASTM D7238	Per formulation		
HP-OIT (min. avg.)	ASTM D5885		%	35
Low Temperature Brittleness	ASTM D746	Certified	°F	- 106
SUPPLY SPECIFICATIONS (Roll dimensions may vary ±1%)				
Roll Dimension - Width			ft	22.3
Roll Dimension - Length			ft	780
Area (Surface/Roll)			sf	17394

NOTES

1. Testing frequency based on standard roll dimension and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
3. Lowest individual and 8 out of 10 readings as per GRI-GM13 / 17, latest version.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
9. Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.

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Solmax is not a design professional and has not performed any design services to determine if Solmax's goods comply with any project plans or specifications, or with the application or use of Solmax's goods to any particular system, project, purpose, installation or specification.

PHASE II APPLICATION
CAMP HOPE RUN LANDFILL
BOGGS TOWNSHIP, CLEARFIELD COUNTY, PENNSYLVANIA

FORM 24
EXHIBIT 24-9.4
Drainage Geocomposites

REVISED JUNE 2019

2-Sided Geocomposite
250mil Geonet

Geonet Component[4]

Property	Test Method	4-250-4	6-250-6	8-250-8	10-250-10	12-250-12
		Minimum Average Roll Value[5]				
Thickness, mil	ASTM D5199	250	250	250	250	250
*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)						
Peak Tensile Strength, lbs./in. (MD)	ASTM D5035	55	55	55	55	55
Melt Flow Index, g/10 minutes (max.)	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Density, g/cm^3	ASTM D792, Method B	0.94	0.94	0.94	0.94	0.94
Carbon Black Content	ASTM D4218	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3
Transmissivity[1], m^2/sec.	ASTM D4716	3 x 10^{-3}	3 x 10^{-3}	3 x 10^{-3}	3 x 10^{-3}	3 x 10^{-3}

Geotextile Component (Prior to Lamination)

Property	Test Method	Minimum Average Roll Value[5]				
Mass per Unit Area, oz./sq. yd.	ASTM D5261	4.0	6.0	8.0	10.0	12.0
Grab Tensile Strength, lbs.	ASTM D4632	100	160	205	250	300
Grab Elongation, %	ASTM D4632	50	50	50	50	50
Trapezoidal Tear, lbs.	ASTM D4533	45	60	80	100	115
Puncture, lbs.	ASTM D4833	60	90	110	155	175
Mullen Burst, psi	ASTM D3786	210	305	350	460	585
Permittivity[2], sec.$^{-1}$	ASTM D4491	1.80	1.40	1.10	0.80	0.80
Water Flow[2], gpm./ft.^{2}	ASTM D4491	135	110	90	75	60
Apparent Opening Size, U.S. Stnd Sieve Size (max.)	ASTM D4751	70	70	80	100	100
UV Resistance after 500 hours, % Strength Retained	ASTM D4355	70	70	70	70	70

Geocomposite[4]

Property	Test Method	Minimum Average Roll Value[5]				
Laminated Strength (Ply Adhesion), lbs./in.	ASTM D7005	1	1	1	1	1
Transmissivity[3], m^2/sec.	ASTM D4716	5 x 10^{-4}	5 x 10^{-4}	5 x 10^{-4}	3 x 10^{-4}	3 x 10^{-4}

Agru America's geomembranes are certified to pass Low Temp. Brittleness via ASTM D746 (-80°C), and Dimensional Stability via ASTM D1204 (±2% @ 100°C).

Notes:
(1) Geonet Transmissivity at a temp. of 21°C, gradient of 0.1 and a load of 10,000psf: seating time 15 min. between steel plates.
(2) At time of manufacture. Handling may change these properties.
(3) Geocomposite Transmissivity at a temp. of 21°C, gradient of 0.1 and a load of 10,000psf: seating time 15 min. between steel plates.
(4) Component properties are prior to Lamination
(5) Geonet, Melt Flow Index is a maximum value, and for Geotextile, AOS is a maximum average roll value.
(6) All roll lengths and widths have a tolerance of ±1%
(7) An alternate textile component may be supplied if required to meet project specifications.
(8) Weight is a TYPICAL value not a minimum average roll value.

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email: salesmkg@agruamerica.com www.AgruAmerica.com

2-Sided Geocomposite
275mil Geonet

Geonet Component[4]

Property	Test Method	4-275-4	6-275-6	8-275-8	10-275-10	12-275-12
		Minimum Average Roll Value[5]				
Thickness, mil	ASTM D5199	275	275	275	275	275
*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)						
Peak Tensile Strength, lbs./in. (MD)	ASTM D5035	65	65	65	65	65
Melt Flow Index, g/10 minutes (max.)	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Density, g/cm^3	ASTM D792, Method B	0.94	0.94	0.94	0.94	0.94
Carbon Black Content	ASTM D4218	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3
Transmissivity[1], m^2/sec.	ASTM D4716	6 x 10^{-3}	6 x 10^{-3}	6 x 10^{-3}	6 x 10^{-3}	6 x 10^{-3}

Geotextile Component (Prior to Lamination)

Property	Test Method	Minimum Average Roll Value[5]				
Mass per Unit Area, oz./sq. yd.	ASTM D5261	4.0	6.0	8.0	10.0	12.0
Grab Tensile Strength, lbs.	ASTM D4632	100	160	205	250	300
Grab Elongation, %	ASTM D4632	50	50	50	50	50
Trapezoidal Tear, lbs.	ASTM D4533	45	60	80	100	115
Puncture, lbs.	ASTM D4833	60	90	110	155	175
Mullen Burst, psi	ASTM D3786	210	305	350	460	585
Permittivity[2], sec.$^{-1}$	ASTM D4491	1.80	1.40	1.10	0.80	0.80
Water Flow[2], gpm./ft.^{2}	ASTM D4491	135	110	90	75	60
Apparent Opening Size, U.S. Stnd Sieve Size (max.)	ASTM D4751	70	70	80	100	100
UV Resistance after 500 hours, % Strength Retained	ASTM D4355	70	70	70	70	70

Geocomposite[4]

Property	Test Method	Minimum Average Roll Value[5]				
Laminated Strength (Ply Adhesion), lbs./in.	ASTM D7005	1	1	1	1	1
Transmissivity[3], m^2/sec.	ASTM D4716	7 x 10^{-4}	7 x 10^{-4}	7 x 10^{-4}	5 x 10^{-4}	5 x 10^{-4}

Agru America's geomembranes are certified to pass Low Temp. Brittleness via ASTM D746 (-80°C), and Dimensional Stability via ASTM D1204 (±2% @ 100°C).

Notes:
(1) Geonet Transmissivity at a temp. of 21°C, gradient of 0.1 and a load of 10,000psf: seating time 15 min. between steel plates.
(2) At time of manufacture. Handling may change these properties.
(3) Geocomposite Transmissivity at a temp. of 21°C, gradient of 0.1 and a load of 10,000psf: seating time 15 min. between steel plates.
(4) Component properties are prior to Lamination
(5) Geonet, Melt Flow Index is a maximum value, and for Geotextile, AOS is a maximum average roll value.
(6) All roll lengths and widths have a tolerance of ±1%
(7) An alternate textile component may be supplied if required to meet project specifications.
(8) Weight is a TYPICAL value not a minimum average roll value.

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email: salesmkg@agruamerica.com www.AgruAmerica.com

2-Sided Geocomposite
300mil Geonet

Geonet Component[4]

Property	Test Method	4-300-4	6-300-6	8-300-8	10-300-10	12-300-12
		Minimum Average Roll Value				
Thickness, mil	ASTM D5199	300	300	300	300	300
*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)						
Peak Tensile Strength, lbs./in. (MD)	ASTM D5035	75	75	75	75	75
Melt Flow Index[5], g/10 minutes (max.)	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Density, g/cm^3	ASTM D792, Method B	0.94	0.94	0.94	0.94	0.94
Carbon Black Content	ASTM D4218	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3
Transmissivity[1], m^2/sec.	ASTM D4716	8 x 10^{-3}	8 x 10^{-3}	8 x 10^{-3}	8 x 10^{-3}	8 x 10^{-3}

Geotextile Component[4]

Property	Test Method	Minimum Average Roll Value				
Mass per Unit Area[7], oz./sq. yd.	ASTM D5261	4.0	6.0	8.0	10.0	12.0
Grab Tensile Strength, lbs.	ASTM D4632	100	160	205	250	300
Grab Elongation, %	ASTM D4632	50	50	50	50	50
Trapezoidal Tear, lbs.	ASTM D4533	45	60	80	100	115
Puncture, lbs.	ASTM D4833	60	90	110	155	175
Mullen Burst, psi	ASTM D3786	210	305	350	460	585
Permittivity[2], sec.$^{-1}$	ASTM D4491	1.80	1.40	1.10	0.80	0.80
Water Flow[2], gpm./ft.^{2}	ASTM D4491	135	110	90	75	60
Apparent Opening Size[5], U.S. Stnd Sieve Size (max.)	ASTM D4751	70	70	80	100	100
UV Resistance after 500 hours, % Strength Retained	ASTM D4355	70	70	70	70	70

Geocomposite

Property	Test Method	Minimum Average Roll Value				
Laminated Strength (Ply Adhesion), lbs./in.	ASTM D7005	1	1	1	1	1
Transmissivity[3], m^2/sec.	ASTM D4716	9 x 10^{-4}	9 x 10^{-4}	9 x 10^{-4}	7 x 10^{-4}	7 x 10^{-4}

Agru America's geomembranes are certified to pass Low Temp. Brittleness via ASTM D746 (-80°C), and Dimensional Stability via ASTM D1204 (±2% @ 100°C).

Notes:
(1) Geonet Transmissivity at a temp. of 21°C, gradient of 0.1 and a load of 10,000psf: seating time 15 min. between steel plates.
(2) At time of manufacture. Handling may change these properties.
(3) Geocomposite Transmissivity at a temp. of 21°C, gradient of 0.1 and a load of 10,000psf: seating time 15 min. between steel plates.
(4) Component properties are prior to Lamination
(5) Geonet, Melt Flow Index is a maximum value, and for Geotextile, AOS is a maximum average roll value.
(6) All roll lengths and widths have a tolerance of ±1%
(7) Geotextile Mass Per Unit Area is a TYPICAL value not a minimum average roll value.

500 Garrison Road, Georgetown, South Carolina 29440 843-546-0600 800-373-2478 Fax: 843-527-2738
email: salesmkg@agruamerica.com www.AgruAmerica.com

PRODUCT DATA SHEET

GSE FabriNet HF Geocomposite

GSE FabriNet HF geocomposite consists of a 250 mil thick GSE HyperNet HF geonet heat-laminated on one or both sides with a GSE nonwoven needle-punched geotextile. The geotextile is available in mass per unit area range of 6 oz/yd² to 16 oz/yd². The geocomposite is designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions.

AT THE CORE:

A 250 mil thick GSE HyperNet HF geonet heat-laminated on one or both sides with a nonwoven needle-punched geotextile.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Roll Value		
Geocomposite			6 oz/yd²	8 oz/yd²	10 oz/yd²
Transmissivity(2), gal/min/ft (m²/sec) Double-Sided Composite Single-Sided Composite	ASTM D 4716	1/540,000 ft²	 2.4 (5 x 10^{-4}) 7.2 (1.5 x 10^{-3})	 2.4 (5 x 10^{-4}) 7.2 (1.5 x 10^{-3})	 1.4 (3 x 10^{-4}) 4.8 (1x 10^{-3})
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft²	1.0	1.0	1.0
Geonet Core(3) – GSE HyperNet HF					
Transmissivity(2), gal/min/ft (m²/sec)	ASTM D 4716		14.5 (3 x 10^{-3})	14.5 (3 x 10^{-3})	14.5 (3 x 10^{-3})
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94
Tensile Strength (MD), lb/in	ASTM D 5035/7179	1/50,000 ft²	55	55	55
Carbon Black Content, %	ASTM D 1603(6)/4218	1/50,000 ft²	2.0	2.0	2.0
Geotextile(3,4)					
Mass per Unit Area, oz/yd²	ASTM D 5261	1/90,000 ft²	6	8	10
Grab Tensile, lb	ASTM D 4632	1/90,000 ft²	160	220	260
Puncture Strength, lb	ASTM D 4833	1/90,000 ft²	90	120	165
AOS, US sieve(1) (mm)	ASTM D 4751	1/540,000 ft²	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, sec^{-1}	ASTM D 4491	1/540,000 ft²	1.5	1.3	1.0
Flow Rate, gpm/ft²	ASTM D 4491	1/540,000 ft²	110	95	75
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	per formulation	70	70	70
NOMINAL ROLL DIMENSIONS					
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft²	250	250	250
Roll Width(5), ft			15	15	15
Roll Length(5), ft	Double-Sided Composite Single-Sided Composite		230 260	210 260	210 250
Roll Area, ft²	Double-Sided Composite Single-Sided Composite		3,450 3,900	3,150 3,900	3,150 3,750

[Product specifications continued on back]

AT THE CORE:

A 250 mil thick HyperNet HF geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.

Product Specifications [continued]

NOTES:

- (1)AOS in mm is a maximum average roll value.
- (2)Gradient of 0.1, normal load of 10,000 psf, water at 70˚F between steel plates for 15 minutes. Contact GSE for performance transmissivity value for use in design.
- (3)Component properties prior to lamination.
- (4)Refer to geotextile product data sheet for additional specifications.
- (5)Roll widths and lengths have a tolerance of ±1%.
- (6)Modified.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

DURABILITY RUNS DEEP

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

PRODUCT DATA SHEET

GSE FabriNet HS Geocomposite

GSE FabriNet HS geocomposite consists of a 275 mil thick GSE HyperNet HS geonet heat-laminated on one or both sides with a GSE nonwoven needle-punched geotextile. The geotextile is available in mass per unit area range of 6 oz/yd² to 16 oz/yd². The geocomposite is designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions.

AT THE CORE:

A 275 mil thick GSE HyperNet HS geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Roll Value		
Geocomposite			6 oz/yd²	8 oz/yd²	10 oz/yd²
Transmissivity[2], gal/min/ft (m²/sec) Double-Sided Composite Single-Sided Composite	ASTM D 4716	1/540,000 ft²	 3.4 (7 x10⁻⁴) 9.6 (2 x 10⁻³)	 3.4 (7 x 10⁻⁴) 9.6 (2 x 10⁻³)	 2.4 (5 x 10⁻⁴) 7.2 (1.5 x 10⁻³)
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft²	1.0	1.0	1.0
Geonet Core[3] – GSE HyperNet HS					
Transmissivity[2], gal/min/ft (m²/sec)	ASTM D 4716		29 (6 x 10⁻³)	29 (6 x 10⁻³)	29 (6 x 10⁻³)
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94
Tensile Strength (MD), lb/in	ASTM D 5035/7179	1/50,000 ft²	65	65	65
Carbon Black Content, %	ASTM D 1603[6]/4218	1/50,000 ft²	2.0	2.0	2.0
Geotextile[3,4]					
Mass per Unit Area, oz/yd²	ASTM D 5261	1/90,000 ft²	6	8	10
Grab Tensile, lb	ASTM D 4632	1/90,000 ft²	160	220	260
Puncture Strength, lb	ASTM D 4833	1/90,000 ft²	90	120	165
AOS, US sieve[1] (mm)	ASTM D 4751	1/540,000 ft²	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, sec⁻¹	ASTM D 4491	1/540,000 ft²	1.5	1.3	1.0
Flow Rate, gpm/ft²	ASTM D 4491	1/540,000 ft²	110	95	75
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	per formulation	70	70	70
NOMINAL ROLL DIMENSIONS					
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft²	275	275	275
Roll Width[5], ft			15	15	15
Roll Length[5], ft	Double-Sided Composite Single-Sided Composite		212 240	200 240	190 230
Roll Area, ft²	Double-Sided Composite Single-Sided Composite		3,180 3,600	3,000 3,600	2,850 3,450

[Product specifications continued on back]

AT THE CORE:

A 275 mil thick HyperNet HS geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.

Product Specifications [continued]

NOTES:

- (1)AOS in mm is a maximum average roll value.
- (2)Gradient of 0.1, normal load of 10,000 psf, water at 70˚F between steel plates for 15 minutes. Contact GSE for performance transmissivity value for use in design.
- (3)Component properties prior to lamination.
- (4)Refer to geotextile product data sheet for additional specifications.
- (5)Roll widths and lengths have a tolerance of ±1%.
- (6)Modified.

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GSE ENVIRONMENTAL™

DURABILITY RUNS DEEP

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

PRODUCT DATA SHEET

GSE FabriNet UF Geocomposite

GSE FabriNet UF geocomposite consists of a 300 mil thick GSE HyperNet UF geonet heat-laminated on one or both sides with a GSE nonwoven needlepunched geotextile. The geotextile is available in mass per unit area range of 6 oz/yd² to 16 oz/yd². The geocomposite is designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions.

AT THE CORE:

A 300 mil thick GSE HyperNet UF geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Roll Value[1]		
Geocomposite			6 oz/yd²	8 oz/yd²	10 oz/yd²
Transmissivity[2], gal/min/ft (m²/sec) Double-Sided Composite Single-Sided Composite	ASTM D 4716	1/540,000 ft²	 4.3 (9 x 10^{-4}) 14.5 (3 x 10^{-3})	 4.3 (9 x 10^{-4}) 14.5 (3 x 10^{-3})	 3.4 (7 x 10^{-4}) 9.6 (2 x 10^{-3})
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft²	1.0	1.0	1.0
Geonet Core [3] – GSE HyperNet UF					
Transmissivity[2], gal/min/ft (m²/sec)	ASTM D 4716		38.6 (8 x 10^{-3})	38.6 (8 x 10^{-3})	38.6 (8 x 10^{-3})
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94
Tensile Strength (MD), lb/in	ASTM D 5035/7179	1/50,000 ft²	75	75	75
Carbon Black Content, %	ASTM D 1603[6]/4218	1/50,000 ft²	2.0	2.0	2.0
Geotextile[3,4]					
Mass per Unit Area, oz/yd²	ASTM D 5261	1/90,000 ft²	6	8	10
Grab Tensile, lb	ASTM D 4632	1/90,000 ft²	160	220	260
Puncture Strength, lb	ASTM D 4833	1/90,000 ft²	90	120	165
AOS, US sieve (mm)	ASTM D 4751	1/540,000 ft²	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, sec^{-1}	ASTM D 4491	1/540,000 ft²	1.5	1.3	1.0
Flow Rate, gpm/ft²	ASTM D 4491	1/540,000 ft²	110	95	75
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	per formulation	70	70	70
NOMINAL ROLL DIMENSIONS					
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft²	300	300	300
Roll Width[5], ft			15	15	15
Roll Length[5], ft	Double-Sided Composite Single-Sided Composite		180 220	170 220	160 200
Roll Area, ft²	Double-Sided Composite Single-Sided Composite		2,700 3,300	2,550 3,300	2,400 3,000

[Product specifications continued on back]

AT THE CORE:

A 300 mil thick HyperNet UF geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.

Product Specifications [continued]

NOTES:

- (1)AOS in mm is a maximum average roll value.
- (2)Gradient of 0.1, normal load of 10,000 psf, water at 70˚F between steel plates for 15 minutes. Contact GSE for performance transmissivity value for use in design.
- (3)Component properties prior to lamination.
- (4)Refer to geotextile product data sheet for additional specifications.
- (5)Roll widths and lengths have a tolerance of ±1%.
- (6)Modified.

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Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

DURABILITY RUNS DEEP

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

SKAPS Industries
571 Industrial Parkway
Commerce, GA 30529 (U.S.A.)
Phone (706) 336-7000 Fax (706) 336-7007
e-mail: info@skaps.com

SKAPS TRANSNET™ (TN)
HDPE GEOCOMPOSITE 250

SKAPS TRANSNET™ geocomposite consists of SKAPS GeoNet made from HDPE resin with non-woven polypropylene geotextile fabric heat bonded on both sides of the the geonet.

Property	Test Method	Unit	Required Value		Qualifier
			With 6 oz.	With 8 oz.	
Geonet					
Thickness	ASTM D 5199	mil.	250±15	250±15	Range
Carbon Black	ASTM D 4218	%	2 to 3	2 to 3	Range
Tensile Strength	ASTM D 5035	lb/in	50	50	Minimum
Melt Flow	ASTM D 1238[3]	g/10 min.	1	1	Minimum
Density	ASTM D 1505	g/cm^3	0.94	0.94	Minimum
Transmissivity[1]	ASTM D 4716	$m^2/sec.$	$2.5x10^{-3}$	$2.5x10^{-3}$	MARV[2]
Composite					
Ply Adhesion (Minimum)	ASTM D7005	lb/in	0.5	0.5	MARV
Ply Adhesion (Average)	ASTM D7005	lb/in	1	1	MARV
Transmissivity[1]	ASTM D 4716	m^2/sec	$2x10^{-4}$	$2x10^{-4}$	MARV
Geotextile					
Fabric Weight	ASTM D 5261	oz/yd^2	6	8	MARV
Grab Strength	ASTM D 4632	lbs	160	225	MARV
Grab Elongation	ASTM D 4632	%	50	50	MARV
Tear Strength	ASTM D 4533	lbs	65	90	MARV
Puncture Resistance	ASTM D 4833	lbs	95	130	MARV
CBR Puncture	ASTM D 6241	lbs	475	650	MARV
Water Flow Rate	ASTM D 4491	gpm/ft^2	125	100	MARV
Permittivity	ASTM D 4491	sec^{-1}	1.63	1.26	MARV
Permeability	ASTM D 4491	cm/sec	0.3	0.3	MARV
AOS	ASTM D 4751	US Sieve	70	80	MARV

Notes:
1. Transmissivity measured using water at 21 ± 2ºC (70 ± 4ºF) with a gradient of 0.1 and a confining pressure of 10000 psf between stainless steel plates after 15 minutes. Values may vary between individual labs.
2. MARV is statistically defined as mean minus two standard deviations and it is the value which is exceeded by 97.5% of all the test data.
3. Condition 190/2.16

SKAPS TRANSNET™ HDPE GEOCOMPOSITE WITH TN 270 GEONET

SKAPS INDUSTRIES
571 Industrial Pkwy,
Commerce, GA 30529
Phone: (706) 336-7000
Fax: (706) 336-7007
E-Mail: contact@skaps.com

SKAPS TRANSNET™ Geocomposite consists of SKAPS Geonet made from HDPE resin with nonwoven polypropylene geotextile fabric heat bonded on one side or both sides of Geonet.

PROPERTY	TEST METHOD	UNIT	VALUE		QUALIFIER
GEONET					
Thickness	ASTM D 5199	mil	250	250	MAV(3)
Carbon Black	ASTM D 4218	%	2.0	2.0	MAV
Tensile Strength	ASTM D 7179	lb/in	55	55	MAV
Melt Flow	ASTM D 1238(2)	g/10 min	1.0	1.0	Maximum
Density	ASTM D 1505	g/cm^3	0.94	0.94	MAV
Transmissivity(1)	ASTM D 4716	gal/min/ft (m^2/sec)	14.50 (3.0×10^{-3})	14.50 (3.0×10^{-3})	MAV
GEOCOMPOSITE			**6 oz/yd²**	**8 oz/yd²**	
Ply Adhesion	ASTM D 7005	lb/in	1.00	1.00	MAV
Transmissivity(1) DS	ASTM D 4716	gal/min/ft (m^2/sec)	**TN 270-2-6**	**TN 270-2-8**	
			2.42 (5.0×10^{-4})	2.42 (5.0×10^{-4})	MAV
Transmissivity(1) SS	ASTM D 4716	gal/min/ft (m^2/sec)	**TN 270-1-6**	**TN 270-1-8**	
			7.25 (1.5×10^{-3})	7.25 (1.5×10^{-3})	MAV
GEOTEXTILE					
Fabric Weight	ASTM D 5261	oz/yd^2	6	8	MARV(4)
Grab Tensile	ASTM D 4632	lb	160	225	MARV
Grab Elongation	ASTM D 4632	%	50	50	MARV
Trapezoid Tear	ASTM D 4533	lb	65	90	MARV
CBR Puncture	ASTM D 6241	lb	450	600	MARV
Water Flow(5)	ASTM D 4491	gpm/ft^2	125	100	MARV
Permittivity(5)	ASTM D 4491	sec^{-1}	1.63	1.26	MARV
Permeability(5)	ASTM D 4491	cm/sec	0.30	0.30	MARV
AOS	ASTM D 4751	US Sieve	70	80	MaxARV

Notes:

(1) Transmissivity measured using water at 21 ± 2 °C (70 ± 4 °F) with a gradient of 0.1 and a confining pressure of 10000 psf between steel plates after 15 minutes. Values may vary with individual labs.
DS - Double Sided, SS - Single Sided

(2) Condition 190/2.16

(3) Minimum average value.

(4) MARV is statistically defined as mean minus two standard deviations and it is the value which is exceeded by 97.5% of all the test data.

(5) At the time of manufacturing. Handling may change these properties.

SKAPS TRANSNET™ HDPE GEOCOMPOSITE WITH TN 330 GEONET

SKAPS INDUSTRIES
571 Industrial Pkwy,
Commerce, GA 30529
Phone: (706) 336-7000
Fax: (706) 336-7007
E-Mail: contact@skaps.com

SKAPS TRANSNET™ Geocomposite consists of SKAPS Geonet made from HDPE resin with nonwoven polypropylene geotextile fabric heat bonded on one side or both sides of Geonet.

PROPERTY	TEST METHOD	UNIT	VALUE		QUALIFIER
GEONET					
Thickness	ASTM D 5199	mil	300	300	MAV(3)
Carbon Black	ASTM D 4218	%	2.0	2.0	MAV
Tensile Strength	ASTM D 7179	lb/in	75	75	MAV
Melt Flow	ASTM D 1238(2)	g/10 min	1.0	1.0	Maximum
Density	ASTM D 1505	g/cm^3	0.94	0.94	MAV
Transmissivity(1)	ASTM D 4716	gal/min/ft (m^2/sec)	38.67 (8.0 x 10^{-3})	38.67 (8.0 x 10^{-3})	MAV
GEOCOMPOSITE			**6 oz/yd²**	**8 oz/yd²**	
Ply Adhesion	ASTM D 7005	lb/in	1.00	1.00	MAV
Transmissivity(1) DS	ASTM D 4716	gal/min/ft (m^2/sec)	**TN 330-2-6**	**TN 330-2-8**	
			4.35 (9.0 x 10^{-4})	4.35 (9.0 x 10^{-4})	MAV
Transmissivity(1) SS	ASTM D 4716	gal/min/ft (m^2/sec)	**TN 330-1-6**	**TN 330-1-8**	
			14.50 (3.0 X 10^{-3})	14.50 (3.0 X 10^{-3})	MAV
GEOTEXTILE					
Fabric Weight	ASTM D 5261	oz/yd^2	6	8	MARV(4)
Grab Tensile	ASTM D 4632	lb	160	225	MARV
Grab Elongation	ASTM D 4632	%	50	50	MARV
Trapezoid Tear	ASTM D 4533	lb	65	90	MARV
CBR Puncture	ASTM D 6241	lb	450	600	MARV
Water Flow(5)	ASTM D 4491	gpm/ft^2	125	100	MARV
Permittivity(5)	ASTM D 4491	sec^{-1}	1.63	1.26	MARV
Permeability(5)	ASTM D 4491	cm/sec	0.30	0.30	MARV
AOS	ASTM D 4751	US Sieve	70	80	MaxARV

Notes:

(1) Transmissivity measured using water at 21 ± 2 °C (70 ± 4 °F) with a gradient of 0.1 and a confining pressure of 10,000 psf between steel plates after 15 minutes. Values may vary with individual labs.
DS - Double Sided, SS - Single Sided

(2) Condition 190/2.16

(3) Minimum average value.

(4) MARV is statistically defined as mean minus two standard deviations and it is the value which is exceeded by 97.5% of all the test data.

(5) At the time of manufacturing. Handling may change these properties.

PHASE II APPLICATION
CAMP HOPE RUN LANDFILL
BOGGS TOWNSHIP, CLEARFIELD COUNTY, PENNSYLVANIA

FORM 24
EXHIBIT 24-9.5
Geotextiles

FEBRUARY 2018

AGRUTEX 061
Polypropylene Geotextile

Agrutex 061 is a polypropylene, staple fiber, needlepunched nonwoven geotextile. The fibers are needled together to form a stable network that retains dimensional stability relative to each other. The geotextile is resistant to ultraviolet degradation and to biological and chemical environments normally found in soils.

Argutex 061 conforms to the property values listed below.[1] Agru America's Laboratories are accredited by the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP).

		MARV	
PROPERTY	**TEST METHOD**	**ENGLISH**	**METRIC**
Physical			
Mass/Unit Area	ASTM D-5261	6.0 oz/yd^2	203 g/m^2
Thickness[2]	ASTM D-5199	65 mils	1.7 mm
Mechanical			
Tensile Strength (Grab)	ASTM D-4632	170 lbs	757 N
Elongation	ASTM D-4632	50%	50%
CBR Puncture	ASTM D-6241	435 lbs	1935 N
Puncture Resistance	ASTM D-4833	95 lbs	423 N
Mullen Burst	ASTM D-3786	330 psi	2274 kPA
Trapezoidal Tear	ASTM D-4533	65 lbs	289 N
Endurance			
UV Resistance % Retained at 500 hrs	ASTM D-4355	70%	70%
Hydraulic			
Apparent Opening Size (AOS)[2, 3]	ASTM D-4751	70 US Std. Sieve	0.212 mm
Permittivity[2]	ASTM D-4491	1.5 sec^{-1}	1.5 sec^{-1}
Permeability[2]	ASTM D-4491	0.25 cm/sec	0.25 cm/sec
Water Flow Rate[2]	ASTM D-4491	110 gpm/ft^2	4479 l/min/m^2
Roll Sizes		15ft x 300ft	4.57m x 91.4m

NOTES:

1. Effective January 2014 and subject to change without notice.
2. Values established at the time of manufacturing. Handling, storage, and shipping may change these properties.
3. Apparent Opening Size, (AOS), reported as maximum average roll value.

Rev: 1/17/2014

Executive Offices: 500 Garrison Road, Georgetown, SC 29440 (843) 546-0600, (800) 321-1379

Manufacturing: 181 Hwy 521 Andrews, SC (843) 221-4121, (800) 321-1379

email: salesmkg@agruamerica.com website: www.agruamerica.com

AGRUTEX 161
Polypropylene Geotextile

Agrutex 161 is a polypropylene, staple fiber, needlepunched nonwoven geotextile. The fibers are needled to form a stable network that retains dimensional stability relative to each other. The geotextile is resistant to ultraviolet degradation and to biological and chemical environments normally found in soils.

Argutex 161 conforms to the property values listed below.[1] Agru America's Laboratories are accredited by the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP).

		MARV	
PROPERTY	**TEST METHOD**	**ENGLISH**	**METRIC**
Physical			
Mass/Unit Area	ASTM D-5261	16.0 oz/yd^2	544 g/m^2
Thickness[2]	ASTM D-5199	125 mils	3.2 mm
Mechanical			
Tensile Strength (Grab)	ASTM D-4632	390 lbs	1736 N
Elongation	ASTM D-4632	50%	50%
CBR Puncture	ASTM D-6241	1125 lbs	5006 N
Puncture Resistance	ASTM D-4833	240 lbs	1055 N
Mullen Burst	ASTM D-3786	740 lbs	5098 kPA
Trapezoidal Tear	ASTM D-4533	150 lbs	668 N
Endurance			
UV Resistance % Retained at 500 hrs	ASTM D-4355	70%	70%
Hydraulic			
Apparent Opening Size (AOS)[2, 3]	ASTM D-4751	100 US Std. Sieve	0.150 mm
Permittivity[2]	ASTM D-4491	0.7 sec^{-1}	0.7 sec^{-1}
Permeability[2]	ASTM D-4491	0.26 cm/sec	0.26 cm/sec
Water Flow Rate[2]	ASTM D-4491	50 gpm/ft^2	2050 l/min/m^2
Roll Sizes		15ft x 300ft	4.57m x 91.4m

NOTES:

1. Effective January 2013 and subject to change without notice.
2. Values established at the time of manufacturing. Handling, storage, and shipping may change these properties.
3. Apparent Opening Size, (AOS), reported as maximum average roll value.

Rev: 5/7/2013

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PRODUCT DATA SHEET

GSE Nonwoven Geotextiles

GSE Nonwoven Geotextiles are a family of staple fiber needlepunched geotextiles. The geotextiles are manufactured using an advanced manufacturing and quality system to produce the most uniform and consistent nonwoven needlepunched geotextile currently available in the industry. GSE combines a fiber selection and approval system with an in-line quality control and a state-of-the-art laboratory to ensure that every roll shipped meets customer specifications.

AT THE CORE:

A family of geotextiles used for separation, filtration, protection and drainage applications.

Product Specifications

These product specifications meet GRI GT12, GRI GT13 and AASHTO M288

Tested Property[1]	Test Method	Frequency	Minimum Average Roll Value					
			NW4	NW6	NW8	NW10	NW12	NW16
AASHTO M288 Class			3	2	1	>1	>>1	>>>1
Mass per Unit Area, oz/yd^2	ASTM D 5261	90,000 ft^2	4	6	8	10	12	16
Grab Tensile Strength, lb	ASTM D 4632	90,000 ft^2	120	160	220	260	320	390
Grab Elongation, %	ASTM D 4632	90,000 ft^2	50	50	50	50	50	50
CBR Puncture Strength, lb	ASTM D 6241	540,000 ft^2	303	435	575	725	925	1,125
Trapezoidal Tear Strength, lb	ASTM D 4533	90,000 ft^2	50	65	90	100	125	150
Apparent Opening Size, Sieve No. (mm)	ASTM D 4751	540,000 ft^2	70 (0.212)	70 (0.212)	80 (0.180)	100 (0.150)	100 (0.150)	100 (0.150)
Permittivity, sec^{-1}	ASTM D 4491	540,000 ft^2	1.80	1.50	1.30	1.00	0.80	0.60
Water Flow Rate, gpm/ft^2	ASTM D 4491	540,000 ft^2	135	110	95	75	60	45
UV Resistance % retained after 500 hours	ASTM D 4355	per formulation		70	70	70	70	70
TYPICAL ROLL DIMENSIONS								
Roll Length[2], ft			850	850	600	500	400	300
Roll Width[2], ft			15	15	15	15	15	15
Roll Area, ft^2			12,750	12,750	9,000	7,500	6,000	4,500

NOTES:

- [1]The property values listed are in weaker principal direction. All values listed are Minimum Average Roll Values except apparent opening size in mm and UV resistance. Apparent opening size (mm) is a Maximum Average Roll Value. UV is a typical value.
- [2]Roll lengths and widths have a tolerance of ±1%.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

DURABILITY RUNS DEEP

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

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SKAPS Nonwoven

ENVIRONMENTAL GEOTEXTILES

PROPERTY	UNIT	ASTM TEST METHOD	GE-140 4 oz	GE-160 6 oz	GE-170 7 oz	GE-180 8 oz	GE-110 10 oz	GE-112 12 oz	GE-114 14 oz	GE-116 16 oz
Weight	oz/yd^2 (g/m^2)	ASTM D 5261	4.0 (135)	6.0 (203)	7.0 (237)	8.0 (271)	10.0 (339)	12.0 (407)	14.0 (475)	16.0 (542)
Thickness*	mils (mm)	ASTM D 5199	70 (1.77)	85 (2.16)	90 (2.29)	100 (2.5)	110 (2.79)	120 (3.05)	135 (3.43)	175 (4.45)
Grab Tensile	lbs (kN)	ASTM D 4632	105 (0.467)	160 (0.711)	200 (0.889)	225 (1.0)	270 (1.20)	330 (1.47)	390 (1.73)	425 (1.89)
Grab Elongation	%	ASTM D 4632	50	50	50	50	50	50	50	50
Trapezoid Tear	lbs (kN)	ASTM D 4533	45 (0.20)	65 (0.29)	75 (0.33)	90 (0.40)	100 (0.44)	125 (0.556)	135 (0.60)	150 (0.667)
Puncture Resistance	lbs (kN)	ASTM D 4833	65 (0.289)	95 (0.42)	115 (0.511)	130 (0.578)	165 (0.733)	190 (0.844)	210 (0.930)	240 (1.07)
Mullen Burst	psi (kPa)	ASTM D 3786	230 (1585)	330 (2274)	370 (2549)	425 (2928)	525 (3617)	625 (4306)	700 (4823)	800 (5512)
Permittivity*	sec^{-1}	ASTM D 4491	2.00	1.63	1.41	1.26	0.94	0.90	0.64	0.57
Permeability*	cm/sec	ASTM D 4491	0.55	0.48	0.46	0.30	0.30	0.30	0.25	0.25
Water Flow*	gpm/ft^2 (1/min/m^2)	ASTM D 4491	160 (6518)	125 (5080)	110 (4470)	100 (4074)	75 (3055)	70 (2544)	50 (2037)	45 (1833)
A.O.S.*	U.S. Sieve (mm)	ASTM D 4751	70 (0.212)	70 (0.212)	70 (0.212)	80 (0.180)	100 (0.150)	100 (0.150)	100 (0.150)	100 (0.150)
U.V. Resistance	%/hrs	ASTM D 4355	70/500	70/500	70/500	70/500	70/500	70/500	70/500	70/500

*** At time of manufacturing. Handling, storage, and shipping may change these properties.**

PACKAGING								
Roll Dimensions (ft)	15 x 1350	15 x 900	15 x 780	15 x 690	15 x 570	15 x 480	15 x 390	15 x 360
Square Yards/Roll	2250	1500	1300	1150	950	800	650	600
Estimated Roll Weight (lbs)	620	620	620	620	620	620	620	620