

**COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT
RCRA PART B
PERMIT ATTACHMENT LF-10.1**

**SPECIFICATIONS FOR SECURE CELL CONSTRUCTION (CELLS 3 THROUGH 7)
AND SURFACE IMPOUNDMENT LINER AND COVER
SYSTEM CONSTRUCTION (CELLS 2 THROUGH 7)**

**CLEAN HARBORS DEER TRAIL, LLC.
HAZARDOUS WASTE
TREATMENT, STORAGE, AND DISPOSAL FACILITY**

ADAMS COUNTY, COLORADO

EPA IDENTIFICATION NUMBER COD991300484

NOTE: This permit attachment is a typical specification for Secure Cell and Surface Impoundment Liner and Cover Construction. Modifications to the plan may be required prior to construction of each secure cell based on final design drawings. The revisions required for each secure cell will be submitted to CDPHE for approval prior to construction.

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SECTION 01010 GENERAL REQUIREMENTS



PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary to construct the secure cell or surface impoundment liner or cover systems at the The Permittee's hazardous waste treatment, storage, and disposal facility (TSDF) in Adams County, Colorado.

- B. The work shall include those items identified in the Contract Documents which may include site preparation and earthwork, clay liner construction, geosynthetic clay liner installation, geomembrane liner/cover installation, drainage layer and drainage pipe installation, protective soil layer placement, quality control, surveying, and related work.

1.02 DEFINITIONS

- A. The following list of definitions is provided for reference.
 - 1. *Atterberg Limits*: The liquid limit, plastic limit, and shrinkage limit for soils as defined by (ASTM D 4318).
 - 2. *CDPHE*: Colorado Department of Public Health and Environment
 - 3. *CDPHE and RCRA Part B Permit (Part B Permit)*: Colorado Department of Public Health and Environment (CDPHE) and Resource Conservation and Recovery Act (RCRA) Part B Permit for the The Permittee hazardous waste TSDF.
 - 4. *Compaction*: The process of increasing the unit weight of soil by rolling, tamping, vibrating, or other mechanical means. As a result of compaction, the hydraulic conductivity of the soil may be decreased.
 - 5. *Construction Drawings*: Design plans used to construct a facility; the plans must be signed and sealed by a Professional Engineer registered in the State of Colorado.
 - 6. *Construction Quality Assurance (CQA)*: A planned and systematic pattern of all means and actions designed to provide adequate confidence that items or services meet contractual and regulatory requirements (see Permit Attachment LF-10.3).

7. *CQA Engineer*: The individual, firm or corporation, independent from the Owner, Contractor, Supplier, or Manufacturer, that is responsible for observing, testing, and documenting construction activities under the terms of the contract. Provided that the Design Engineer and the Owner are not the same party, the CQA Engineer may be the same as the Design Engineer. The CQA Engineer will provide a Construction Quality Assurance Resident Engineer (CQA Resident Engineer). The CQA Engineer is responsible for certification of cell construction according to the specifications contained herein and will be a Professional Engineer registered in the State of Colorado.
8. *CQA Plan*: Site-specific document which addresses the following: (i) CQA personnel responsibilities, authorities, and qualifications; (ii) inspection, monitoring, and testing activities necessary to ensure that the facility is constructed to meet or exceed design criteria, plans, and specifications; and (iii) CQA documentation requirements, (see LF-10).
9. *Contract Documents*: The contract documents for construction of the secure cell or surface impoundment including the General Specifications, the Construction Drawings, the CQA Plan, any supplemental requirements, and the General Agreement.
10. *Contractor*: The individual, firm, or corporation undertaking the execution of the work under the terms of the contract.
11. *Design Engineer*: The individual, firm or corporation having direct responsibility for the design of the secure cell or surface impoundment structure. The Design Engineer must provide a Professional Engineer registered in the State of Colorado. The Design Engineer may be the same as the Owner.
12. *Dewatering*: Process of lowering ground water level(s) or removing storm water to permit construction activities to be made "in the dry" (not drying of fill material).
13. *General Specifications*: Specifications written which apply to the construction of all secure cells and surface impoundments.
14. *Geocomposite*: A planar, polymeric drainage material consisting of a polyethylene geonet core and geotextile filter layers that have been heat-bonded to the top and bottom surfaces of the geonet.
15. *Geomembrane*: A nonporous polymeric membrane liner or barrier used in civil engineering projects.
16. *Geonet*: A net consisting of two sets of transverse polymeric strands which create high in-plane flow capacity; used as a drainage medium in civil engineering projects.

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17. *Geosynthetics*: Polymeric materials used to perform various functions in construction projects (i.e., geomembranes, geonets, geocomposites, geotextiles, etc.).
 18. *Geosynthetic Clay Liner (GCL)*: A factory manufactured, hydraulic barrier typically consisting of bentonite clay or other very low permeability material, supported by geotextiles and/or geomembranes which are held together by needling, stitching, or chemical adhesives.
 19. *Geotextile*: A permeable textile material used with foundation, soil, rock, earth, or any other geotechnical engineering-related material that is an integral part of a man-made project, structure, or system.
 20. Clean Harbors Deer Trail, LLC: The owner and operator of the hazardous waste treatment, storage, and disposal facility under construction; referred to as the Owner.
 21. *Hydraulic Conductivity*: The rate at which a fluid flows through a porous medium. It is a function of the physical characteristics of both the porous medium and the fluid.
 22. *In-situ*: "As is", or as it exists in place naturally.
 23. *Laboratory*: The individual, firm, or corporation, independent from the Owner, Manufacturer, Supplier, or Contractor, responsible for conducting tests on construction materials to assure conformance with the General Specifications.
 24. *Leachate Collection System*: The drainage layer above the primary composite liner of the secure cell and associated piping, risers, etc. that enable collection and removal of leachate from the secure cell.
 25. *Leak Detection System*: The drainage layer sandwiched between the primary and secondary liners of the secure cell or surface impoundment and associated piping, risers, etc., that enable detection, collection, and removal of leachate, if any, that leaks through the primary liner.
 26. *Liner System*: The system of natural and synthetic liners and drainage layers beneath the secure cell or surface impoundment, used to contain leachate while allowing its collection and removal.
 27. *Manufacturer*: The individual, firm, or corporation responsible for manufacturing a specific component (e.g., a geomembrane liner) used in surface impoundment or secure cell construction.

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28. *Moisture Content*: Ratio of quantity of water in the soil (by weight) to the weight of the soil solids (dry soil), expressed in percentage; also referred to as water content.
 29. *Optimum Moisture Content (OMC)*: Moisture content corresponding to maximum dry unit weight as determined in the standard Proctor or modified Proctor compaction test (i.e., ASTM D 698 or D 1557).
 30. *Owner*: The party known as Laidlaw Environmental Services (Deer Trail), Inc. (LES), a Colorado Corporation, and the operator of the hazardous waste treatment storage and disposal facility under construction. The Owner shall hire the Contractor(s) to execute the work under the terms of the General Agreement. The activities of the Owner in the General Specifications, any supplemental requirements, and CQA Plan may be performed by the Owner or other party representing the Owner such as, but not limited to, a representative of The Permittee, the Design Engineer, or CQA Engineer.
 31. *Particle-Size Distribution*: Distribution of particle sizes within a soil; determined using ASTM D 422.
 32. *Permanent Sump*: The drainage layer beneath the sump area of the secondary liner of the secure cell that enables the detection, collection, and removal of leachate if any, that leaks through the secondary liner in that area.
 33. *Permeability*: Ability of pore fluid to travel through a soil mass via interconnected voids. "High" permeability indicates relatively rapid flow, and vice versa. Rates of permeability are generally reported in centimeters per second.
 34. *Plasticity*: Ability of soil mass to flow or be remolded without raveling or breaking apart. Generally that range of soil water content between the liquid and plastic limit.
 35. *Primary Composite Liner*: Top composite liner in a double-liner system consisting of two or more low-permeability components of different materials in contact with each other.
 36. *Primary Geomembrane Liner*: Top geomembrane liner in a double-liner system.
 37. *Primary Soil Liner*: Top soil liner in a double-liner system.
 38. *RCRA*: Resource Conservation and Recovery Act; Federal hazardous waste regulations.

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39. *Secondary Composite Liner*: Bottom composite liner in a double-liner system consisting of two or more low-permeability components of different materials in contact with each other.
 40. *Secondary Geomembrane Liner*: Bottom geomembrane liner in a double-liner system.
 41. *Secondary Soil Liner*: Bottom soil liner in a double-liner system.
 42. *Secondary Structure*: The macrostructure of a geologic stratum. Structural features in a soil or rock deposit which can be seen with little or no magnification, to include, but not be limited to, pockets, lenses, layers, seams, or partings of varying soil types, slickensided fissures, laminated structure, bedding planes, and/or mineral concretions or staining.
 43. *Secure Cell*: A discrete landfill cell designed and constructed to store industrial and/or hazardous wastes in an environmentally safe manner and in accordance with Federal, State, and local regulations.
 44. *Sieve (200 Mesh)*: Refers to the soil particle size that passes (smaller than or equal to) the U.S. Sieve No. 200 (ASTM Specification E-11) which has a 75 micrometer (0.00295 inch) opening.
 45. *Specifications*: Detailed descriptions of requirements, dimensions, materials, construction methods, etc., necessary for the construction of a secure cell or surface impoundment.
 46. *Subcontractor*: The individual, firm, or corporation that contracts to perform some service or provide some material necessary for the performance of another's contract.
 47. *Supplier*: The individual, firm, or corporation responsible for supplying a contractor or a manufacturer with a specific material (e.g., gravel, granular material, resin, etc.) required for construction of a manufactured product or for the construction of the secure cell or surface impoundment.
 48. *Surface Impoundment*: A discrete impoundment designed and constructed to hold an accumulation of potentially contaminated rainwater and runoff from processing, hauling, or waste handling operations or designed and operated to contain hazardous waste during treatment of the waste.
 49. *TSDf*: treatment, storage, and disposal facility.
 50. *Unified Soil Classification System*: Soil classification system in accordance with ASTM D 2487.

51. *Unit Weight*: Weight of soil per unit volume; usually reported in pounds per cubic foot.
52. *"Walking Out"*: Continually rising effect experienced by a sheepsfoot roller during compaction of soil; an indication that the soil is approaching the proper degree of compaction.

PART 2 CONTRACT DOCUMENTS

2.01 INCLUDED DOCUMENTS

- A. The Contract Documents for construction of the secure cell or surface impoundment shall include, as applicable: (i) General Specifications, (ii) Supplemental Specifications; (iii) CQA Plan; (iv) Construction Drawings; and (v) General Agreement.

2.02 GENERAL SPECIFICATIONS

- A. The secure cell or surface impoundment shall be constructed in accordance with these General Specifications and other applicable Contract Documents.

2.03 SUPPLEMENTAL SPECIFICATION

- A. The supplemental specifications provide additional requirements for construction of a specific secure cell liner or cover or surface impoundment that relate to construction contractual considerations, and are not permit-related.

2.04 CQA PLAN

- A. The materials, procedures, and test methods and frequencies used in the construction quality assurance of the secure cell or surface impoundment construction shall conform to the requirements of the CQA Plan (Part B Permit Attachment LF-10).

2.05 CONSTRUCTION DRAWINGS

- A. The secure cell or surface impoundment shall be constructed not only in accordance with the General Specifications but also in accordance with the Construction Drawings for the specific structure.

2.06 GENERAL AGREEMENT

- A. The contractual agreement, and all terms and conditions thereof, between the Owner and the Contractor.

PART 3 PROJECT ORGANIZATION AND CONTROL

3.01 ORGANIZATION CHART

- A. The project organization chart for the parties involved in construction of the secure cells and surface impoundments is provided in Figure 01010-1.

3.02 RESPONSIBILITIES OF PARTIES

- A. *Owner:* The Owner is the facility manager, responsible for facility administration, regulatory oversight, health and safety, accounting, purchasing, etc. The Owner has direct authority over the Contractor, CQA Engineer, and Design Engineer and coordinates activities by these parties.
- B. *Contractor:* The Contractor is responsible for constructing the secure cell or surface impoundment in accordance with the General Specifications, other applicable contract documents, Construction Drawings and CQA Plan. The Contractor may be responsible for earthwork, geosynthetics, and other components of secure cell or surface impoundment landfill construction. The contracting and administration of contract requirements for secure cell or surface impoundment construction shall be the responsibility of the Owner. Different contractors may be used to construct different components of the secure cell or surface impoundment.
- C. *CQA Engineer:* The CQA Engineer is responsible for monitoring construction activities on-site and certifying that the facility is constructed in accordance with the plans and specifications. The CQA Engineer provides information, reports, test results, and observations to the Owner. The CQA Engineer may communicate directly with the Contractor and Design Engineer to coordinate activities and receive information. The CQA Engineer provides an on-site CQA Resident Engineer.
- D. *Design Engineer:* The Design Engineer is responsible for the design of the secure cell or surface impoundment. The Design Engineer reports to the Owner. The Design Engineer may communicate directly with the Contractor and CQA Engineer.

PART 4 SEQUENCE OF CONSTRUCTION

4.01 OVERALL SEQUENCE

- A. The overall sequence of construction for a specific secure cell or surface impoundment shall be as described in the Construction Drawings for the specific structure and in accordance with the Contract Documents.

4.02 SEQUENCE OF LINER AND COVER SYSTEM CONSTRUCTION

- A. The sequence of liner systems and cover systems construction shall be as follows, recognizing that not all liner and cover system components may be used in all cases.

Secure Cell Liner Systems:

1. Site Preparation and Earthwork
2. Permanent Sump
3. Secondary Clay Liner
4. Secondary Geomembrane Liner
5. Leak Detection System
6. Primary Clay Liner
7. Primary Geosynthetic Clay Liner
8. Primary Geomembrane Liner
9. Leachate Collection System
10. Protective Soil Layer

Cover Systems:

1. Interim Soil Cover
2. GCL
3. Geomembrane Cover
4. Drainage Layer
5. General Fill Soil
6. Vegetative Cover Soil

- B. Several of the above-listed components may be constructed concurrently.

PART 5 REFERENCE STANDARDS

5.01 APPLICABLE ORGANIZATIONS

- A. Organizations whose standards are referenced herein are as follows:

1. AASHTO - American Association of State Highway and Transportation Officials
2. ASTM - American Society for Testing and Materials
3. CHS - Colorado Department of Highways (Standard Specifications for Road and Bridge Construction)
4. GRI - Geosynthetics Research Institute
5. OSHA - Occupational Safety and Health Administration
6. USEPA - United States Environmental Protection Agency

5.02 APPLICABLE STANDARDS

- A. Any reference to standards of any society, institute, association, or government agency shall be the edition in effect as of the date of the contract, unless stated otherwise.

5.03 SPECIFIC STANDARDS

- A. Specific test standards cited in the General Specifications are given in Table 01010-1.

PART 6 GENERAL REQUIREMENTS

- A. *Reference Points:* Construction reference monuments and benchmarks have been established by the Owner for use in controlling the construction work. All work shall be constructed based on and in relation to these reference points. The Contractor shall be responsible for re-establishing any reference points disturbed during construction. Disturbed or destroyed points shall be re-established at the Contractor's expense, as directed by the Owner.
- B. *Soils Investigation:* Site soil investigations will be performed by the Owner. Soil investigation reports will be available for the Contractor's use. The Contractor shall not assume that information within these reports accurately reflects the soil conditions at all locations within the project area, but that they only depict soil conditions at specific points where samples were taken.
- C. *Surveying:* The Contractor shall perform all surveying required to lay out and control the work. Surveying shall be conducted such that all applicable standards required by the State of Colorado are followed. Required Record Drawings shall be as specified in these General Specifications. All surveying shall be performed under the direction of a surveyor licensed to perform such work in the State of Colorado. All Record Drawings shall be signed and sealed by the licensed surveyor who directed the survey work. Record drawings shall be at a scale not smaller than 1 inch = 50 feet. The required surveying of liner system elevations shall be carried out on a grid; approximately 50-foot square on slopes of 25 percent or less and 100-foot square on slopes greater than 25 percent. The survey locations shall be close enough to define the following features in the secure cell or surface impoundment: toe of slope, crest of slope, anchor trench, leachate collection sump, leak detection sump, permanent sump, and perimeter drainage ditch. The thicknesses of the liner system components on the Conceptual Site Development Plan Drawings shall be interpreted as minimums. All surveys shall be referenced to the Owner's site coordinate grid system.
- D. *Construction Tolerances:* Unless otherwise stated herein and where practical, construction tolerances shall be " 0.2 feet horizontally, and, provided that minimum thickness requirements are met, " 0.1 feet vertically. All surfaces shall be reasonably free from irregularities with slopes or grades within " 10 percent of their nominal values. All liner and cover surfaces shall be free-draining with no standing water except at low points designated on the Construction Drawings.

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- E. *Permits*: The Contractor shall not be required to obtain any environmental or general construction permits applying to the general design of the facility. The Contractor shall be required to obtain permits, such as over-size haul permits, related to specific construction equipment or techniques he intends to employ to accomplish the work.
- F. *Sedimentation, Erosion Control, and Dewatering*: Contractor shall comply with all requirements of the Owner's Specification 34-0230 for controlling erosion, water pollution, and dust emissions resulting from construction activities; the Contractor shall be responsible for any fines imposed due to noncompliance. Within the disturbed areas in which the Contractor is working, the Contractor shall seal-roll disturbed surfaces when required and maintain temporary grades and ditches to promote water drainage and prevent infiltration. The Contractor shall provide all equipment necessary to dewater excavations within 12 hours after a storm event.
- G. *Work Limits*: All clearing, stripping, excavation, backfill and surfacing shall be done to the lines, grades, and dimensions called for on the Construction Drawings and General Specifications unless directed otherwise by the Owner. All work done beyond designated limits without prior approval shall be corrected to the Owner's satisfaction, at no additional cost to the Owner.
- H. *Protection of Existing Services and Wells*: The Contractor shall exercise care to avoid disturbing or damaging existing monitor wells, electrical poles and lines, permanent below-ground utilities, permanent drainage structures, temporary utilities and structures, or items which the Owner has marked with red flagging. If the Contractor encounters any unexpected underground utilities during the course of the work, the Contractor shall immediately inform the Owner who will determine whether or not the utility is active. When the work requires the Contractor to be near or cross known utilities, the Contractor shall carefully uncover, support and protect these utilities and shall not cut, damage, or otherwise disturb them without prior authorization from the Owner. All utilities, wells, or other items damaged by the Contractor shall be immediately repaired or replaced by the Contractor to the satisfaction of the Owner at no additional cost to the Owner.
- I. *Explosives*: The use of explosives for demolition or excavation is not expected to be required and will not be permitted without prior written approval of the Owner.
- J. *Burning*: The use of open fires on site for any reason is prohibited.
- K. *Temporary Roads*: The Contractor shall be responsible for constructing and maintaining all temporary roads and laydown areas which the Contractor may require in the execution of his work.
- L. *Construction Water*: The quality of construction water used to accomplish construction work is crucial due to the nature of the facilities being constructed. The Owner will provide water for construction and dust control and will specify the source and periodically obtain water quality samples. The Contractor shall not add substances to construction water without the express written consent of the Owner. The Contractor shall utilize measuring devices that allow him to measure and record the

volume of water used. Such usage records shall be maintained by the Contractor and provided to the Owner.

- M. *Cooperation:* The Contractor shall cooperate with all other parties engaged in project-related activities to the greatest extent possible. Disputes or problems shall be referred to the Owner for resolution.
- N. *Familiarization:* The Contractor is responsible for becoming familiar with all aspects of work prior to performing the work.
- O. *Safeguards:* The Contractor shall provide and use all personnel safety equipment, barricades, guardrails, signs, lights, flares, and flagmen as required by OSHA, state, or local codes and ordinances. No excavations deeper than 4 feet with side slopes steeper than 2:1 (horizontal:vertical) shall be made without the prior approval of the Owner. When shoring is required, the design and inspection of such shoring shall be the Contractor's responsibility and subject to the review of the Owner prior to use. No personnel shall work within or next to an excavation requiring shoring until such shoring has been installed, inspected, and approved by an Engineer registered in the State of Colorado, provided by the Contractor. The Contractor shall be responsible for any fines imposed due to violation of any laws and regulations relating to the safety of the Contractor's personnel.
- P. *Construction Access Plan:* Prior to mobilization to the site, the Contractor shall submit a plan to the Owner showing where he intends to place staging areas, stockpile areas, temporary on-site access roads, temporary erosion control structures, etc. This plan must be approved by the Owner prior to mobilization.
- Q. *Clean-up:* The Contractor shall be responsible for general house-keeping during construction. Upon completion of work, the Contractor shall remove all of his equipment, facilities, construction materials, and trash. All disturbed areas shall be revegetated or otherwise put into a condition satisfactory to the Owner. Revegetation shall be carried out in accordance with the requirements in Owner's Specification 34-0229.
- R. *Security:* The Contractor is responsible for the safety and condition of all of his tools and equipment. The Owner will not be responsible for lost or stolen materials or equipment.
- S. *Acceptance of Work:* Except as otherwise provided within the General Conditions, the Contractor shall retain ownership and responsibility for all work until accepted by Owner. The Owner will accept ownership and responsibility for the liner system: (I) when all work is completed; (ii) after the Contractor has submitted all required documentation, including manufacturing quality control documentation, manufacturing certifications, and Record Drawings signed and sealed by a Professional Land Surveyor licensed in the State of Colorado (if required by Owner); and (iii) after the CQA Engineer has submitted the Final CQA Report which certifies that the liner has been constructed in accordance with the Construction Drawings and these

Specifications and Record Drawings signed and sealed by a Professional Engineer registered in the State of Colorado.

- T. *Health and Safety Training:* The Contractor shall provide necessary health and safety training for all of the Contractor's on-site personnel in accordance with the Site Health and Safety Plan. The Owner may require evidence of health and safety training at any time for any of the Contractor's personnel working on site.
- U. *Exclusion Areas:* The Contractor's personnel shall not enter any areas on-site identified with signs as exclusion areas without approval of the Owner, and without proper personal protective equipment. The Contractor shall confine activities to the work limits shown on the Construction Drawings.
- V. *Hazardous Waste Management Operations:* The Contractor shall not enter areas where active hazardous waste management operations are being performed.
- W. *CQA Activities:* The Owner will utilize an independent CQA Engineer to perform CQA activities. The Contractor shall be aware of all CQA activities and shall allow sufficient time in his construction schedule to accommodate CQA activities. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of CQA activities.
- X. All quality control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.

TABLE 01010-1 TEST METHODS CITED IN GENERAL SPECIFICATIONS AND CQA PLAN		
AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS		
1.	AASHTO T96	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine.
2.	AASHTO T104	Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
AMERICAN SOCIETY OF TESTING AND MATERIALS		
1.	ASTM A 307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
2.	ASTM A 726	Standard Specification for Cold-Rolled Carbon Steel Sheet, Magnetic Laminated Quality, Types 1, 2, and 2S.
3.	ASTM D 374C D 1777	Method for Measuring Thickness of Geotextile Materials.
4.	ASTM D 422	Standard Method for Particle-Size Analysis of Soils.
5.	ASTM D 570	Standard Test Method for Water Absorption of Plastics.
6.	ASTM D 638	Standard Test Method for Tensile Properties of Plastics.
7.	ASTM D 698	Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop.
8.	ASTM D 746	Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
9.	ASTM D 751	Standard Methods of Testing Coated Fabrics.
10.	ASTM D 792	Standard Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement.
11.	ASTM D 882	Standard Test Methods for Tensile Properties of Thin Plastic Sheeting.
12.	ASTM D 1004	Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting.
13.	ASTM D 1204	Standard Plastics Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.
14.	ASTM D 1238	Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
15.	ASTM D 1248	Standard Specification for Polyethylene Plastic Molding and Extrusion Metals.
16.	ASTM D 1505	Standard Test Methods for Density of Plastics by Density-Gradient Technique.
17.	ASTM D 1556	Standard Test Method for Density of Soil In Place by the Sand-Cone Method.
18.	ASTM D 1593	Standard Specification for Nonrigid Vinyl Chloride Plastic Sheeting.
19.	ASTM D 1603	Standard Test Method for Carbon Black in Olefin Plastics.
20.	ASTM D 2167	Standard Test Method for Density and Unit Weight of Soils in Place by the Rubber Balloon Method.
21.	ASTM D 2216 or D 4643	Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.
22.	ASTM D 2434	Standard Test Method for Permeability of Granular Soils (Constant Head).
23.	ASTM D 2487	Standard Test Method for Classification of Soils for Engineering Purposes.
24.	ASTM D 2657	Standard Practice for Heat-Joining for Polyolefin Pipe and Fittings.
25.	ASTM D 2663	Carbon-Black Dispersion in Rubber.
26.	ASTM D 2837	Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.
27.	ASTM D 2922	Standard Test Method for Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth).
28.	ASTM D 3015	Recommended Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds.
29.	ASTM D 3017	Standard Test Method for Moisture Content of Soil and Rock In Place by Nuclear Methods

TABLE 01010-1		
TEST METHODS CITED IN GENERAL SPECIFICATIONS AND CQA PLAN		
		(Shallow Depth).
30.	ASTM D 3083	Standard Specification for Flexible Poly (Vinyl Chloride) Plastic Sheeting for Pond, Canal, and Reservoir Lining.
31.	ASTM D 3350	Standard Specifications for Polyethylene Plastic Pipe and Fittings Materials.
32.	ASTM D 3776	Mass Per Unit Area (Weight) of Woven Fabric.
33.	ASTM D 4253	Standard Test Method for Maximum Index Density of Soils Using a Vibratory Table
34.	ASTM D 4254	Standard Test Method for Minimum Index Density of Soils and Calculations of Relative Density.
35.	ASTM D 4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
36.	ASTM D 4373	Standard Test Method for Calcium Carbonate Content of Soils.
37.	ASTM D 4437	Standard Test Methods for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Geomembranes.
38.	ASTM D 4491	Standard Test Method for Water Permeability of Geotextiles by the Permittivity Method.
39.	ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
40.	ASTM D 4632	Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Elongation Method and Peel Strength).
41.	ASTM D 4643	Determination of Water (Moisture) Content of Soil by the Microwave Oven Method
42.	ASTM D 4716	Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
43.	ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
44.	ASTM D 4716	Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
45.	ASTM D 4833	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
46.	ASTM D 5261	Measuring mass per unit area of geotextile.
47.	ASTM D 5321	Coefficient of soil and geosynthetics or geosynthetics and geosynthetics friction by direct shear.
48.	ASTM D 5890	Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
49.	ASTM D 5891	Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
50.	ASTM E 11	Specification for Wire-Cloth Sieves for Testing Purposes.
51.	ASTM F 714	Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
52.	ASTM C 31	Making and Curing Concrete Test Specimen in the Field.
53.	ASTM C 39	Compressive Strength of Cylindrical Concrete Specimens.
54.	ASTM C 143	Test Method for Slump of Hydraulic Cement Concrete.
55.	ASTM C 173	Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
56.	ASTM C 231	Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY		
1.	USEPA Method 9090	Compatibility Test for Wastes and Membrane Liners.

[END OF SECTION]

SECTION 02010 SUBSURFACE INVESTIGATION

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Prior to the start of construction of each secure cell, the Owner will execute the subsurface investigation described in this Section. The investigation will include test borings, sampling, and analysis in the area selected for the location of the secure cell. The work will be carried out in accordance with this General Specification.

1.02 RELATED SECTIONS

- A. Section 02110 - Site Preparation and Earthwork

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.01 TEST BORINGS

- A. At a minimum, test borings will be made at each corner and in the center of the secure cell (5 total). Additional test borings may be performed at the discretion of the Owner depending on the variability of the stratigraphy at a given secure cell location. The number of test borings required within the perimeter of the secure cell shall be kept to a minimum. The Contractor should not assume that sufficient subsurface information will be developed to accurately reflect the soil and/or bedrock conditions at all locations within the project area.
- B. Test borings will be carried to depths selected by the Owner. The test borings at the perimeter of the secure cell will penetrate a minimum of 10 feet below the lowest planned excavation. Other test borings within the cell perimeter may be advanced to a shallower depth as directed by the Owner.
- C. Each test boring will be logged by a qualified geologist or geotechnical engineer supplied by the Owner. Accurate logs of the materials encountered will be maintained. The method of drilling, diameter of the borehole, and other pertinent information will be reported on the boring logs.
- D. The type and characteristics of the soil and/or bedrock encountered, as well as strata depths and thicknesses, will be evaluated from the test borings, and noted on the boring logs. The geologist or geotechnical engineer will investigate the macrostructure of the strata. A detailed description of these features will be included on the boring logs.

- E. The water level in each test boring will be observed and recorded, if water is encountered during drilling. The initial water level and water level after a 24-hour period (or cave in depth, should that situation occur) will be noted.
- F. After drilling, logging, sampling, and water level measurement, each test boring will be decommissioned. Decommissioning will be accomplished by grouting using the tremie method with a grout mix of 7 gallons of water to 1 bag (94 lb) of Type 1 Portland cement and 2 percent bentonite (by dry weight of cement). Test borings will be grouted to their full depth after the 24-hour water level reading. The amount of grout used at each borehole will be recorded on the boring log.

3.02 SAMPLING AND RECORD KEEPING

- A. Soil samples will be taken from the borings and carefully transported to the laboratory to minimize disturbance of the soil and thereby maintain the physical and index properties, and other pertinent in-situ characteristics of the soil.
- B. A minimum of two of the five borings (at opposite corners of the secure cell) will be sampled semi-continuously (typically 2-foot intervals) to a minimum depth of 40 feet and sampled at 5-foot intervals thereafter. Depending on the subsurface conditions encountered in the test borings, the remaining test borings may also be sampled semi-continuously or, alternatively, they may be sampled at a predetermined sample interval not to exceed 5 feet. Typically, cohesive soils will be sampled by hydraulically advancing a thin-walled tube sampler, and cohesionless soils will be sampled by driving a 2-inch diameter split-spoon sampler. A pitcher-barrel sampler, dennison sampler, or other sampler maybe used, depending on the actual soil conditions encountered in the borings.

3.03 LABORATORY ANALYSIS

- A. Laboratory tests will be performed on selected soil samples recovered from the test borings to characterize the samples in order to develop a description of subsurface conditions at the location of the test borings. Tests will include, but may not be limited to, moisture content, Atterberg limits, permeability (clays), particle size, and standard Proctor compaction. Not all tests will be performed on all samples.

3.04 SURVEYING

- A. The locations and elevations of the test borings will be surveyed before the test borings are decommissioned. The surveyor shall be licensed as a Land Surveyor in the State of Colorado.

3.05 GEOTECHNICAL REPORT

- A. A geotechnical report will be prepared that provides field and laboratory data, including documentation of the borehole grouting. The report will be prepared by a Professional Engineer registered in the State of Colorado or by a qualified geologist. The report will provide boring logs, laboratory test results, and cross sections of the

subsurface soil, bedrock and groundwater conditions encountered in the test borings at the proposed cell locations, and other information that may be pertinent to the cell construction and applicable regulations.

3.06 OTHER SUBSURFACE INVESTIGATION TECHNIQUES

Electrical resistivity, seismic refraction, or other remote sensing techniques, may be utilized in conjunction with the sample borings.

[END OF SECTION]

SECTION 02110 SITE PREPARATION AND EARTHWORK

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary to perform all site preparation, excavation, backfilling, and grading required to construct the secure cell or surface impoundment. The work shall be carried out in accordance with this General Specification, the Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02010 - Subsurface Investigation
- B. Section 02120 - Permanent Sump
- C. Section 02221 - Secondary Clay Liner

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. Work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all testing activities outlined in the CQA Plan and shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. Soil testing (both field and laboratory testing) required by the CQA Plan will be the responsibility of the CQA Engineer. All Quality Control testing required by the General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. The Contractor shall cooperate with the CQA Engineer during all testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling and shall provide access to all areas requiring testing. The Contractor shall repair any damage to finished work caused by the CQA Engineer's sampling or testing activities, except when specifically not required by the General Specifications.

- D. The CQA Engineer will coordinate independent surveying required by the CQA Plan. Surveying by the CQA Engineer does not relieve the Contractor of his responsibility to lay out, control, and document the work.
- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Fill materials shall be obtained from the excavation of the secure cell or surface impoundment, from the excavation of diversion ditches, or from borrow sources identified by the Owner.
- B. Soil shall be classified as one of the following: (I) structural or general fill; (ii) clay liner material; (iii) topsoil; (iv) protective soil layer material; or (v) spoil.
 - 1. Soil that is classified according to the Unified Soil Classification System (USCS) as SM, CL, ML, SC or GM or GC (ASTM D 2487) and has a maximum particle size of 4 inches; or other material approved by the Owner, may be used as structural fill or general fill. Structural or general fill shall be placed at the locations shown on the Construction Drawings and in all areas requiring fill that are within 50 feet of the secure cell or surface impoundment liner system. Beyond the 50 foot requirement structural or general fill material characteristics may be modified with the approval of the Owner.
 - a. General fill is required in the cover section on top of the geocomposite drainage layer.
 - 2. Soil that meets the requirements of Section 02221 and 02222 of these General Specifications may be used as clay liner material.
 - 3. Soil classified as topsoil may be used for revegetation of disturbed areas or for other purposes shown on the Construction Drawings. All revegetation activities shall be carried out in accordance with this Section and the Owners requirements listed in LF-12.
 - 4. Soil that meets the requirements of Section 02716 of these General Specifications may be used as protective soil layer material.
 - 5. Soil not classified as structural fill or general fill, clay liner material, protective soil layer material, or topsoil shall be classified as spoil material. Spoil may be used for purposes specified in the Construction Drawings or by the Owner, or it may be disposed of on site in a manner approved by the Owner.

PART 3 EXECUTION

3.01 SITE PREPARATION

- A. The Contractor shall develop access to the construction area in accordance with the requirements of the Construction Drawings.
- B. The Contractor shall install silt fences immediately down-slope of each area to be disturbed prior to the beginning of work in that area. The Contractor shall maintain the silt fences for the duration of construction. Accumulated sediment behind the silt fences shall be disposed of on-site by the Contractor in a manner approved by the Owner. The area around the top of secure cells and surface impoundments shall be graded to direct surface water away from the structure, wherever possible.
- C. All brush, vegetation, rubbish, and other objectionable material shall be removed from the construction area and disposed of in an area designated by the Owner.
- D. All topsoil shall be removed from the construction area and stockpiled in areas designated by the Owner for subsequent use on site.
- E. A 30-foot wide work area shall be maintained clear of objectionable materials around the edge of the secure cell or surface impoundment construction area.
- F. Diversion ditches, either permanent or temporary, shall be constructed in accordance with the Construction Drawings or as approved by the Owner. The Contractor shall be responsible for constructing diversion ditches as required to divert run-on around the construction area. The construction of temporary ditches not shown on the Construction Drawings shall not be undertaken until the Contractor's plan for constructing the ditches is approved by the Owner.
- G. Temporary access roads to the construction area shall be constructed in accordance with the Construction Drawings or as approved by the Owner.

3.02 STOCKPILING

- A. Prior to the start of excavation and if required by the Owner, the Contractor shall prepare a written excavation plan. The plan shall indicate the areas and sequence of excavation, and the anticipated classification of the excavated material (e.g., structural or general fill, clay liner material). This excavation plan must be reviewed and approved by the Owner. The Contractor shall take into account that the stockpiling portion of the excavation plan may be modified during construction based on the results of any conformance testing of the excavated material required by the CQA Plan.
- B. Excavated materials classified as fill shall be stockpiled in designated areas free of incompatible soil, clearing debris, or other objectionable materials. Stockpile areas will be shown on the Construction Drawings or designated by the Owner.

- C. Excavated material classified as spoil shall be segregated from fill and stockpiled or disposed of in the manner shown on the Construction Drawings or as specified by the Owner.
- D. The CQA Engineer shall assist in the determination of what excavation material is select fill or spoil material.
- E. Stockpiles of fill or spoil shall be no steeper than 3:1 (horizontal:vertical) or other slope approved by the Owner, graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the Owner, and dressed daily during periods of active placement of fill taken from the stockpile. The Contractor may cover fill stockpiles with plastic sheeting or other material approved by the Owner in order to preserve the moisture content of the fill.
- F. Stockpiles that will remain out of active use for a period greater than seven months shall either be covered as described in this section or stabilized by revegetation in accordance with the requirements for revegetation given in Permit Attachment LF-12.
- G. The Contractor shall not remove fill material from the project site without the prior written approval of the Owner.

3.03 EXCAVATION

- A. Upon completion of site preparation, the secure cell or surface impoundment shall be excavated to the elevations and grades for the subgrade shown on the Construction Drawings. The excavation shall include provisions for any leakage detection system sump or permanent sump shown on the Construction Drawings. All excavation work shall be carried out in compliance with all applicable OSHA regulations.
- B. During construction of the secure cell or surface impoundment, the Contractor shall make excavations, as necessary, to ensure the drainage of water to a single area (i.e., a sump) to facilitate water collection and removal. A pump shall be provided for removing water from the sump. The pump shall have a capacity sufficient to meet the requirements of Section 01010 of these General Specifications. Water that accumulates in the sump shall be pumped to the on-site construction water tank or to such other location as designated by the Owner. The Contractor shall maintain the secure cell or surface impoundment excavation in a dry and workable condition. Damaged work or delays caused by water from any source shall be the responsibility of the Contractor.
- C. Permeability tests will be conducted on the soil at the base of the excavation in accordance with the CQA Plan. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling, if necessary.
- D. For subgrades on slopes steeper than 5:1 (horizontal:vertical) which will serve as foundations for structural fill, the subgrade shall be terraced or keyed to anchor the fill

material and prevent slip failures. Each terrace shall be at least 10 feet wide with a maximum vertical elevation difference between terraces of 10 feet. Terraces shall generally run perpendicular to the fall line of the slope. Terraces shall have grades of not less than 2 percent or more than 5 percent away from the face of the embankment. Surface drainage shall be maintained at all times. This requirement does not apply to structural fills placed within the secure cell or surface impoundment such as ramps or berms.

- E. After excavation or stripping to final grade, the CQA Engineer will inspect the subgrade on the side slopes of the secure cell or surface impoundment. The CQA Engineer will identify areas that require additional excavation of weak or excessively weathered subgrade materials on the slopes of the secure cell or surface impoundment excavation. The Owner will direct the Contractor to excavate the soft areas identified by the CQA Engineer. Such excavations shall be backfilled with structural fill or clay liner material. Backfill shall be placed and compacted in accordance with the requirements for structural fill given in this section. If secondary clay liner material is used to backfill these areas, it shall be placed in accordance with Section 02221 of these General Specifications. However, permeability tests will not be required.
- F. After excavation to final grade, the CQA Engineer will inspect the subgrade on the base of the secure cell or surface impoundment. The CQA Engineer may identify areas of the subgrade to be proofrolled. If proofrolling is necessary, the Contractor shall use a 20-ton pneumatic-tired roller or other approved equipment. If soft spots or unsuitable materials are found, the Owner may direct the Contractor to excavate the soft material and either fill the excavated area with the same material (assuming the existing material will provide adequate support if recompacted) or structural fill material. Backfill shall be placed and compacted in accordance with the requirements for structural fill given in this section or secondary clay liner material given in Section 02221.
- G. The Contractor shall scarify the portion of the subgrade on the base of the secure cell or surface impoundment that is comprised of soil and not treated for soft spots, to a depth of not less than 8 inches and compact it in accordance with the requirements for structural fill as directed by the Owner.
- H. The subgrade surface shall be seal-rolled to prevent moisture infiltration unless fill is to be immediately placed on the subgrade.
- I. Excavation of the secure cell or surface impoundment shall not be considered complete, and no fill shall be placed on the subgrade, until the CQA Engineer confirms that the minimum elevations and grades shown on the Construction Drawings have been achieved in the field. The Contractor shall be responsible for notifying the CQA Engineer that the excavation (or a significant portion thereof) is complete and the Contractor shall plan for the time required for the CQA Engineer to confirm the elevations and grades of the excavation.
- J. Upon completion of excavation of secure cells, a geologist or geotechnical engineer provided by the Owner will map the exposed natural soils on the side slopes and

bottom of the excavation. Each distinct soil stratum will be sampled and classified according to ASTM D 2487. Soil maps and grain-size analyses will be included in each secure cell certification report. This requirement only applies to secure cells. The Contractor shall cooperate with the geologist or geotechnical engineer so that the necessary mapping and sampling can be carried out.

- K. The Contractor shall remove soils which the CQA Engineer and Owner have determined to have a Unified Soil Classification System (USCS) gradation coarser than SM (silty sand) found at the limits of the secure cell excavation.
- L. Soils with a USCS gradation coarser than SM determined in accordance with the CQA Plan shall be removed at the time of cell excavation for a predetermined from the nearest point of the secure cell secondary geomembrane liner. Removed soil shall be replaced with compacted soil of a thickness and permeability that has a travel time equal to or greater than a 100 foot thick clay with a permeability of 1×10^{-7} cm/sec.
- M. If directed by the Owner, the Contractor shall excavate additional low-density materials (in-place dry densities of less than 95 pounds per cubic foot) around the edges of the secure cell excavation. Such excavations shall extend no more than 10 feet beyond the subgrade limits shown on the Construction Drawings, and no deeper than 15 feet below the existing ground surface. Any such overexcavation shall be backfilled as part of, and in accordance with the requirements for, secondary clay liner placement, Section 02221.

3.04 PLACEMENT AND COMPACTION OF STRUCTURAL AND GENERAL FILL

- A. Specific requirements for placement and compaction of structural and general fill shall be as specified herein unless other requirements are given on the Construction Drawings.
- B. Fill lifts after compaction shall have an average thickness of no more than 6 inches and a maximum thickness of no more than 7 inches. The loose thickness shall be no greater than the length of the pad foot and drum groove of the compaction equipment (7 to 8 inches for a CAT 825).
- C. The CQA Engineer must complete field testing of fill placed and compacted to determine compliance with these specifications in accordance with the CQA Plan. The Contractor shall not place a new lift of fill over a preceding lift until approval is given by the CQA Engineer. If the Contractor fails to comply with this requirement, he will be required to remove and replace all unauthorized work at his own expense.
- D. Prior to placement of a lift of fill, the previous compacted lift shall be thoroughly scarified to provide good bonding between lifts. Scarification shall be accomplished by raking with a grader, discing, or an alternate method approved by the Owner.
- E. The subgrade may be compacted at its natural moisture content.

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- F. Unless otherwise required by the Construction Drawings, structural fill shall be compacted at a moisture content between 3 percent dry to 3 percent wet of the optimum moisture content and to a minimum dry unit weight of 95 percent of the maximum dry unit weight determined in the standard Proctor compaction test (ASTM D 698). If the moisture content of the structural fill is outside of the acceptable range, the soil shall be wetted or dried back, as appropriate. During wetting or drying, the soil shall be regularly disced or otherwise mixed so that uniform moisture conditions are obtained.
 - G. Unless otherwise required by the Construction Drawings, general fill shall be compacted at a moisture content near optimum moisture content and to a minimum dry unit weight of 90 percent of the maximum dry unit weight determined in the standard Proctor compaction test (ASTM D 698). If the moisture content of the general fill is outside of the acceptable range, the soil shall be wetted or dried back, as appropriate. During wetting or drying, the soil shall be regularly disced or otherwise mixed so that uniform moisture conditions are obtained. Where general fill is placed over geosynthetic materials, the first lift shall be placed, spread and compacted with a low ground pressure dozer. Extreme care shall be taken during placement and spreading operations to ensure that the earthworks equipment does not damage the underlying geosynthetics.
 - H. The Contractor may moisture-condition fill in either the stockpile area or work area.
 - I. Compaction of lifts shall be performed with an appropriately heavy, properly ballasted, penetrating-foot compactor subject to the approval of the CQA Engineer.
 - J. The Contractor shall not place frozen fill, nor shall he place fill on frozen ground.
 - K. If fill freezes during construction, the Contractor shall remove the frozen fill, scarify the remaining unfrozen fill, and then place and compact new fill in accordance with these General Specifications. The frozen fill shall not be reused until it has thawed, and been thoroughly blended, and then reworked to an acceptable moisture content.

3.05 SURVEY CONTROL

- A. The Surveyor shall survey the location and elevation of the excavation for the secure cell or surface impoundment. He shall also survey the location and elevation of the top of subgrade shown on the Construction Drawings. Surveying shall be performed in general accordance with Section 01010 of these General Specifications.
- B. The Surveyor shall provide Record Drawings of the location and elevation of the excavation and the top of subgrade (or top of interim cover for cover systems) for the secure cell or surface impoundment, in accordance with the requirements of Section 01010 of these General Specifications. The Surveyor shall submit this drawing to the Owner prior to the start of secondary clay liner placement or cover GCL placement unless otherwise approved by Owner and CQA Engineer. The Surveyor may submit a partial Record Drawing to obtain approval for a portion of work. The Owner will define the minimum requirements for a partial submittal.

3.06 FIELD QUALITY CONTROL

- A. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.

3.07 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and all partially-completed and completed work of these General Specifications.
- B. In the event of damage, the Owner will identify areas requiring repair, and the Contractor shall make all repairs and replacements necessary to the approval of the Owner at no additional cost to the Owner.
- C. At the end of each day, the Contractor shall verify that the entire work area was left in a state that promotes surface drainage off and away from the area and from finished work. If threatening weather conditions are forecast, compacted surfaces shall be seal-rolled or covered with plastic sheeting to protect finished work.

3.08 REVEGETATION

- A. At the end of construction, all disturbed areas with exposed soil (including borrow areas, soil stockpiles, material storage areas, Contractor access roads, etc.) shall be graded and revegetated as directed by the Owner or in accordance with the requirements for revegetation in the Owner's Specification.

3.09 SEDIMENTATION AND EROSION CONTROL

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the installation of geotextiles for sedimentation and erosion control during construction. The work shall be carried out in accordance with the requirements of Sections 420.06 and 420.07 of the Colorado Department of Highways Standard Specifications for Road and Bridge Construction, pertaining to erosion control and silt fences. Silt fences shall be placed as necessary downslope of all disturbed areas, and shall remain until such areas are successfully revegetated.

3.10 PERFORATIONS

- A. Perforations in the subgrade or fill resulting from CQA activities will be filled. Such perforations may include, but are not limited to, the following:
 - 1. Nuclear density test probe locations;
 - 2. Shelby tube sample locations; and

3. Sand-cone or rubber balloon test locations.
 - B. Perforations resulting from nuclear density tests will be filled by the CQA Engineer. All other perforations resulting from construction and/or CQA activities shall be filled by the Contractor. The CQA Engineer will provide the Contractor with the locations of any perforations made as part of CQA activities, except nuclear density tests.
 - C. Perforations from construction and/or CQA sampling activities (except nuclear density tests) shall be backfilled by the Contractor with structural fill material. The structural fill material shall be placed and compacted in accordance with the requirements of this section. Perforations from nuclear density tests will be backfilled by the CQA Engineer with bentonite (sodium montmorillonite) powder or flakes or a soil-bentonite mixture and compacted by hand tamping.

[END OF SECTION]

SECTION 02119 SAND LAYER CLAY PLUG

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the construction of the sand layer clay plug for the secure cell or surface impoundment. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02110 - Site Preparation and Earthwork
- B. Section 02780 - Geosynthetic Clay Liner

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualifications and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. Work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all testing activities outlined in the CQA Plan and shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. Soil testing (both field and laboratory testing) required by the CQA Plan will be the responsibility of the CQA Engineer. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. The Contractor shall cooperate with the CQA Engineer during all testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling. The Contractor shall provide access to all areas requiring testing. The Contractor shall repair any damage to finished work caused by the CQA Engineer's sampling or testing activities.
- D. The CQA Engineer will coordinate independent surveying. Surveying by the CQA Engineer does not relieve the Contractor of his responsibility to lay out, control, and document the work.

- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 MATERIALS

Clay plug material may only be used for construction if it has been shown to be suitable in a test fill program. The test fill program will have been performed prior to construction of the secure cell or surface impoundment, and it is not part of the work included in this General Specification. Depending on the results of future test fills in the secure cell, either the weathered Pierre shale or the on-site silty clay may be used. These General Specifications may be modified per the results of future test fills.

- A. Clay plug material shall be obtained from borrow areas or stockpiles identified by the Owner.
- B. Clay plug material for secure cell or surface impoundment construction shall:
1. Be classified according to the Unified Soil Classification System (USCS) as CL or CH (ASTM D 2487) and exhibit a minimum liquid limit of 30 and a minimum plasticity index of 11.
 2. Have a percentage of gravel (i.e., dry weight retained on a U.S. No. 4 sieve) of less than 15 percent.
 3. Have particles no larger than 2 inches (in largest dimension) after processing but prior to placement (4 inches post-processing and 2 inches post-compaction for the weathered Pierre shale).
 4. Have a hydraulic conductivity in the range of 1×10^{-7} m/s when compacted in accordance with these General Specifications and tested in the laboratory in accordance with ASTM D 5084 at a confining pressure of 12 psi. Bentonite additives may be admixed with weathered Pierre shale or on-site silty clay to achieve the required hydraulic conductivity of 1×10^{-7} cm/s. Bentonite will be added at percentages defined in the test fill and/or laboratory test programs.
- C. The intent of the clay plug is to provide a barrier of a given thickness and permeability that will result in a travel time equal to a clay 100 feet thick with a permeability 1×10^{-7} cm/sec.
- D. The water used to increase the moisture content of the clay plug shall be provided by the Owner. The Contractor shall maintain an accurate record of his water usage.

PART 3 EXECUTION

The requirements of Part 3 may be modified based on the results of future test fills, as a Class 1 modification with prior approval.

3.01 CLAY PLUG COMPACTION CRITERIA

- A. The compaction moisture content and the minimum dry unit weight of on-site clay, if used as clay plug material, shall be as follows:
 - 1. The compaction moisture content of the clay plug material used shall be at least optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the clay plug material shall be at least 99 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698).
 - 2. If the CAT 825 compactor is used, the compaction moisture content of the clay plug material used in the sideslopes of the cell shall be between 1-1/2 and 4 percent above optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the clay plug material shall be at least 95 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698). The combination of compacted in-place dry density and moisture content shall result in a minimum degree of saturation of 89 percent.
 - 3. If the REX 3-35 compactor is used, the compaction moisture content of the clay plug material used in the sideslopes of the cell shall be between optimum and 3 percent above optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the clay plug material shall be at least 100 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698).
- B. The compaction moisture content of the weathered Pierre shale, if used as clay plug material, shall be between optimum moisture content and 3 percent wet of the optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the weathered Pierre shale liner material shall be at least 95 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698).
- C. Compaction and moisture content requirements for either the weathered Pierre shale or on-site clay may vary if bentonite admix is used. The specific placement and compaction criteria will be determined as part of a test fill program.

3.02 CLAY PLUG MATERIAL PLACEMENT

- A. The clay plug material shall be placed a minimum of 1 foot above the maximum elevation of the sand seam and a minimum of 1 foot below the minimum elevation of the sand seam.
- B. Clay plug placement shall begin only after completion of all, or an approved portion of, excavation and structural fill placement in the secure cell or surface impoundment. Placement shall not begin until the Contractor has verified that sand seam material has been exposed and required portions have been removed.
- C. The Contractor shall not place clay plug material on a surface or subgrade that contains debris, branches, vegetation, mud, ice, or frozen material. If frozen subgrade material is encountered, it shall be removed and replaced in accordance with these General Specifications.
- D. The Contractor shall construct the clay plug in lifts. Each lift of the clay plug shall meet the minimum requirements of this General Specification.
- E. If a CAT 825 compactor is used, the average lift thickness after compaction shall be no more than 6 inches, and the maximum lift thickness shall be 7 inches after compaction. If a REX 3-35 compactor is used, the average lift thickness after compaction shall be no more than 4 inches and the maximum lift thickness shall be 5 inches after compaction. The loose lift thickness shall be no greater than the length of the compactor pad.
- F. Clay plug material shall be placed and compacted in horizontal lifts.
- G. Prior to placement of a lift of clay plug material, Contractor shall allow the CQA Engineer to complete field testing in accordance with the CQA Plan. The Contractor shall not place a new lift of clay plug material over a preceding lift until approval is given by the CQA Engineer. If the Contractor fails to comply with this requirement, he will be required by the Owner to remove and replace all unauthorized work at no additional cost to the Owner.
- H. Prior to placement of a lift of clay plug material, the previous lift shall be thoroughly scarified to a nominal depth of about 1 to 2 inches to provide good bonding between lifts. Scarification shall be accomplished by discing, raking with a grader penetration by a sheepsfoot compactor or an alternative method approved by the Owner.
- I. The excessive trafficking of scarified surfaces by non-placement trucks or other equipment shall not be permitted during the period between scarification and placement of the following lift.
- J. If normal handling does not reduce the maximum clod size in clay plug material to an acceptable size, the Contractor shall use a Caterpillar SS250 soil stabilizer, mechanical mixer, or approved equivalent equipment to break up the clods. The clay plug material

shall be pulverized until the maximum soil clod size is reduced to 2 inches or less in largest dimension.

- K. Moisture conditioning of the clay plug material shall be accomplished in the processing area prior to clay plug construction. The processing area location shall be approved by the Owner. Clay plug material shall be moisture conditioned using a Caterpillar SS250 soil stabilizer or approved equivalent. If the clay plug material is wetter than required, it shall be repeatedly mixed using a Caterpillar SS250 soil stabilizer, harrowing disc, grader, or equivalent to achieve drying.
- L. No more than 1.5 percent moisture shall be added to the clay plug material at the time of compaction. Clay plug material requiring more than 1.5 percent moisture shall be removed, returned to the processing area, and conditioned until the proper moisture content is achieved. If the in-place moisture content is too high, the clay may be dozed, windrowed, disced, and/or otherwise mixed to facilitate drying.
- M. Clay plug material shall not be placed or compacted during a sustained period of temperature below 32°F that results in frozen clay either in place or in the borrow area. Clay plug material may be placed and compacted during periods of early morning freezing temperatures if above-freezing temperatures are anticipated during the day.
- N. The Contractor shall not place frozen clay nor shall the Contractor place clay on frozen ground.
- O. If clay plug material freezes after compaction, the Contractor shall either rework the material after it thaws or remove the frozen material. The Contractor shall then place and compact new clay or rework clay in accordance with the General Specifications. Frozen clay shall not be reused until it has thawed and been reworked to an acceptable moisture content. The Contractor shall be responsible for protecting compacted lifts of clay plug material from freezing. If extended freezing conditions are anticipated, the Contractor shall prepare a plan for approval of the Owner which outlines the measures he will take to protect finished work.
- P. Clay plug material shall not be placed during periods of unfavorable weather conditions.
- Q. If a bentonite admix program is used, the dry bentonite shall be thoroughly mixed prior to moisture conditioning with the dry borrow source material using a soil stabilizer or by discing.

3.03 CLAY PLUG COMPACTION

- A. The sequence of compaction of the clay plug for a secure cell or surface impoundment shall be as described in the General Specifications or as shown on the Construction Drawings.

- B. Compaction of clay plug on the base of the cell or surface impoundment shall be performed using a Caterpillar 825 compactor. Compaction of material on the sideslopes shall be performed using either a Caterpillar 825 compactor or a REX 3-35 compactor.

- C. The daily work area shall extend a sufficient distance so as to maintain soil moisture conditions within an acceptable range to allow continuous operations. Desiccation and crusting of the lift surface shall be avoided as much as possible.

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- D. The CQA Engineer will identify any areas of significant desiccation and crusting of a lift surface. The Contractor shall scarify the surface of such areas to a nominal depth of 1 to 2 inches or to the depth of desiccation identified by the CQA Engineer, and then water condition, disc or mix as necessary, and recompact the area.
- E. The transition from an existing full-depth section of clay plug to the beginning of an adjacent section that is to be constructed subsequently shall be accomplished by sloping (cutting back) the end of the full-depth section at 3:1 (horizontal:vertical) or flatter, scarifying the slope of the existing full-depth liner at the transition, and then immediately placing the adjacent lifts of clay plug.
- F. If a dual-drum compactor which has the drums laterally separated by the operator's cab and the differential (such as a CAT 825) is used, one trip up and a staggered trip back, to cover the uncompacted area between the drums, shall be considered one pass. The minimum number of compactor passes on each lift of the clay plug shall be as follows:
1. The base of the clay plug shall be compacted with a minimum of 10 passes of the CAT 825 if the on-site clay is used. If the weathered Pierre shale is used, it shall be compacted with a minimum of 6 passes of the CAT 825.
 2. If the CAT 825 is used on the sideslopes of the clay plug, then a minimum of 8 passes are required.
 3. If the REX 3-35 is used on the sideslopes of the clay plug, then a minimum of 15 passes are required.

It should be noted that more than the minimum number of passes may be necessary to satisfy the other compaction criteria.

- G. The number of compactor passes may be modified for bentonite admixed soil based on a test fill.
- H. Corners and other areas inaccessible to driven compaction equipment shall be compacted using hand operated equipment (such as a walk-behind roller) approved by the Owner.

3.04 SURVEY CONTROL

- A. The Surveyor shall survey the final location and elevations of the top and bottom of the clay plug. Surveying shall be performed in accordance with Section 01010 of these General Specifications. The survey will ensure:
1. The specified thickness of compacted clay plug has been achieved.
- B. The Surveyor shall provide a Record Drawing to the Owner of the final location and elevation of the top and bottom of the clay plug, including the location of the sand seam. The Surveyor shall submit this drawing prior to liner construction unless

otherwise approved by the Owner and the CQA engineer. The Contractor may submit a partial record to obtain approval for a portion of the work. The Owner will define the minimum requirements for a partial submittal.

3.05 FIELD QUALITY CONTROL

- A. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.
- B. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at his own expense until acceptable test results are obtained.

3.06 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and partially-completed and completed work of these General Specifications.
- B. In the event of damage, the CQA Engineer will identify areas requiring repair, and the Contractor shall make repairs and replacements necessary to the approval of the Owner and at no additional cost to the Owner.
- C. The Contractor shall minimize, to the maximum extent feasible, desiccation cracking of clay plug material. The Contractor shall sprinkle the clay with water if cracking is observed or if directed by the Owner. The Contractor may seal roll the surface of the clay to reduce drying and desiccation. The Contractor may protect exposed surfaces using light-colored or translucent membranes, such as Visqueen, to inhibit drying of the clay. The CQA Engineer will identify areas of significant cracking of the surface of the clay plug and the Contractor shall repair the identified area to the satisfaction of the Owner and at no additional cost to the Owner.
- D. Desiccation cracks larger than 0.2 feet deep or 0.25 inches wide shall be excavated to the full depth of the crack and repaired. Desiccation cracks on the liner surface less than 0.2 feet deep and 0.25 inches wide shall be moistened and compacted with a smooth drum roller until the surfaces meet the requirements of the CQA plan.

3.07 PERFORATIONS

- A. Perforations in the clay plug resulting from construction and CQA activities shall be filled. Such perforations may include, but are not limited to, the following:
 - 1. Nuclear density test probe locations;
 - 2. Shelby tube sample locations;
 - 3. Sand-cone or rubber-balloon test locations;
 - 4. Survey stake locations.

- B. Perforations in the clay plug resulting from nuclear density tests will be filled by the CQA Engineer. All other perforations in the clay plug resulting from construction and/or CQA sampling activities shall be filled by the Contractor. The CQA Engineer will provide the Contractor with the locations of any tests made as part of CQA activities, except nuclear density tests.

- C. Perforations from construction and/or CQA sampling activities (except nuclear density tests) shall be backfilled by the Contractor with clay plug material. The clay plug material shall be placed and compacted (hand tamped) in accordance with the requirements of this section. Perforations in the clay plug from nuclear density tests will be backfilled by the CQA Engineer with bentonite (sodium montmorillonite) powder or flakes or a soil-bentonite mixture and compacted by hand tamping.

[END OF SECTION]

SECTION 02120 PERMANENT SUMP

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the construction of the permanent sump below the secure cell liner system. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02010 - Subsurface Investigation
- B. Section 02110 - Site Preparation and Earthwork
- C. Section 02221 - Secondary Clay Liner
- D. Section 02225 - Sump and Pipe Bedding Gravel and Road Base Aggregate
- E. Section 02714 - Geotextile Filter, Cushion, or Sacrificial Layer
- F. Section 02718 - Polyethylene Pipe and Fittings
- G. Section 02775 - Geomembrane Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. All work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all testing activities outlined in the CQA Plan and shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. Soil testing (both field and laboratory testing) required by the CQA Plan and geosynthetic conformance testing required by the CQA Plan will be the responsibility of the CQA Engineer. All Quality Control testing required by the General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. The Contractor shall cooperate with the CQA Engineer during all testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling and he shall also provide access to all areas requiring testing. Any geosynthetic rolls that do not meet the requirements of the

General Specifications will be rejected. The Contractor shall be required to replace the rejected material with new material that conforms to the specification requirements at his own expense. The Contractor shall repair any damage to finished work caused by the CQA Engineer's sampling or testing activities.

- D. The CQA Engineer will coordinate independent surveying required by the CQA Plan. Surveying by the CQA Engineer does not relieve the Contractor of his responsibility to lay out, control and document the work.
- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Materials used to construct the permanent sump shall be those shown on the Construction Drawings. The materials may include geosynthetic clay liners, structural fill, clay liner material, geomembrane liners, sump and pipe bedding gravel, polyethylene pipe and fittings, and geotextile cushion or filter layers.
- B. Structural fill materials used to construct the permanent sump shall conform to the requirements of Section 02110 of these General Specifications.
- C. Geomembrane liners used to construct the permanent sump shall conform to Section 02775 of these General Specifications.
- D. Sump and pipe bedding gravel used to construct the permanent sump shall conform to Section 02225 of these General Specifications.
- E. Polyethylene pipe and fittings used to construct the permanent sump shall conform to Section 02718 of these General Specifications.
- F. Geotextile filter layers or cushion layers used to construct the permanent sump shall conform of Section 02714 of these General Specifications.

2.02 MANUFACTURING QUALITY CONTROL

- A. Manufacturing quality control requirements for the materials used to construct the permanent sump are provided in the appropriate section of these General Specifications for the material required.
- B. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.

PART 3 EXECUTION

3.01 HANDLING, PLACEMENT, INSTALLATION, AND/OR COMPACTION

- A. A permanent sump for the secure cell shall be constructed at the location shown, and in accordance with, the Construction Drawings.
- B. The procedures for handling, placement, installation and/or compaction of each material used to construct the permanent sump shall be the same as the procedures given in these General Specifications related to liner system construction for the same corresponding material.
- C. The Contractor shall dewater the permanent sump as necessary following any precipitation events. Dewatering shall be performed in a timely manner to minimize softening of the sump area.

3.02 SEAMING, OVERLAPPING, AND REPAIRING

- A. The procedures for seaming, overlapping, and repairing each geosynthetic or pipe material used to construct the permanent sump shall be the same as the procedures given in these General Specifications related to liner system construction for the same corresponding material.

3.03 PLACEMENT OF OVERLYING MATERIALS

- A. The procedures for placing soil materials over geosynthetics and pipe used to construct the permanent sump shall be the same as the procedures given in these General Specifications related to liner system construction for the same corresponding material.

3.04 SURVEY CONTROL

- A. The Surveyor shall survey the location and elevation of the top of subgrade for the permanent sump shown on the Construction Drawings. Surveying shall be performed in accordance with Section 01010 of these General Specifications.
- B. The Surveyor shall provide Record Drawings of the location and elevation of the top of subgrade for the permanent sump, in accordance with the requirement of Section 01010 of these General Specifications. The Surveyor shall provide the Record Drawing prior to the placement of the overlying clay liner in the sump unless otherwise approved by Owner and CQA Engineer.

3.05 FIELD QUALITY CONTROL

- A. All Quality Control testing required by the General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.

3.06 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and all partially-completed and completed work of these General Specifications.
- B. In the event of damage, the CQA Engineer will identify areas requiring repair, and the Contractor shall make all repairs and replacements necessary to the approval of the Owner and at no additional cost to the Owner.

[END OF SECTION]

SECTION 02221 SECONDARY CLAY LINER

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the construction of the secondary clay liner component of the liner system for the secure cell or surface impoundment. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02110 - Site Preparation and Earthwork
- B. Section 02120 - Permanent Sump
- C. Section 02222 - Primary Clay Liner
- D. Section 02775 - Geomembrane Liners
- E. Section 02780 - Geosynthetic Clay Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualifications and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. Work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all testing activities outlined in the CQA Plan and shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. Soil testing (both field and laboratory testing) required by the CQA Plan will be the responsibility of the CQA Engineer. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. The Contractor shall cooperate with the CQA Engineer during all testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling. The Contractor shall provide access to all areas requiring testing. The Contractor shall repair any damage to finished work caused by the CQA Engineer's sampling or testing activities.

- D. The CQA Engineer will coordinate independent surveying. Surveying by the CQA Engineer does not relieve the Contractor of his responsibility to lay out, control, and document the work.
- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 MATERIALS

Clay liner material may only be used for construction if it has been shown to be suitable in a test fill program. The test fill program will have been performed prior to construction of the secure cell or surface impoundment, and it is not part of the work included in this General Specification. Depending on the results of future test fills, either the weathered Pierre Shale or the on-site silty clay may be used on the base and/or the side slopes of the secure cell. These General Specifications may be modified per the results of future test fills.

- A. Clay liner material shall be obtained from borrow areas or stockpiles identified by the Owner.
- B. If used, weathered Pierre shale satisfying the requirements of this section shall only be used in areas where the grades are less than 5 percent (base portions of the secure cell liner system). If weathered Pierre shale is used in the base of the cell, it shall be obtained from the existing Pierre shale stockpile. On-site clay material may be used on the base and shall be used on the side slopes of the secure cell liner system.
- C. Clay liner material for secure cell or surface impoundment construction shall:
 - 1. Be classified according to the Unified Soil Classification System (USCS) as CL or CH (ASTM D 2487) and exhibit a minimum liquid limit of 30 and a minimum plasticity index of 11.
 - 2. Have a percentage of gravel (i.e., dry weight retained on a U.S. No. 4 sieve) of less than 15 percent.
 - 3. Have particles no larger than 2 inches (in largest dimension) after processing but prior to placement (4 inches post-processing and 2 inches post-compaction for the weathered Pierre shale).
 - 4. Have a hydraulic conductivity of not more than 1×10^{-7} cm/s when compacted in accordance with these General Specifications and tested in the laboratory in accordance with ASTM D 5084 at the conditions given in Permit Attachment LF-8.

- D. The water used to increase the moisture content of the clay liner shall be provided by the Owner. The Contractor shall maintain an accurate record of his water usage.

PART 3 EXECUTION

The requirements of Part 3 may be modified based on the results of future test fills, as a Class 1 modification with prior approval.

3.01 SECONDARY CLAY LINER COMPACTION CRITERIA

- A. The compaction moisture content and the minimum dry unit weight of on-site clay, if used as secondary clay liner material, shall be as follows:
 - 1. The compaction moisture content of the secondary clay liner material used in the base of the cell shall be at least optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the clay liner material shall be at least 99 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698).
 - 2. If the CAT 825 compactor is used, the compaction moisture content of the secondary clay liner material used in the sideslopes of the cell shall be between 1-1/2 and 4 percent above optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the clay liner material shall be at least 95 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698). The combination of compacted in-place dry density and moisture content shall result in a minimum degree of saturation of 89 percent.
 - 3. If the REX 3-35 compactor is used, the compaction moisture content of the secondary clay liner material used in the sideslopes of the cell shall be between optimum and 3 percent above optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the clay liner material shall be at least 100 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698).
- B. The compaction moisture content of weathered Pierre shale, if used as secondary clay liner material, shall be between optimum moisture content and 3 percent wet of the optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the weathered Pierre shale shall be at least 95 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698).

3.02 SECONDARY CLAY LINER PLACEMENT

- A. The secondary clay liner shall be constructed to the elevations, grades, and thicknesses shown on the Construction Drawings. The thickness of the clay liner at any location shall be measured perpendicular to the plane of the slope at that location. The compacted secondary clay liner shall be three foot thick across the bottom of the secure cell and 4.5 feet up the side slopes.

- B. Secondary clay liner placement shall begin only after completion of all, or an approved portion of, excavation and structural fill placement in the secure cell or surface impoundment. Placement shall not begin until the Contractor has verified that subgrade elevations and grades conform to the Construction Drawings and the CQA Engineer has completed testing and surveying of the subgrade required by the CQA Plan.
- C. The Contractor shall not place secondary clay liner material on a surface or subgrade that contains debris, branches, vegetation, mud, ice, or frozen material. If frozen subgrade material is encountered, it shall be removed and replaced in accordance with these General Specifications. Immediately prior to clay liner placement, any wet or soft areas of the subgrade shall be proof-rolled as directed by the Owner. Any excessively wet or soft areas shall be excavated and replaced with properly compacted structural fill.
- D. The Contractor shall construct the secondary clay liner in lifts. Each lift of the secondary clay liner shall meet the minimum requirements of this General Specification.
- E. If a CAT 825 compactor is used, the average lift thickness after compaction shall be no more than 6 inches, and the maximum lift thickness shall be 7 inches after compaction. If a REX 3-35 compactor is used, the average lift thickness after compaction shall be no more than 4 inches and the maximum lift thickness shall be 5 inches after compaction. The loose lift thickness shall be no greater than the length of the compactor pad.
- F. On slopes of 3:1 (horizontal:vertical) or flatter, secondary clay liner material may either be placed and compacted in lifts that are parallel to the slope or in horizontal lifts. For steeper slopes, secondary clay liner material shall be placed and compacted in horizontal lifts.
- G. Prior to placement of a lift of secondary clay liner material, Contractor shall allow the CQA Engineer to complete field testing in accordance with the CQA Plan. The Contractor shall not place a new lift of secondary clay liner material over a preceding lift until approval is given by the CQA Engineer. If the Contractor fails to comply with this requirement, he will be required by the Owner to remove and replace all unauthorized work at no additional cost to the Owner.
- H. Prior to placement of a lift of secondary clay liner material, the previous lift shall be thoroughly scarified to a nominal depth of about 1 to 2 inches to provide good bonding between lifts. Scarification shall be accomplished by discing, raking with a grader penetration by a sheepsfoot compactor or an alternative method approved by the Owner.
- I. The excessive trafficking of scarified surfaces by non-placement trucks or other equipment shall not be permitted during the period between scarification and placement of the following lift.

- J. If normal handling does not reduce the maximum clod size in on-site clay to an acceptable size, the Contractor shall use a Caterpillar SS250 soil stabilizer, mechanical mixer, or approved equivalent equipment to break up the clods. The on-site clay material shall be pulverized until the maximum soil clod size is reduced to 2 inches or less in largest dimension. The weathered Pierre shale material shall also be pulverized using a Caterpillar SS250 soil stabilizer (or an approved equivalent piece of equipment) until the maximum soil clod size is reduced to 4 inches or less (in largest dimension). The maximum soil clod size after compaction of the weathered Pierre shale shall be 2 inches or less in largest dimension. The use of a specific stabilizer or mixer shall be approved by the Owner prior to use.
- K. Moisture conditioning of the secondary clay liner material shall be accomplished in the processing area prior to clay liner construction. The processing area location shall be approved by the Owner. Clay liner material shall be moisture conditioned using a Caterpillar SS250 soil stabilizer or approved equivalent. If the clay liner material is wetter than required, it shall be repeatedly mixed using a Caterpillar SS250 soil stabilizer, harrowing disc, grader, or equivalent to achieve drying.
- L. No more than 1.5 percent moisture shall be added to the clay liner material at the time of compaction. Clay liner material requiring more than 1.5 percent moisture shall be removed, returned to the processing area, and conditioned until the proper moisture content is achieved. If the in-place moisture content is too high, the clay may be dozed, windrowed, disced, and/or otherwise mixed to facilitate drying.
- M. Secondary clay liner material shall not be placed or compacted during a sustained period of temperature below 32°F that results in frozen clay, either in place or in the borrow area. Secondary clay liner material may be placed and compacted during periods of early morning freezing temperatures if above-freezing temperatures are anticipated during the day.
- N. The Contractor shall not place frozen clay nor shall the Contractor place clay on frozen ground.
- O. If clay liner material freezes after compaction, the Contractor shall remove the frozen material, scarify the remaining unfrozen clay, and then place and compact new clay in accordance with the General Specifications. Frozen clay shall not be reused until it has thawed and been reworked to an acceptable moisture content. The Contractor shall be responsible for protecting compacted lifts of clay liner material from freezing. If extended freezing conditions are anticipated, the Contractor shall prepare a plan for approval of the Owner which outlines the measures he will take to protect finished work.
- P. Clay liner material shall not be placed during periods of unfavorable weather conditions.

3.03 SECONDARY CLAY LINER COMPACTION

- A. The sequence of compaction of the secondary clay liner for a secure cell or surface impoundment shall be as described in the General Specifications or as shown on the Construction Drawings.

- B. Compaction of secondary clay liner on the base of the cell or surface impoundment shall be performed using a Caterpillar 825 compactor. Compaction of material on the sideslopes shall be performed using either a Caterpillar 825 compactor or a REX 3-35 compactor.

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- C. The first lift of secondary clay liner material placed over the permanent sump shall be placed and compacted using a light ground-pressure dozer or a smooth-drum roller operating in the static mode, or other method approved by the Owner, in order to protect the underlying geosynthetics. Wheeled vehicles and footed compactors will not be allowed on this first lift. The compaction and permeability criteria for the first lift will be waived to ensure that the compaction effort and/or testing activities do not result in damage to the underlying geosynthetics.
- D. The daily work area shall extend a sufficient distance so as to maintain soil moisture conditions within an acceptable range to allow continuous operations. Desiccation and crusting of the lift surface shall be avoided as much as possible.
- E. The CQA Engineer will identify any areas of significant desiccation and crusting of a lift surface. The Contractor shall scarify the surface of such areas to a nominal depth of 1 to 2 inches or to the depth of desiccation identified by the CQA Engineer, and then water condition, disc or mix as necessary, and recompact the area.
- F. The transition from an existing full-depth section of clay liner to the beginning of an adjacent section that is to be constructed subsequently shall be accomplished by sloping (cutting back) the end of the full-depth section at 3:1 (horizontal:vertical) or flatter, scarifying the slope of the existing full-depth liner at the transition, and then immediately placing the adjacent lifts of clay liner.
- G. If a dual-drum compactor which has the drums laterally separated by the operator's cab and the differential (such as a CAT 825) is used, one trip up and a staggered trip back, to cover the uncompacted area between the drums, shall be considered one pass. The minimum number of compactor passes on each lift of the secondary clay liner shall be as follows:
1. The base of the secondary clay liner shall be compacted with a minimum of 10 passes of the CAT 825 if the on-site clay is used. If the weathered Pierre shale is used, it shall be compacted with a minimum of 6 passes of the CAT 825.
 2. If the CAT 825 is used on the sideslopes of the secondary clay liner, then a minimum of 8 passes are required.
 3. If the REX 3-35 is used on the sideslopes of the secondary clay liner, then a minimum of 15 passes are required.

It should be noted that more than the minimum number of passes may be necessary to satisfy the other compaction criteria.

- H. Corners and other areas inaccessible to driven compaction equipment shall be compacted using hand operated equipment (such as a walk-behind roller) approved by the Owner.

3.04 SURVEY CONTROL

- A. The Surveyor shall survey the final location and elevation of the top of the secondary clay liner. Surveying shall be performed in accordance with Section 01010 of these General Specifications. As part of this work, the Surveyor shall survey the location and elevation of the leak detection system sump. The survey will ensure:
1. The specified thickness of secondary compacted clay liner (3 feet) has been achieved.
 2. The top of the secondary clay liner slopes diagonally across the secure cell at about 3 percent grade toward the collection sump; and
 3. The top of the secondary clay liner in the collection sump area is at the grades and elevations specified on the contract drawings.
- B. The Surveyor shall provide a Record Drawing to the Owner of the final location and elevation of the top of the secondary clay liner, including the location and elevation of the leak detection system sump, in accordance with the requirements of Section 01010 of these General Specifications. The Surveyor shall submit this drawing prior to secondary geomembrane liner construction unless otherwise approved by the Owner and the CQA engineer. The Contractor may submit a partial record to obtain approval for a portion of the work. The Owner will define the minimum requirements for a partial submittal.

3.05 FIELD QUALITY CONTROL

- A. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.
- B. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at his own expense until acceptable test results are obtained.

3.06 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and partially-completed and completed work of these General Specifications.
- B. In the event of damage, the CQA Engineer will identify areas requiring repair, and the Contractor shall make repairs and replacements necessary to the approval of the Owner and at no additional cost to the Owner.
- C. The Contractor shall minimize, to the maximum extent feasible, desiccation cracking of clay liner material. The Contractor shall sprinkle the clay with water if cracking is observed or if directed by the Owner. The Contractor may seal roll the surface of the

clay to reduce drying and desiccation. The Contractor may protect exposed surfaces using light-colored or translucent membranes, such as Visqueen, to inhibit drying of the clay. The CQA Engineer will identify areas of significant cracking of the surface of the secondary clay liner and the Contractor shall repair the identified area to the satisfaction of the Owner and at no additional cost to the Owner.

- D. The secondary clay liner surface shall be seal rolled and made smooth and free from ruts or indentations at the end of every working day when precipitation is forecast and/or at the completion of compaction operations in an area.
- E. The Contractor shall maintain the clay liner surface in a condition suitable for geomembrane installation as specified in the CQA plan until the surface is covered. Desiccation cracks larger than 0.2 feet deep or 0.25 inches wide shall be excavated to the full depth of the crack and repaired. Desiccation cracks on the liner surface less than 0.2 feet deep and 0.25 inches wide shall be moistened and compacted with a smooth drum roller until the surfaces meet the requirements of the CQA Plan.
- F. The layer of over-built material shall be removed prior to placement of geomembrane liner. The over-built material may be removed in sections to coordinate with geomembrane placement. Where the over-built material is removed, the finished surface shall be protected and maintained as required by the specifications. The surface of the secondary clay liner on the side slope shall be trimmed to meet the requirements of Section 02775 prior to installation of the geomembrane liner.
- G. No synthetic sealants or other chemical treatments may be applied to the clay liner material.
- H. The CQA Engineer will issue an approval of the installation of the secondary clay liner to the Owner prior to placement of material over the clay liner in accordance with the requirements of the CQA Plan.

3.07 PERFORATIONS

- A. Perforations in the secondary clay liner resulting from construction and CQA activities shall be filled. Such perforations may include, but are not limited to, the following:
 - 1. Nuclear density test probe locations;
 - 2. Shelby tube sample locations;
 - 3. Sand-cone or rubber-balloon test locations;
 - 4. Survey stake locations.
- B. Perforations in the secondary clay liner resulting from nuclear density tests will be filled by the CQA Engineer. All other perforations in the secondary clay liner resulting from construction and/or CQA sampling activities shall be filled by the Contractor. The CQA Engineer will provide the Contractor with the locations of any tests made as part of CQA activities, except nuclear density tests.

- C. Perforations from construction and/or CQA sampling activities (except nuclear density tests) shall be backfilled by the Contractor with clay liner material. The clay liner material shall be placed and compacted (hand tamped) in accordance with the requirements of this section. Perforations in the secondary clay liner from nuclear density tests will be backfilled by the CQA Engineer with bentonite (sodium montmorillonite) powder or flakes or a soil-bentonite mixture and compacted by hand tamping.

[END OF SECTION]

SECTION 02222 PRIMARY CLAY LINER

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the construction of the primary clay liner component of the liner system for the secure cell or surface impoundment. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02110 - Site Preparation and Earthwork
- B. Section 02221 - Secondary Clay Liner
- C. Section 02710 - Geocomposite Detection or Collection Layer
- D. Section 02712 - Geonet Detection or Collection Layer
- E. Section 02775 - Geomembrane Liners
- F. Section 02780 - Geosynthetic Clay Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualifications and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. Work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all testing activities outlined in the CQA Plan and shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. Soil testing (both field and laboratory testing) required by the CQA Plan will be the responsibility of the CQA Engineer. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. The Contractor shall cooperate with the CQA Engineer during all testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling. The Contractor shall provide access to all areas requiring testing. The Contractor shall repair any damage to finished work caused by the CQA Engineer's sampling or testing activities.

- D. The CQA Engineer will coordinate independent surveying. Surveying by the CQA Engineer does not relieve the Contractor of his responsibility to lay out, control, and document the work.
- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 MATERIALS

Clay liner material may only be used for construction if it has been shown to be suitable in a test fill program. The test fill program will have been performed prior to construction of the secure cell or surface impoundment, and it is not part of the work included in this General Specification. Depending on the results of future test fills, either the Weathered Pierre Shale or the on-site silty clay may be used on the base and/or the side slopes of the secure cell. These general specifications may be modified per the results of future test fills.

- A. Clay liner material shall be obtained from on-site borrow areas or stockpiles identified by the Owner.
- B. If used, weathered Pierre shale satisfying the requirements of this section shall only be used in areas where the grades are less than 5 percent (base portions of the secure cell liner system). If weathered Pierre shale is used in the base of the cell, it shall be obtained from the existing Pierre shale stockpile. On-site clay material may be used on the base and shall be used on the side slopes of the secure cell liner system.
- C. Clay liner material for secure cell or surface impoundment construction shall:
 - 1. Be classified according to the Unified Soil Classification System (USCS) as CL or CH (ASTM D 2487) and exhibit a minimum liquid limit of 30 and a minimum plasticity index of 11.
 - 2. Have a percentage of gravel (i.e., dry weight retained on a U.S. No. 4 sieve) of less than 15 percent.
 - 3. Have particles no larger than 2 inches (in largest dimension) after processing and prior to placement (4 inches post-processing and 2 inches post-compaction for the weathered Pierre shale).
 - 4. Have a hydraulic conductivity of not more than 1×10^{-7} cm/s when compacted in accordance with this General Specification and tested in the laboratory in accordance with ASTM D 5084 at the conditions given in Permit Attachment LF-8.

- D. The water used to increase the moisture content of the clay liner shall be provided by the Owner. The Contractor shall maintain an accurate record of his water usage.

PART 3 EXECUTION

The requirements of Part 3 may be modified based on the results of future test fills as a Class 1 modification with prior approval.

3.01 PRIMARY CLAY LINER COMPACTION CRITERIA

- A. The compaction moisture content and the minimum dry unit weight of on-site clay, if used as primary clay liner material, shall be as follows:
1. The compaction moisture content of the clay liner material used in the base of the cell shall be at least optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the clay liner material shall be at least 99 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698).
 2. If the CAT 825 compactor is used, the compaction moisture content of the clay liner material used in the sideslopes of the cell shall be between 1-1/2 and 5 percent above optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the clay liner material shall be at least 95 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698). The combination of compacted in-place dry density and moisture content shall result in a minimum degree of saturation of 89 percent.
- B. The compaction moisture content of the weathered Pierre shale, if used as primary clay liner material, shall be between optimum moisture content and 3 percent wet of the optimum moisture content determined in the standard Proctor compaction test (ASTM D 698) and the minimum dry unit weight of the weathered Pierre shale liner material shall be at least 95 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D 698).

3.02 PRIMARY CLAY LINER PLACEMENT

- A. Upon completion of the leak detection system, the primary liner will be constructed. The primary clay liner shall be constructed to the elevations, grades, and thicknesses shown on the Construction Drawings. The thickness of the clay liner at any location shall be measured perpendicular to the plane of the slope at that location. The compacted primary clay liner shall be a minimum of three feet thick across the bottom of the secure cell. A compacted primary clay liner shall not be placed on the side slope of the secure cell except at the toe of slope.

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- B. Primary clay liner placement shall begin only after completion of all, or an approved portion of, the leak detection layer, the leak detection system sump, and associated piping. Placement shall not begin until the sampling and testing activities of the CQA Engineer are complete for work to be covered by the primary clay liner.
- C. The Contractor shall not place primary clay liner material on the surface of the leak detection layer unless it is free of debris, branches, vegetation, mud, ice, or other deleterious material. Excessive wrinkles in the geosynthetic components of the leak detection layer shall have been worked out or repaired by the Contractor to the satisfaction of the CQA Engineer.
- D. The Contractor shall construct the primary clay liner in lifts. Each lift of the primary clay liner shall meet the minimum requirements of this General Specification.
- E. If a CAT 825 compactor is used, the average lift thickness after compaction shall be no more than 6 inches, and the maximum lift thickness shall be 7 inches after compaction. If a REX 3-35 compactor is used, the average lift thickness after compaction shall be no more than 4 inches and the maximum lift thickness shall be 5 inches after compaction. The loose lift thickness shall be no greater than the length of the compactor pad.
- F. At the 3:1 (horizontal:vertical) toe of slope area, primary clay liner material shall be placed and compacted by hand in horizontal lifts.
- G. The first lift of primary clay liner material above the leak detection layer shall be constructed using a 9-inch thick loose lift. The lift shall be placed and spread using a low-ground pressure dozer (e.g., Caterpillar D6H LGP or other equipment approved by the Owner). Extreme care shall be taken during placement and spreading operations to ensure that the earthwork equipment does not damage the underlying geosynthetics.
- H. When primary clay liner material is placed on secure cell side slopes in horizontal lifts, extreme care shall be taken not to damage the underlying geosynthetics. Mechanized clay placement and compaction equipment (except the REX 3-35) shall not operate within a three-foot (one-foot for the REX 3-35) wide zone (measured horizontally) from the surface of the leak detection layer. The Contractor shall spread fill in this zone by orienting the dozer blade toward the slope face and with laborers using hand tools.
- I. Prior to placement of a lift of primary clay liner material, the Contractor shall allow the CQA Engineer to complete field testing to determine compliance with these specifications. The Contractor shall not place a new lift of primary clay liner material over a preceding lift until approval is given by the CQA Engineer in accordance with the CQA Plan. If the Contractor fails to comply with this requirement, he will be required by the Owner to remove and replace all unauthorized work at no additional cost to the Owner.

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- J. Prior to placement of a lift of primary clay liner material over an existing lift, the previous lift shall be thoroughly scarified to a nominal depth of 1 to 2 inches to provide good bonding between lifts. Scarification shall be accomplished by discing, raking with a grader, penetration by a sheepsfoot compactor, or an alternate method approved by Owner.
- K. The excessive trafficking of scarified surfaces by non-placement trucks or other equipment shall not be permitted during the period between scarification and placement of the following lift.
- L. If normal handling does not reduce the maximum clod size in on-site clay to an acceptable size, the Contractor shall use a Caterpillar SS250 soil stabilizer, mechanical mixer, or approved equivalent equipment to break up the clods. The on-site clay material shall be pulverized until the maximum soil clod size is reduced to 2 inches or less in largest dimension. The weathered Pierre shale material shall be pulverized using a Caterpillar minimum of four passes of the SS250 soil stabilizer (or an approved equivalent piece of equipment) until the maximum soil clod size is reduced to 4 inches or less (in largest dimension). The maximum soil clod size after compaction of the weathered Pierre shale shall be 2 inches or less in largest dimension. The use of a specific stabilizer or mixer shall be approved by the Owner prior to use.
- M. Moisture conditioning of the primary clay liner material shall be accomplished in the processing area using a Caterpillar SS250 soil stabilizer or approved equivalent prior to clay liner construction. The processing area location shall be approved by the Owner. Moisture shall be uniformly distributed throughout the clay liner material. If the clay liner material is wetter than required, then it shall be repeatedly mixed using a Caterpillar SS250 soil stabilizer, harrowing disc, grader, or equivalent to facilitate drying.
- N. No more than 1.5 percent moisture shall be added to the clay liner material at the time of compaction. Clay liner material requiring more than 1.5 percent moisture shall be removed, returned to the processing area, and conditioned until the proper moisture content is achieved. If the in-place moisture content is too high, the clay may be dozed, windrowed, disced, and/or mixed to facilitate drying.
- O. Primary clay liner material shall not be placed or compacted during a sustained period of temperature below 32°F that results in frozen clay, either in place or in the borrow area. Primary clay liner material may be placed and compacted during periods of early morning freezing temperatures if above-freezing temperatures are anticipated during the day.
- P. The Contractor shall not place frozen clay nor shall the Contractor place clay on frozen ground.
- Q. If clay liner material freezes after compaction, the Contractor shall remove the frozen material, scarify the remaining unfrozen clay, and then place and compact new clay in accordance with the General Specifications. Frozen clay shall not be reused until it

has thawed and been reworked to an acceptable moisture content. The Contractor shall be responsible for protecting compacted lifts of clay liner material from freezing. If extended freezing conditions are anticipated, the Contractor shall prepare a plan for the Owner's approval which outlines the measures he will take to protect finished work.

- R. Clay liner material shall not be placed during periods of unfavorable weather conditions.

3.03 PRIMARY CLAY LINER COMPACTION

- A. The sequence of compaction of the primary clay liner for a secure cell or surface impoundment shall be as described in the General Specifications or as shown on the Construction Drawings.
- B. Except as noted in this Section, compaction of lifts on the base of the cell shall be performed using a Caterpillar 825 compactor.
- C. The first lift of primary clay liner material on the base of the secure cell shall be placed and compacted using a light ground-pressure dozer and a smooth-drum roller operating in the static mode, or other method approved by the Owner, in order to protect the underlying geosynthetics. Wheeled vehicles and footed compactors will not be allowed on this first lift. The compaction and permeability criteria for the first lift will be waived to ensure that the compaction effort and/or testing activities do not result in damage to the underlying geosynthetics.
- D. On side slopes in the toe of slope area, compaction of the three-foot (one-foot if the REX 3-35 is used) wide zone (measured horizontally) of primary clay liner material immediately adjacent to the leak detection layer shall be achieved using hand-operated equipment (such as a walk-behind roller, or other equipment) approved by the Owner. At the Owner's discretion CQA testing may be performed in this zone. Hand-operated equipment shall not be used within 3 inches (measured horizontally) of the side slope and the CQA Engineer will not perform field testing within this zone.
- E. The daily work area shall extend a sufficient distance so as to maintain soil moisture conditions within an acceptable range to allow continuous operations. Desiccation and crusting of the lift surface shall be avoided as much as possible.
- F. The CQA Engineer will identify any areas of significant desiccation and crusting of a lift surface. The Contractor shall scarify the surface of such areas to a nominal depth of 1 to 2 inches or to the depth of desiccation identified by the CQA Engineer, and then water condition, disc or mix as necessary, and recompact the area.
- G. The transition from an existing full-depth section of clay liner to the beginning of an adjacent section that is to be constructed subsequently shall be accomplished by sloping (cutting back) the end of the full-depth section at 3:1 (horizontal:vertical) or flatter, scarifying the slope of the existing full-depth liner at the transition, and then immediately placing the adjacent lifts of clay liner.

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- H. If a dual-drum compactor which has the drums laterally separated by the operator's cab and the differential (such as a CAT 825) is used, one trip up and a staggered trip back to cover the uncompacted area between the drums will be considered one pass. The minimum number of compactor passes on each lift of the primary clay liner shall be as follows:
1. The base of the primary clay liner shall be compacted with a minimum of 10 passes of the CAT 825 if the on-site clay is used. If the weathered Pierre shale is used it shall be compacted with a minimum of 6 passes of the CAT 825.
 2. More than the minimum number of passes may be necessary to satisfy the other compaction criteria.
- I. Corners and other areas inaccessible to driven compaction equipment shall be compacted using hand operated equipment (such as a walk-behind roller) approved by the Owner.

3.04 SURVEY CONTROL

- A. The Surveyor shall survey the final location and elevation of the top of the primary clay liner. Surveying shall be performed in accordance with Section 01010 of these General Specifications. As part of this work, the Surveyor shall survey the location and elevation of the leachate collection system sump. The survey will ensure:
1. The specified thickness of primary compacted clay liner (3 feet on the bottom) has been achieved;
 2. The top of the primary clay liner slopes diagonally across the secure cell at about 3% grade toward the collection sump; and
 3. The top of the primary clay liner in the collection sump area is at the grades and elevations specified in the contract drawings.
- B. The Surveyor shall provide a Record Drawing to the Owner of the final location and elevation of the top of the primary clay liner, including the location and elevation of the leachate collection system sump, in accordance with the requirements of this Section 01010 of these General Specifications. The Surveyor shall submit this drawing prior to primary geomembrane liner construction unless otherwise approved by Owner and CQA Engineer. The Contractor may submit a partial record to obtain approval for a portion of the work. The Owner will define the minimum requirements for a partial submittal.

3.05 FIELD QUALITY CONTROL

- A. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.

- B. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at his own expense until acceptable test results are obtained.

3.06 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and partially-completed and completed work of these General Specifications.
- B. In the event of damage, the CQA Engineer will identify areas requiring repair, and the Contractor shall make repairs and replacements necessary to the approval of the Owner and at no additional cost to the Owner.
- C. The Contractor shall minimize, to the maximum extent feasible, desiccation cracking of clay liner material. He shall sprinkle the clay with water if cracking is observed or if directed by the Owner. The Contractor may seal roll the surface of the clay to reduce drying and desiccation. The Contractor may also protect exposed surfaces using light-colored or translucent membranes, such as Visqueen, to inhibit drying of the clay. The CQA Engineer will identify areas of significant cracking of the surface of the primary clay liner; and the Contractor shall repair the identified area to the satisfaction of the Owner and at no additional cost to the Owner.
- D. The primary clay liner surface shall be seal rolled and made smooth and free from ruts or indentations at the end of every working day when precipitation is forecast and/or at the completion of placement and compaction operations in an area.
- E. The Contractor shall maintain the clay liner surface in a condition suitable for geosynthetic clay liner installation as specified in the CQA plan until the surface is covered. Desiccation cracks larger than 0.2 feet deep or 0.25 inches wide shall be excavated to the full depth of the crack and repaired. Desiccation cracks on the liner surface less than 0.2 feet deep and 0.25 inches wide shall be moistened and compacted with a smooth drum roller until the surface of the clay liner meets the requirements of the CQA Plan.
- F. The over-built layer of soil shall be removed prior to placement of geomembrane liner. The over-built soil layer may be removed in sections to coordinate with geomembrane placement. Where the over-built soil layer is removed, the finished surface shall be protected and maintained as required by these General Specifications. The surface of the primary clay liner shall be trimmed to meet all requirements of Section 02775 and Section 02780 of these General Specifications prior to installation of the geosynthetic clay liner.
- G. No synthetic sealants or other chemical treatments may be applied to the clay liner material.

- H. The CQA Engineer will issue an approval of the installation of the primary clay liner to the Owner in accordance with the CQA Plan prior to placement of material over the clay liner.

3.07 PERFORATIONS

- A. Perforations in the primary clay liner resulting from construction and CQA activities shall be filled. Such perforations may include, but are not limited to, the following:
1. Nuclear density test probe locations;
 2. Shelby tube sampling locations;
 3. Sand-cone or rubber-balloon test locations;
 4. Survey stake locations.
- B. Perforations in the primary clay liner resulting from nuclear density tests will be filled by the CQA Engineer. All other perforations in the primary clay liner resulting from construction and/or CQA sampling activities shall be filled by the Contractor if necessary. The CQA Engineer will provide the Contractor with the locations of any tests made as part of CQA activities, except nuclear density tests.
- C. Perforations from construction and/or CQA sampling activities (except nuclear density tests) shall be backfilled by the Contractor with clay liner material. The clay liner material shall be placed and compacted (hand tamped) in accordance with the requirements of this section. Perforations in the primary clay liner from nuclear density tests will be backfilled by the CQA Engineer with bentonite (sodium montmorillonite) powder or flakes or a soil-bentonite mixture and compacted by hand tamping.

[END OF SECTION]

SECTION 02224

GRANULAR LEACHATE COLLECTION LAYER

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the placement of the granular component of the leachate collection system in the secure cell. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02225 - Sump and Pipe Bedding Gravel and Road Base Aggregate
- B. Section 02712 - Geonet Collection or Detection Layer
- C. Section 02714 - Geotextile Filter, Cushion, or Sacrificial Layer
- D. Section 02718 - Polyethylene Pipe and Fittings
- E. Section 02775 - Geomembrane Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. Work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all activities outlined in the CQA Plan and the Contractor shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. Testing specified in the CQA Plan for the granular leachate collection system materials (which does not include quality control testing at the source) will be the responsibility of the CQA Engineer. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. The Contractor shall cooperate with the CQA Engineer during all sampling and testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling. The Contractor shall provide access to all areas requiring testing. The Contractor shall repair any damage to finished work caused by the CQA Engineer's sampling or testing activities.

- D. Quality control testing (in accordance with Part 2.02 of this section) of the granular material at the source shall be the responsibility of the Contractor.
- E. The CQA Engineer will coordinate independent surveying. Surveying by the CQA Engineer does not relieve the Contractor of his responsibility to lay out, control, and document the work.
- F. If the CQA Engineer's test indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 MATERIAL FOR GRANULAR LEACHATE COLLECTION LAYER

- A. Granular material for this work shall consist of clean, hard, durable, non-carbonate particles which are free of metals, roots, trees, stumps, concrete, construction debris, organic matter, and deleterious materials and coatings.
- B. Granular material shall classify as SW (well-graded sand) or SP (poorly-graded sand) according to the Unified Soil Classification System (ASTM D 2487). The granular material shall have 100 percent passing the No. 4 U.S. standard sieve and not more than 3 percent passing the No. 200 U.S. standard sieve after placement, when tested in accordance with ASTM D 422.
- C. Granular material shall have a hydraulic conductivity of at least 1×10^{-2} cm/s when compacted in the laboratory to at least 70 percent relative density obtained from the relative density test (ASTM D 4253 and 4254) and then tested in accordance with ASTM D 2434.
- D. Granular material shall meet the requirements of AASHTO T104 for soundness.
- E. Granular material shall have less than 5 percent loss of weight, when tested for calcium carbonate content in accordance with ASTM D 4373. This requirement may be waived by Owner if it can be demonstrated that material does not contain a significant carbonate content.

2.02 GRANULAR MATERIAL SUPPLIER QUALITY CONTROL

- A. The Contractor shall require that the granular material Supplier sample and test the material in accordance with the methods specified in Part 2.01 of this section to demonstrate that it conforms to the requirements of Part 2.01. The Contractor shall require the granular material Supplier provide to the Owner written certification along with tests results, that the specified tests have been performed on representative samples of the granular material that will be delivered to the Owner's site and that material meets the requirements of Part 2.01 of this section.

- B. If a granular material sample fails to meet the quality control requirements of this General Specification, the Contractor shall require the granular material Supplier to perform sufficient sampling and testing to identify the extent of the nonconforming material to the satisfaction of the CQA Engineer. The Contractor shall not use nonconforming material.
- C. The Contractor shall require that the granular material Supplier comply with the certification and submittal requirements of the CQA Plan.

2.03 TRANSPORTATION

- A. Transportation of granular material shall be the responsibility of the Contractor.

2.04 HANDLING AND STORAGE

- A. Handling, stockpiling, and protection of the granular material prior to and following incorporation in the work is the responsibility of the Contractor. The Contractor shall be liable for any mixing of the material with other materials incurred prior to final acceptance.
- B. The Contractor shall be responsible for storage of the granular material at the site. The Contractor shall store the material at a location approved by the Owner and in such a manner that it is not adversely affected by dust, dirt, mud, or vegetation. During stockpiling, the Contractor may elect to place the granular material on a protective sheet and/or to cover it to prevent mixing with other materials. The CQA Engineer will identify contaminated material which will be rejected by the Owner.

PART 3 EXECUTION

3.01 GRANULAR MATERIAL COMPACTION CRITERIA

- A. The granular leachate collection system shall be placed in a single lift and compacted as described in Part 3.02 of this section.

3.02 PLACEMENT AND COMPACTION

- A. Granular material shall be placed in the leachate collection system at the locations and to the thicknesses shown on the Construction Drawings.
- B. Prior to placing the granular material, the Contractor shall verify by visual inspection that the underlying geosynthetic components are free of holes, tears, excessive wrinkles, or foreign objects. The Contractor, accompanied by the CQA Engineer, will visually inspect the geosynthetics and identify excessive wrinkles prior to placement of granular material. The Contractor shall "work out" or repair wrinkles to the satisfaction of the CQA Engineer prior to placement of the granular material. Wrinkles shall not be of a size that they could, in the opinion of the CQA Engineer, fold back on themselves.

- B. To minimize the impact on the underlying geomembrane, spreading of granular material shall be conducted prior to 12:00 Noon, unless otherwise approved by the Owner.

- C. Granular material shall be spread in a single lift using a low ground-pressure dozer (Caterpillar D6H-LGP or other equivalent equipment approved by the Owner), low-ground pressure tracked front-end loader, or belt conveyor. The tracked equipment shall operate only over previously-placed granular material. The granular material shall be compacted with a minimum of three passes of the dozer. The Contractor shall not operate equipment directly on geomembranes, geotextiles, geonets, or geocomposites.
- D. Unless otherwise specified by the Owner, the equipment used to haul and spread granular leachate collection material shall not exert ground pressures exceeding the following:

<u>Allowable Equipment Ground Pressure (psi)</u>	<u>Thickness of Granular Material Above Uppermost Geosynthetic (inches)</u>
<5	12
<10	18
<20	24
>20	36

The maximum allowable equipment ground pressure shall be 65 psi. The acceptability of equipment operating at ground pressures greater than 65 psi will be evaluated by the Owner at the Contractor's expense.

- E. When placing granular material with any mechanized equipment, the maximum acceptable drop height is 3 feet.
- F. The Contractor shall operate equipment in a manner that is protective of underlying geosynthetics. If it is suspected that damage to the underlying geosynthetics may have occurred during granular material placement, the Contractor shall uncover the suspect area to expose the potentially-damaged geosynthetics. The Contractor shall repair any observed damage of the underlying geosynthetics, at no additional cost to the Owner, in accordance with the repair requirements of the applicable section of these General Specifications.
- G. Within 1 foot of the toe of a slope, granular material shall be spread by hand. Extreme care shall be taken when placing granular material to protect the installed components of the liner system.
- H. Geotextile filter layers shall be placed as shown on the Construction Drawings. Geotextile filter layer placement shall be in accordance with Section 02714 of these General Specifications.

3.03 SURVEY CONTROL

- A. The Surveyor shall survey the final location and elevation of the top of the granular leachate collection layer. Surveying shall be performed in accordance with Section 01010 of these General Specifications.
- B. The Surveyor shall provide a Record Drawing to the Owner of the final location and elevation of the top of the granular leachate collection layer, in accordance with the requirements of Section 01010 of these General Specifications. The Record Drawing shall be provided prior to the placement of the protective soil layer unless otherwise approved by the Owner and CQA Engineer. The Surveyor may submit a partial drawing to obtain approval for a portion of the work. The Owner will define the minimum requirements for a partial submittal.

3.04 FIELD QUALITY CONTROL

- A. All Quality Control testing required by the General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.
- B. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor, at his own expense, until acceptable test results are obtained.

3.05 PROTECTION OF WORK

- A. After the granular material has been placed, the Contractor shall maintain it free of ruts, depressions, and damage resulting from the hauling and handling of any material, equipment, tools, etc.
- B. The Contractor shall use all means necessary to protect all materials and partially-completed and completed work of these General Specifications.
- C. In the event of damage, the CQA Engineer will identify any areas requiring repair, and the Contractor shall make all repairs and replacements necessary to the approval of the Owner and at no additional cost to the Owner.

[END OF SECTION]

SECTION 02225

SUMP AND PIPE BEDDING GRAVEL AND ROAD BASE AGGREGATE

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the placement of gravel associated with the leachate collection system and leak detection system sumps, collector pipes, and riser pipes. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

- B. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, testing, and installation services necessary for the installation of road base aggregate where shown on the Construction Drawings. The work shall be carried out in accordance with the Construction Drawings and the requirements of Section 304 of the State of Colorado Highway Department Standard Specifications for Road and Bridge Construction, except that the aggregate shall satisfy the gradation requirements for AASHTO No. 57 coarse aggregate rather than the gradation requirements of Subsection 703.03.

1.02 RELATED SECTIONS

- A. Section 02224 - Granular Leachate Collection Layer
- B. Section 02710 - Geocomposite Detection or Collection Layer
- C. Section 02712 - Geonet Detection or Collection Layer
- D. Section 02714 - Geotextile Filter or Cushion Layer
- E. Section 02718 - Polyethylene Pipe and Fittings
- F. Section 02775 - Geomembrane Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. Work will be monitored and tested in accordance with the requirements of the CQA Plan.

- B. The Contractor shall be aware of all activities outlined in the CQA Plan, and the Contractor shall account for these activities in the construction schedule.

- C. On-site testing as specified in the CQA Plan for the sump and pipe bedding gravel (which does not include quality control testing at the source) will be the responsibility of the CQA Engineer. The Contractor shall cooperate with the CQA Engineer during all sampling and testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling. The Contractor shall provide access to all areas requiring testing. The Contractor will repair any damage to finished work caused by the CQA Engineer's sampling and testing activities.
- D. Quality control testing (in accordance with Part 2.02 of this section) of the sump and pipe bedding gravel at the source shall be the responsibility of the Contractor.

PART 2 PRODUCTS

2.01 MATERIAL FOR SUMP AND PIPE BEDDING GRAVEL AND ROAD BASE AGGREGATE

- A. Gravel for the work shall consist of clean, hard, durable, non-carbonate, rounded, sub-rounded to sub-angular particles which are free of metals, roots, trees, stumps, concrete, construction debris, other organic matter, and deleterious materials and coatings.
- B. The gravel shall be screened and washed to have a gradation (when tested in accordance with ASTM D 422) after placement equivalent to AASHTO No. 57 coarse aggregate. This requirement may be waived by the Owner for gravel to be used as road base aggregate (see Section 3.01.I).
- C. Gravel shall have a hydraulic conductivity of at least 1 cm/s when compacted in the laboratory to at least 70 percent relative density obtained from the relative density test (ASTM D 4253 and 4254) and tested in accordance with ASTM D 2434. This requirement does not apply to road base aggregate.
- D. Gravel shall meet the requirements of AASHTO T96 for abrasion and AASHTO T104 for soundness. This requirement does not apply to road base aggregate.
- E. Gravel shall have less than 5 percent loss of weight, when tested for calcium carbonate content in accordance with ASTM D 4373. This requirement may be waived by the owner if it can be otherwise demonstrated that the material contains no significant carbonate content.

2.02 GRAVEL SUPPLIER QUALITY CONTROL

- A. The Contractor shall require that the gravel Supplier sample and test the gravel to demonstrate that the material conforms to the requirements of Part 2.01 of this section. The Contractor shall require the gravel Supplier provide to the Owner written certification along with test results, that tests have been performed on representative samples of the gravel material that will be delivered to the Owner's site. The analysis shall demonstrate that tests (i.e., ASTM D 422, ASTM D 2434, ASTM D 4373,

AASHTO T96, and AASHTO T104) have been performed and that acceptable results were obtained.

- B. If a gravel sample fails to meet the quality control requirements of this General Specification, the Contractor shall require the gravel Supplier to perform sufficient sampling and testing to identify the extent of the nonconforming material to the satisfaction of the CQA Engineer. The Contractor shall not use nonconforming material.
- C. The Contractor shall require that the gravel Supplier comply with the certification and submittal requirements of the CQA Plan.
- D. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.

2.03 TRANSPORTATION

- A. Transportation of gravel shall be the responsibility of the Contractor.

2.04 HANDLING AND STORAGE

- A. Handling, stockpiling, and protection of the gravel prior to and following incorporation into the work is the responsibility of the Contractor. The Contractor shall be liable for contamination of the material incurred prior to final acceptance.
- B. The Contractor shall be responsible for storage of the gravel at the site. The Contractor shall store the gravel at a location approved by the Owner and in such a manner so that it is not contaminated by dirt, mud, vegetation, or excessive dust. During stockpiling, the Contractor may elect to place the gravel on a protective sheet and/or to cover it to prevent contamination. The CQA Engineer will identify contaminated material which will be rejected by the Owner.

PART 3 EXECUTION

3.01 GRAVEL COMPACTION CRITERIA

- A. Gravel used for construction of sumps and pipe bedding and access ramp road base aggregate shall be placed in maximum 12 inch thick loose lifts. Gravel shall be compacted using two passes of a hand operated vibrating compactor such as a hand tamper or walk-behind vibrating compactor or other method approved by the Owner.

3.02 PLACEMENT AND COMPACTION

- A. Gravel shall be placed at the locations and to the thicknesses shown on the Construction Drawings. These locations may include the leachate collection system sump, leak detection system sump, and bedding for collection laterals, mains, and/or riser pipes for the leachate collection system and leak detection system. Gravel shall also be placed as road base aggregate, as shown on the Construction Drawings.

- B. Gravel shall not be placed directly on the primary or secondary geomembrane liner. Gravel may be placed on top of a geotextile cushion layer, geonet, geocomposite drainage layer, or geomembrane rub sheet, as shown on the Construction Drawings. Gravel may be placed using a backhoe, front-end loader, belt conveyor, spreader box, or other method approved by the Owner, as long as the ground-pressure requirements of this Section are not exceeded. The maximum acceptable gravel drop height is 3 feet.
- C. Final spreading of the gravel may be performed using a low ground-pressure dozer (Caterpillar D6H-LGP or other similar equipment approved by the CQA Engineer), low-ground pressure front-end loader, or by hand. The tracked equipment shall operate only over previously-placed gravel or other soil. The Contractor shall not operate equipment directly on geosynthetics.
- D. Unless otherwise specified by the Owner, the equipment used to spread gravel shall not exert ground pressures exceeding the following:

<u>Allowable Equipment Ground Pressure (psi)</u>	<u>Thickness of Gravel Above Geosynthetic (inches)</u>
<5	12
<10	18
<20	24
>20	36

The maximum allowable equipment ground pressure shall be 65 psi. The acceptability of equipment operating at ground pressures greater than 65 psi will be evaluated by the Owner at the Contractor's expense.

- E. The Contractor shall operate equipment in a manner that is protective of polyethylene pipes and underlying geosynthetics. If it is suspected that damage to polyethylene pipes or underlying geosynthetics may have occurred, the Owner will instruct the Contractor to remove the overlying material to expose the potentially-damaged materials. The Contractor shall repair, at his own expense, any observed damage, in accordance with the requirements of these General Specifications.
- F. Within 1 foot of the toe of a slope, gravel shall be spread by hand. Extreme care shall be taken when placing gravel to protect the installed components of the liner system.
- G. Geotextile filter or cushion layers shall be placed as shown on the Construction Drawings. Geotextile filter and cushion layer placement shall be in accordance with Section 02714 of these General Specifications.
- H. Gravel for road base aggregate shall be placed and compacted in accordance with Section 304.04 of the State of Colorado Highway Department Standard Specifications for Road and Bridge Construction.

3.03 FIELD QUALITY CONTROL

- A. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.
- B. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at his own expense until acceptable test results are obtained.

3.04 PROTECTION OF WORK

- A. After the gravel has been incorporated into the work, the Contractor shall maintain it free of ruts, depressions, and damage resulting from the hauling and handling of any material, equipment, tools, etc.
- B. The Contractor shall use all means necessary to protect all prior work, materials and completed and partially completed work of other Sections of these General Specifications.
- C. In the event of damage, the CQA Engineer will identify areas requiring repair, and the Contractor shall make repairs and replacements necessary, to the approval of the Owner at no additional cost to the Owner.

3.05 SURVEY CONTROL

- A. The Surveyor shall survey the final location and elevation of the top of the road base. Surveying shall be performed in accordance with of Section 01010 of these General Specifications.
- B. The Surveyor shall provide a Record Drawing to the Owner of the final location and elevation of the final surface of the road base, in accordance with the requirements of Section 01010 of these General Specifications.

[END OF SECTION]

SECTION 02710

GECOMPOSITE DETECTION OR COLLECTION LAYER

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the installation of the geocomposite leak detection or leachate collection layer of the secure cell or surface impoundment. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02222 - Primary Clay Liner
- B. Section 02225 Sump and Pipe Bedding Gravel and Road Base Aggregate
- C. Section 02712 - Geonet Detection or Collection Layer
- D. Section 02714 - Geotextile Filter or Cushion Layer
- E. Section 02716 - Protective Soil Layer
- F. Section 02775 - Geomembrane Liners
- G. Section 02780 - Geosynthetic Clay Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. Work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all activities outlined in the CQA Plan, and the Contractor shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. If testing is not completed prior to delivery to the site, the Contractor shall deliver geocomposite to the site at least 14 calendar days prior to installation to allow sufficient time for testing required by the CQA Plan.
- D. Any geocomposite rolls that do not meet the requirements of these General Specifications will be rejected. The Contractor shall replace the rejected material with

new material that conforms to the specification requirements, at no additional cost to the Owner.

- E. If the CQA Engineer's test indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 GEOCOMPOSITE PROPERTIES

- A. The Contractor shall require that the geocomposite Manufacturer furnish material with minimum average roll values, as defined by the Federal Highway Administration (FHWA), meeting or exceeding the criteria specified in Table 02710-1. The Contractor shall require that the Manufacturer provide results for tests performed using the procedures listed in Table 02710-1, as well as a certification that the material delivered to the site meets or exceeds the specified values.
- B. In addition to the property values listed in Table 02710-1, the geocomposite shall:
1. Retain its structure during handling, placement, and long-term service.
 2. Be capable of withstanding outdoor (i.e., ultra-violet light) exposure for a minimum of 30 days with no measurable degradation in the specified physical properties.
 3. Meet any additional requirements of the Construction Drawings.
 4. Be manufactured with a geonet that does not contain any reclaimed polymer, nor any foaming or blowing agents.

2.02 MANUFACTURING QUALITY CONTROL

- A. The Contractor shall require that the geocomposite Manufacturer sample and test the geocomposite to demonstrate that the material conforms to the requirements of these General Specifications. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. Test results shall be provided to the Owner. Sampling shall, in general, be performed on sacrificial portions of the geocomposite material such that repair is not required. The Contractor shall require that the geocomposite Manufacturer sample and test the geocomposite, at a minimum, as specified below and perform the following manufacturing quality control tests:

	<u>Test</u>	<u>Procedure</u>
Geonet Component 1/40,000 ft ²	Specific gravity	ASTM D 1505
	Thickness	ASTM D 374C or D1777
	Carbon black	ASTM D 1603
Geotextile Component 1/40,000 ft ²	<u>Test</u>	<u>Procedure</u>
	Mass per unit area	ASTM D 3776
	Apparent opening size	ASTM D 4751
	Permitivity	ASTM D 4491
	Grab strength	ASTM D 4632
	Tear strength	ASTM D 4533
	Puncture strength	ASTM D 4833
<i>Geocomposite Component</i>	Peel strength	ASTM F 904

- B. Any geocomposite sample that does not comply with these General Specifications shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to the Owner.
- C. If a geocomposite sample fails to meet the quality control requirements of this General Specification the Contractor shall require that the geocomposite Manufacturer sample and test each roll manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results as determined by the CQA Engineer is established.
- D. Additional sample testing may be performed, at the geocomposite Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.
- E. If required by the Owner the Contractor shall require the geocomposite Manufacturer to retain a coupon of geocomposite (10 feet by 2 feet) provided for the project for every 20,000 ft² of geocomposite produced for the project until the work is accepted by the Owner.
- F. The Contractor shall require that the geocomposite Manufacturer comply with the certification and submittal requirements of the CQA Plan.

2.03 LABELING

- A. Geocomposite rolls shall be labeled with the following information.
1. Name of Manufacturer;
 2. Product identification;
 3. Lot number;
 4. Roll number; and
 5. Roll dimensions.

- B. If any special handling is required, it shall be so marked on the geocomposite itself, e.g., "This Side Up" or "This Side Against Soil To Be Retained".

2.04 TRANSPORTATION

- A. Transportation of the geocomposite shall be the responsibility of the Contractor. The Contractor shall be liable for damage to the geocomposite incurred prior to and during transportation to the site. The Contractor shall replace damaged rolls at no additional cost to the Owner.

2.05 HANDLING AND STORAGE

- A. Geocomposite shall be shipped and stored in watertight and opaque protective covers.
- B. Handling, storage, and care of the geocomposite prior to and following incorporation into the work is the responsibility of the Contractor. The Contractor shall be liable for damage to the material incurred prior to final acceptance by the Owner. The Contractor shall repair damage in accordance with Part 3.03 of this section and at no additional cost the Owner.
- C. The Contractor shall be responsible for storage of the geocomposite at the site. The geocomposite shall be stored off the ground and out of direct sunlight and shall be protected from puncture, cutting, and excessive heat, cold, moisture, mud, dirt, dust or any other damaging or deleterious condition. The geocomposite shall be stored in accordance with any additional requirements of the geocomposite Manufacturer.

PART 3 EXECUTION

3.01 HANDLING AND PLACEMENT

- A. Geocomposite shall be installed at all locations shown on the Construction Drawings.
- B. The Contractor shall handle the geocomposite in such a manner as to ensure the geocomposite is not damaged in any way.
- C. When placing geocomposite on geomembrane, the geomembrane liner that will underlie the geocomposite shall be clean and free of excessive dust and dirt, stones, rocks, or other obstructions that could potentially damage the geomembrane. The geomembrane shall be swept clean prior to geocomposite placement. At the direction of the Owner, the Contractor shall clean the geomembrane with water.
- D. The Contractor shall take all necessary precautions to prevent damage to underlying layers during placement of the geocomposite.
- E. In the presence of excessive wind, the Contractor shall weight the geocomposite with sandbags or equivalent weight approved by the Owner.

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- F. On side slopes, the geocomposite shall be secured, by the Contractor, at the top of the slope and then rolled down the slope.
 - G. If necessary, the Contractor shall position the geocomposite by hand after it is unrolled to minimize wrinkles.
 - H. Geocomposite shall be clean when installed. During installation, care shall be taken by the Contractor not to entrap stones, excessive dirt, or moisture that could damage the underlying geomembrane, clog drains or filters, or hamper subsequent seaming.
 - I. Geocomposite shall not be welded to the geomembrane liners. Geocomposite shall only be cut using a cutter approved by the geocomposite Manufacturer and the Owner.
 - J. Tools shall not be left on or in the geocomposite.
 - K. After placing the geocomposite, the geocomposite shall not be left exposed for a period in excess of 30 days unless a longer exposure period is approved by the Owner based on a formal demonstration from the Contractor (e.g., a certification from the geocomposite Manufacturer) that the geotextile component of the geocomposite is stabilized against ultra-violet (UV) light degradation for a period in excess of 30 days.
 - L. If white colored geotextile is used in the geocomposite, precautions shall be taken against "snow blindness" of personnel.

3.02 SEAMS AND OVERLAPS

- A. The components of the geocomposite (e.g., geotextile-geonet-geotextile) are not bonded together at the ends and edges of the rolls. Each component shall be secured or seamed to the like component at overlaps.
- B. No horizontal seams shall be allowed on slopes steeper than 5:1 (horizontal:vertical), unless approved by the Owner.
- C. Geonet Components:
 - 1. The geonet components shall be overlapped by at least 4 inches. These overlaps shall be secured by tying.
 - 2. Tying shall be achieved by nylon strings, plastic fasteners, or polymer braid. Metallic devices shall not be used. Tying devices shall be provided in a color different than the geonet to allow easy inspection.
 - 3. For slopes steeper than 5:1 (horizontal:vertical), tying shall be every 5 feet along the slope, every 2 feet across the slope, and every 6 inches in the anchor trench. For slopes flatter than 5:1 (horizontal:vertical), tying shall be every 10 feet in both directions and every 6 inches in the anchor trench.

4. In all cases, at least 2 ties per panel dimension shall be installed.
 5. When more than one layer of geocomposite is installed, joints shall be staggered at least 1 foot.
 6. The joints on adjacent geocomposite panels shall be staggered at least 1 foot.
- D. Geotextile Components:
1. The bottom layers of the geotextile shall be overlapped.
 2. The top layers of geotextiles shall be continuously sewn (i.e., spot sewing is not allowed). Geotextiles shall be overlapped a minimum of 3 inches prior to sewing.
 3. Polymeric thread shall be used for all sewing. The seam type shall be Federal Standard (No. 751.a) Type SSa. The seams shall be sewn using Stitch Type 401.

3.03 REPAIR

- A. Any holes or tears in the geocomposite shall be repaired by placing a patch extending 1 foot beyond the edges of the hole or tear. The patch shall be secured over the hole or tear by tying fasteners through the geocomposite patch, and through the top geotextile and geonet beneath the patch. The patch shall be secured every 6 inches with approved tying devices. A larger geotextile patch shall be placed over the geocomposite patch and shall be heat sealed to the top geotextile of the geocomposite needing repair. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area shall be cut out and the two portions of the geocomposite shall be joined in accordance with Part 3.02 of this section.

3.04 PLACEMENT OF OVERLYING MATERIALS

- A. The primary clay liner (secure cell floor), geosynthetic clay liner, geomembrane liner, or protective soil layer as required by the Construction Drawings, shall be placed as soon as possible after placement and approval of the geocomposite leakage detection layer or leachate collection layer. Placement of each overlying material shall be in accordance with the appropriate sections of these General Specifications.
- B. The Contractor shall place overlying soil materials in such a manner as to ensure that:
1. The geocomposite and underlying geosynthetic materials are not damaged;
 2. Minimal slippage occurs between the geocomposite and underlying layers; and
 3. Excessive stresses are not produced in the geocomposite.

- C. Unless otherwise specified by the Owner, the equipment operating on soil material overlying a geocomposite shall comply with the following:

<u>Maximum Allowable Equipment Ground Pressure (psi)</u>	<u>Thickness of Soil Above Geocomposite (inches)</u>
<5	12
<10	18
<20	24
>20	36

The maximum allowable equipment ground pressure shall be 65 psi. The acceptability of equipment operating at ground pressures greater than 65 psi will be evaluated by the Owner at the Contractor's expense.

The requirements do not apply to equipment used to construct the secondary or primary clay liners; however, the Owner can restrict the use of equipment that, in the Owner's opinion, may be potentially damaging to the geocomposite.

- D. The CQA Engineer will provide monitoring of the spreading of soils over the geocomposite in accordance with the CQA Plan.

3.05 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and partially completed and completed work of these General Specifications.
- B. The CQA Engineer will identify any areas requiring repair. The Contractor shall immediately make repairs and replacements necessary, to the approval of the Owner and at no additional cost to Owner.
- C. The CQA Engineer will issue an approval of the geocomposite detection or collection layer installation to the Owner prior to placement of material over the geocomposite in accordance with the CQA Plan.

TABLE 02710-1 REQUIRED GEOCOMPOSITE PROPERTIES			
Properties	Units	Specified Values⁽⁴⁾	Test Method
Geonet Component:			
Polymer composition	%	95 polyethylene by weight	
Polymer specific gravity		0.92	ASTM D 1505
Polymer melt index	g/10 min.	0.1 - 0.5	ASTM D 1238
Carbon black content	%	2 - 3	ASTM D 1603
Nominal thickness	mm	5	ASTM D 374C or D1777
Geotextile Component:			
Polymer composition	%	95 polyester polypropylene, or polyethylene by weight	
Mass per unit area	oz/yd ²	5.7	ASTM D 3776
Apparent opening size	mm	0 ₉₅ 0.212mm	ASTM D 4751
Permittivity	sec ⁻¹	0.1	ASTM D 4491
Grab strength	lb	150	ASTM D 4632 ⁽¹⁾
Tear strength	lb	50	ASTM D 4533 ⁽²⁾
Puncture strength	lb	80	ASTM D 4833 ⁽³⁾
Geocomposite:			
Transmissivity	m ² /s	5 X 10 ⁻⁴	ASTM D 4716 ⁽⁵⁾
NOTES:			
(1) Minimum of values measured in machine and cross machine directions with 1 inch clamp on constant rate of extension (CRE) machine. (2) Minimum value measured in machine and cross machine direction. (3) Tension testing machine with a 1.75-inch diameter ring clamp, the steel ball being replaced with a 0.31-inch diameter solid steel cylinder with flat tip centered within the ring clamp. (4) Values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table). Where ranges of values are specified, the average roll value must be within the specified range. The apparent opening size specified is a maximum average roll value. (5) The design transmissivity is the hydraulic transmissivity of the geocomposite measured using water at 68/F " 3/F with a hydraulic gradient of not less than 0.1, nor more than 0.5, under a compressive stress of not less than 10,000 psf. For the test, the geocomposite shall be sandwiched between a layer of clay material representative of the clay that will be used at the The Permittee site and an 80-mil thick HDPE geomembrane. The minimum test duration shall be 24 hours and the report of results shall include measurements at intervals over the entire test duration.			

[END OF SECTION]

SECTION 02712

GEONET DETECTION OR COLLECTION LAYER

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the installation of the geonet leak detection layer or geonet leachate collection layer of the secure cell or surface impoundment. The work shall be carried out in accordance with this General Specification, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02221 - Secondary Clay Liner
- B. Section 02222 - Primary Clay Liner
- C. Section 02224 - Granular Leachate Collection Layer
- D. Section 02225 - Sump and Pipe Bedding Gravel and Road Base Aggregate
- E. Section 02710 - Geocomposite Detection or Collection Layer
- F. Section 02714 - Geotextile Filter or Cushion Layer
- G. Section 02775 - Geomembrane Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. All work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all activities outlined in the CQA Plan, and the Contractor shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. If CQA testing is not completed prior to delivery at the site, the Contractor shall deliver geonet to the site at least 14 calendar days prior to installation to allow sufficient time for testing required by the CQA Plan.
- D. Any geonet rolls that do not meet the requirements of these General Specifications will be rejected. The Contractor shall replace the rejected material with new material that conforms to the specification requirements, at no additional cost to the Owner.

- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 GEONET PROPERTIES

- A. The Contractor shall require that the geonet Manufacturer furnish material with minimum average roll values, as defined by the Federal Highway Administration (FHWA), meeting or exceeding the criteria specified in Table 02712-1. The Contractor shall require that the geonet Manufacturer provide results for tests performed using the procedures listed in Table 02712-1, as well as a certification that the material properties for the material delivered to the site will meet or exceed the specified values.
- B. In addition to the property values listed in Table 02712-1, the geonet shall:
1. Retain its structure during handling, placement, and long-term service.
 2. Meet any additional requirements of the Construction Drawings.
 3. Not be manufactured from any reclaimed polymer, nor any foaming or blowing agents.

2.02 MANUFACTURING QUALITY CONTROL

- A. The Contractor shall require that the geonet Manufacturer sample and test the geonet to demonstrate that the material conforms to the requirements of these General Specifications. All Quality Control testing required by the General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. Test results shall be provided to the Owner. Sampling shall, in general, be performed on sacrificial portions of the geonet material such that repair is not required. The Contractor shall require that the geonet Manufacturer sample and test the geonet, at a minimum, once every 40,000 ft² and perform the following manufacturing quality control tests:

<u>Test</u>	<u>Procedure</u>
Specific gravity	ASTM D 1505
Thickness	ASTM D 374C or D1777
Carbon black	ASTM D 1603

- B. Any geonet sample that does not comply with these General Specifications shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to the Owner.

- C. If a geonet sample fails to meet the quality control requirements of these General Specifications, the Contractor shall require that the geonet Manufacturer sample and test each roll manufactured, in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established as specified within the CQA Plan.
- D. Additional sample testing may be performed, at the geonet Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.
- E. If requested by Owner, the Contractor shall require the geonet Manufacturer to retain a coupon of geonet (10 feet by 2 feet) provided for the project for every 20,000 ft² of geonet produced for the project until the work is accepted by the Owner.
- F. The Contractor shall require that the geonet Manufacturer comply with the certification and submittal requirements of the CQA Plan.

2.03 LABELING

- A. Geonet rolls shall be labeled with the following information.
 - 1. Name of Manufacturer;
 - 2. Product identification;
 - 3. Lot number;
 - 4. Roll number; and
 - 5. Roll dimensions.

2.04 TRANSPORTATION

- A. Transportation of geonet shall be the responsibility of the Contractor. The Contractor shall be liable for damage to the geonet incurred prior to and during transportation to the site. The Contractor shall repair or replace damaged rolls at no additional cost to the Owner.

2.05 HANDLING AND STORAGE

- A. Geonet shall be protected from damage during shipping and storage.
- B. Handling, storage, and care of the geonet prior to and following incorporation into the work is the responsibility of the Contractor. The Contractor shall be liable for damage to the material incurred prior to final acceptance by the Owner. The Contractor shall repair damage in accordance with Part 3.03 of this Section and at no additional cost to the Owner.
- C. The Contractor shall be responsible for storage of the geonet at the site. The geonet shall be stored off the ground and shall be protected from excessive heat or cold, moisture mud, dirt, dust, or any other damaging or deleterious condition. The geonet

shall be stored in accordance with any additional requirements of the geonet Manufacturer.

PART 3 EXECUTION

3.01 HANDLING AND PLACEMENT

- A. Geonet shall be installed at all locations shown on the Construction Drawings.
- B. The Contractor shall handle the geonet in such a manner as to ensure the geonet is not damaged in any way.
- C. Just prior to geonet placement, the geomembrane liner that will underlie the geonet shall be clean and free of dust, dirt, stones, rocks, or other obstructions that could potentially damage the geomembrane. The geomembrane shall be swept clean prior to geonet placement. At the direction of the Owner, the Contractor shall clean the geomembrane with water.
- D. The Contractor shall take all necessary precautions to prevent damage to underlying layers during placement of the geonet.
- E. In the presence of excessive wind, the geonet shall be weighted by the Contractor with sandbags or equivalent weight approved by the Owner.
- F. On side slopes, the geonet shall be secured by the Contractor at the top of slope and then rolled down the slope.
- G. If necessary, the Contractor shall position the geonet by hand after it is unrolled to minimize wrinkles.
- H. Geonet shall be clean when installed. During installation, care shall be taken by the Contractor not to entrap stones and excessive dirt or moisture that could damage the underlying geomembrane or clog drains or filters.
- I. Geonet shall not be welded to geomembrane liners. Geonet shall only be cut using a cutter approved by the geonet Manufacturer and the Owner.
- J. Tools shall not be left on or in the geonet.
- K. Geonet shall not be placed in direct contact with textured geomembrane liner unless specifically called for on the Construction Drawings.

3.02 STACKING AND JOINING

- A. When two or more layers of geonets are stacked, care shall be taken to prevent the strands of one layer of geonet from penetrating the channels of an overlying or underlying layer.
- B. A layer of geonet shall not be installed in a direction perpendicular to an underlying layer of geonet unless approved by the Owner.
- C. In the corners of the side slopes, where overlaps between perpendicular geonet strips are required, an extra layer of geonet shall be provided on top of the previously installed geonets, from top to bottom of the slope, as shown on the Construction Drawings.
- D. Adjacent rolls of geonet shall be overlapped by at least 4 inches. The overlaps shall be secured by tying.
- E. Tying shall be achieved by nylon strings, plastic fasteners, or polymer braid. Metallic devices shall not be used. Tying devices shall be provided in a color different than the geonet to allow for easy inspection.
- F. For slopes steeper than 5:1 (horizontal:vertical), tying shall be every 5 feet along the slope, every 2 feet across the slope, and every 6 inches in the anchor trench. For slopes flatter than 5:1 (horizontal:vertical), tying shall be every 10 feet in both directions, and every 6 inches in the anchor trench.
- G. In all cases, at least 2 ties per panel dimension shall be installed.
- H. When more than one layer of geonet is installed, joints shall be staggered at least 1 foot.
- I. The joints on adjacent geonet panels shall be staggered at least 1 foot.
- J. No horizontal seams shall be allowed on slopes steeper than 5:1 (horizontal:vertical), unless approved by the Owner.

3.03 REPAIR

- A. Any holes or tears in the geonet shall be repaired by placing a patch over the hole or tear extending 1 foot beyond the edges of the hole or tear. The patch shall be secured to the original geonet by tying every 6 inches with approved tying devices. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area shall be cut out and the two portions of the geonet shall be joined in accordance with Part 3.02 of this section.

3.04 PLACEMENT OF OVERLYING MATERIALS

- A. An installed layer of geonet shall be covered with an overlying layer (geotextile or geomembrane), as required by the Construction Drawings, as soon as possible after installation and approval to minimize the accumulation of dirt or dust in the geonet and the potential for damage to the geonet or the underlying geomembrane. If dust or dirt accumulates in the geonet layer prior to placement of the overlying layer, the Contractor shall clean the geonet by sweeping or washing with water. Placement of each overlying material shall be in accordance with these General Specifications.
- B. Soil shall not be placed in direct contact with geonets. Geonets shall be separated from soil materials by a geotextile filter or other material, as indicated on the Construction Drawings. The only exception to this shall be at those locations shown on the Construction Drawings where sump or pipe bedding gravel directly overlies one or more layers of geonet.
- C. The Contractor shall place soil above geonet layers (e.g., above a geotextile filter which overlies the geonet) in such a manner as to ensure that:
1. The geonet and underlying geomembrane are not damaged;
 2. Minimal slippage occurs between the geonet and the underlying geomembrane; and
 3. Excessive stresses are not produced in the geonet.
- D. Unless otherwise specified by the Owner, all equipment operating on soil material overlying a geonet shall comply with the following:

<u>Maximum Allowable Equipment Ground Pressure (psi)</u>	<u>Thickness of Soil Above Geonet (inches)</u>
<5	12
<10	18
<20	24
>20	36

The maximum allowable equipment ground pressure shall be 65 psi. The acceptability of equipment operating at ground pressures greater than 65 psi will be evaluated by the Owner at the Contractor's expense.

The equipment pressure requirements do not apply to equipment used to construct the secondary or primary clay liners; however, the Owner may restrict the use of equipment that, in the Owner's opinion, may be potentially damaging to the geonet.

- E. The CQA Engineer will provide monitoring of the placement of soil materials over the geonet or overlying layer in accordance with the CQA Plan.

3.05 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and partially completed and completed work of these General Specifications.
- B. The CQA Engineer will identify any areas requiring repair. The Contractor shall make repairs and replacements as necessary, to the approval of the Owner and at no additional cost to the Owner.
- C. The CQA Engineer will issue an approval of the geonet detection or collection layer installation to the Owner prior to placement of material over the geonet in accordance with the CQA Plan.

TABLE 02712-1 REQUIRED GEONET PROPERTIES			
PROPERTIES	UNITS	SPECIFIED VALUES⁽²⁾	TEST METHOD
Polymer composition	%	95 polyethylene by weight	
Polymer specific gravity		0.92	ASTM D 1505 ⁽¹⁾
Polymer melt index	g/10 min.	0.1 - 0.5	ASTM D 1238
Carbon black content	%	2-3	ASTM D 1603
Nominal thickness	Mm	5	ASTM D 374C or D1777
Transmissivity	m ² /s	5 X 10 ⁻⁴	ASTM D 4716 ⁽³⁾
NOTES:			
(1) The specific gravity of the geonet polymer shall not exceed that of the geomembrane.			
(2) Values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table). Where ranges of values are specified, the average roll values must be within the specified range.			
(3) The design transmissivity is the hydraulic transmissivity of the geonet measured using water at 68°F with a hydraulic gradient of not less than 0.1, nor more than 0.5, under a compressive stress of not less than 10,000 psf. For the test, the geonet shall be sandwiched between an 80-mil thick HDPE geomembrane on bottom, and on top, either: (i) a 60-mil or 80-mil thick HDPE geomembrane (if the Construction Drawings show the geonet sandwiched between two geomembranes); or (ii) a geotextile filter layer and a layer of soil representative of the protective soil layer that will be used at the The Permittee site (if the Construction Drawings show the geonet overlain by a geotextile filter layer and protective soil layer). The minimum test duration shall be 24 hours and the report for the test results shall include measurements at intervals over the entire test duration.			

[END OF SECTION]

SECTION 02714 GEOTEXTILE FILTER, OR CUSHION LAYER

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the installation of the geotextile filter layer, cushion layer (also called a separation layer), or sacrificial layer in the secure cell or surface impoundment. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02120 - Permanent Sump
- B. Section 02222 - Primary Clay Liner
- C. Section 02224 - Granular Leachate Collection Layer
- D. Section 02225 - Sump and Pipe Bedding Gravel and Road Base Aggregate
- E. Section 02712 - Geonet Detection or Collection Layer
- F. Section 02716 - Protective Soil Layer
- G. Section 02775 - Geomembrane Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. Work will be monitored and tested in accordance with requirements of the CQA Plan.
- B. The Contractor shall be aware of all activities outlined in the CQA Plan, and the Contractor shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. If CQA testing is not completed prior to delivery, the Contractor shall deliver geotextile to the site at least 14 calendar days prior to installation to allow sufficient time for testing required by the CQA Plan.
- D. Any geotextile rolls that do not meet the requirements of these General Specifications will be rejected. The Contractor shall replace the rejected material with new material that conforms to the specification requirements, at no additional cost to the Owner.

- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 GEOTEXTILE PROPERTIES

- A. The Contractor shall require that the geotextile Manufacturer furnish geotextile with minimum average roll values, as defined by the Federal Highway Administration (FHWA), meeting or exceeding the criteria specified in Tables 02714-1 (for filter layers), or Table 02174-2 (for cushion layers). The Contractor shall require that the geotextile Manufacturer provide results for tests performed using the procedures in Table 02714-1, or 02714-2, as well as a certification that the material delivered to the site meets or exceeds the specified values.
- B. Geotextile products shall be needle-punched, non-woven materials manufactured from continuous filaments or stapled fibers.
- C. In addition to the property values listed in Table 02714-1 or 02714-2, the geotextile filter or cushion layer shall:
1. Retain its structure during handling, placement, and long-term service.
 2. Be capable of withstanding outdoor (i.e., ultra-violet) light for a minimum of 30 days with no measurable degradation in the specified physical properties.
 3. Meet any additional requirements of the Construction Drawings.

2.02 MANUFACTURING QUALITY CONTROL

- A. The Contractor shall require that the geotextile Manufacturer sample and test the geotextile to demonstrate that the material conforms to the requirements of this General Specification. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. Test results shall be provided to the Owner. Sampling shall, in general, be performed on sacrificial portions of the geotextile material such that repair is not required. The Contractor shall require that the geotextile Manufacturer sample and test the geotextile, at a minimum, once every 40,000 ft² and perform the following manufacturing quality control tests:

Test Procedure

Mass per unit area	ASTM D 3776
Apparent opening size (if the geotextile is being used as a filter)	ASTM D 4751
Permitivity (if the geotextile is being used as a filter)	ASTM D 4491
Grab strength	ASTM D 4632
Tear strength	ASTM D 4533
Puncture strength	ASTM D 4833

- B. Any geotextile sample that does not comply with this General Specification shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected roll at no additional cost to the Owner.
- C. If a geotextile sample fails to meet the quality control requirements of this General Specification, the Contractor shall require that geotextile Manufacturer sample and test each roll manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established in accordance with the CQA Plan.
- D. Additional sample testing may be performed, at the geotextile Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.
- E. If requested by the Owner, the Contractor shall require the geotextile Manufacturer to retain a coupon of geotextile (10 feet by 2 feet) provided for the project for every 20,000 ft² of geotextile produced for the project until the work is accepted by the Owner.
- F. The Contractor shall require that the geotextile Manufacturer comply with the certification and submittal requirements of the CQA Plan.

2.03 LABELING

- A. Geotextile rolls shall be marked or tagged with the following information:
1. Name of Manufacturer;
 2. Product identification;

3. Lot number;
4. Roll number; and,
5. Roll dimensions.

- B. If any special handling is required, it shall be so marked on the geotextile itself, e.g., "This Side Up" or "This Side Against Soil to be Retained".

2.04 TRANSPORTATION

- A. Transportation of the geotextile is the responsibility of the Contractor. The Contractor shall be liable for damage to the geotextile incurred prior to and during transportation to the site. The Contractor shall repair or replace damaged rolls at no additional cost to the Owner.

2.05 HANDLING AND STORAGE

- A. Geotextile shall be shipped and stored in watertight and opaque protective covers.
- B. Handling, storage, and care of the geotextile prior to and following incorporation into the work is the responsibility of the Contractor. The Contractor shall be liable for damage to the geotextile incurred prior to final acceptance by the Owner. The Contractor shall repair damage in accordance with Part 3.03 of this section and at no additional cost to the Owner.
- C. The Contractor shall be responsible for storage of the geotextile at the site. The geotextile shall be stored off the ground and out of direct sunlight and precipitation, and shall be protected from puncture, cutting, excessive heat, cold, moisture, mud, dirt, dust, or any other damaging or deleterious condition. The geotextile shall be stored in accordance with any additional requirements of the geotextile Manufacturer.

PART 3 EXECUTION

3.01 HANDLING AND PLACEMENT

- A. Geotextile shall be installed at the locations shown on the Construction Drawings.
- B. The Contractor shall handle the geotextile in such a manner as to ensure the geotextile is not damaged in any way.
- C. The Contractor shall take all necessary precautions to prevent damage to underlying layers during placement of the geotextile.
- D. After placing the geotextile, the geotextile shall not be left exposed for a period in excess of 30 days unless a longer exposure period is approved by the Owner, based on a demonstration from the Manufacturer (e.g., a certification from the geotextile Manufacturer) that the geotextile is stabilized against ultra-violet light (UV)

degradation for a period in excess of 30 days. This requirement does not apply to material used as sacrificial geotextile.

- E. If white colored geotextile is used, precautions shall be taken against "snow blindness" of personnel.
- F. Just prior to geotextile placement, the layer that will underlie the geotextile, if it is a geosynthetic, shall be clean and free of dust, dirt, stones, rocks, or other obstructions that could potentially damage the liner system. At the direction of the Owner, the Contractor shall clean the underlying layer with water.
- G. In the presence of excessive wind, the geotextile shall be weighted with sandbags or equivalent weight approved by the Owner.
- H. On side slopes, the geotextile shall be secured at the top of the slope and then rolled down the slope.
- I. If necessary, the Contractor shall position the geotextile by hand after it is unrolled to minimize wrinkles.
- J. Geotextile shall be clean when installed. During installation, care shall be taken not to entrap stones, and excessive dirt or moisture that could damage the underlying layers, clog drains or filters, or hamper subsequent seaming.
- K. Tools shall not be left in or on the geotextile.
- L. The Contractor shall examine the entire geotextile surface after installation to ensure that no potentially harmful foreign objects (including broken sewing needles) are present. The Contractor shall remove any such foreign objects and shall replace any damaged geotextile. Broken sewing needles may need to be located using a metal detector or other method approved by the Owner.
- M. Geotextile shall only be cut using a cutter approved by the geotextile Manufacturer and the Owner.

3.02 SEAMS AND OVERLAPS

- A. All geotextile overlaps shall be continuously sewn (i.e., spot sewing and thermal bonding are not allowed). Geotextiles shall be overlapped a minimum 3 inches prior to sewing. No horizontal seams shall be allowed on slopes steeper than 5:1 (horizontal:vertical) (i.e., seams shall be along, not across, the slopes), except as part of a patch, unless approved by the Owner.
- B. Polymeric thread shall be used for all sewing. The seam type shall be Federal Standard Type (No. 751.a) SSa. The seams shall be sewn using Stitch Type 401.

3.03 REPAIR

- A. Any holes or tears in the geotextile shall be repaired as follows:
1. On slopes steeper than 5:1 (horizontal:vertical), a patch made from the same geotextile shall be overlapped a minimum three inches and double seamed into place (with each seam approximately 0.5 inches apart and no closer than 1 inch from any edge). Should a tear exceed 10 percent of the width of the roll, that roll shall be removed from the work and replaced with new material, at no additional cost to the Owner.
 2. On slopes equal to or flatter than 5:1 (horizontal:vertical), a patch made from the same geotextile shall be overlapped a minimum of 3 inches and stitched into place.
- B. Care shall be taken to remove soil or other material which may have penetrated the torn geotextile.

3.04 PLACEMENT OF OVERLYING MATERIALS

- A. The Contractor shall place all overlying soil materials in such manner as to ensure that:
1. The geotextile and underlying geosynthetic materials are not damaged;
 2. Minimum slippage occurs between the geotextile and underlying layers; and,
 3. Excessive stresses are not produced in the geotextile.
- B. The CQA Engineer will monitoring the spreading of soil materials over the geotextile in accordance with the CQA Plan.
- C. Unless otherwise specified by the Owner, all equipment operating on soil material overlying the geotextile shall comply with the following (Note: a greater thickness shall be required as per Sections 02710, 02712, and 02775 if the geotextile is directly underlain by a geocomposite, geonet, or geomembrane):

<u>Maximum Allowable Equipment Ground Pressure (psi)</u>	<u>Thickness of Soil Above Geotextile (inches)</u>
<5	6
<10	12
<20	18
>20	24

The maximum allowable equipment ground pressure shall be 65 psi. The acceptability of equipment operating at ground pressures greater than 65 psi will be evaluated by the Owner at the Contractor's expense.

The equipment ground pressure requirements do not apply to separator geotextiles used below aggregate road base nor to equipment used to construct the secondary and primary clay liners; however, the Owner may restrict the use of equipment that, in the Owner's opinion, may potentially damage the underlying geotextiles.

3.05 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all prior work, materials and partially-completed and completed work of these General Specifications.
- B. The CQA Engineer will identify any areas requiring repair. The Contractor shall make repairs and replacements as necessary, to the approval of the Owner, and at no additional cost to Owner.
- C. The CQA Engineer will issue an approval of geotextile filter, cushion, separator, or sacrificial layer installation in accordance with the CQA Plan prior to placement of material over the geotextile.

TABLE 02714-1 REQUIRED GEOTEXTILE PROPERTIES			
Properties	Units	Specified Values ⁽⁴⁾	Test Method
Polymer composition	%	95 [polypropylene, polyester, or polyethylene by weight]	
Mass per unit area	oz/yd ²	8	ASTM D 3776
Apparent opening size	mm	0 ₉₅ 0.212mm	ASTM D 4751
Permittivity	sec ⁻¹	0.1	ASTM D 4491
Grab strength	lb	200	ASTM D 4632 ⁽¹⁾
Tear strength	lb	85	ASTM D 4533 ⁽²⁾
Puncture strength	lb	100	ASTM D 4833 ⁽³⁾
NOTES:			
<ol style="list-style-type: none"> 1. Minimum values for both machine and cross machine direction with 1 inch clamp on constant rate of extension (CRE) machine. 2. Minimum value measured in machine and cross machine direction. 3. Tension testing machine with a 1.75-inch diameter ring clamp, the steel ball being replaced with a 0.31-inch diameter solid steel cylinder with flat tip centered within the ring clamp. 4. Values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table). The specified apparent opening size is a maximum average roll value. 			

TABLE 02714-2 REQUIRED GEOTEXTILE PROPERTIES CUSHION GEOTEXTILES				
Properties	Qualifier	Units	Specified Values ⁽⁴⁾	Test Method
Polymer composition	minimum	%	95 [polypropylene, polyester, or polyethylene by weight]	
Mass per unit area	minimum	oz/yd ²	12	ASTM D 3776
Grab strength	minimum	lb	300	ASTM D 4632 ⁽¹⁾
Tear strength	minimum	lb	110	ASTM D 4533 ⁽²⁾
Puncture strength	minimum	lb	135	ASTM D 4833 ⁽³⁾
NOTES:				
<ol style="list-style-type: none"> 1. Minimum values for both machine and cross machine direction with 1 inch clamp on constant rate of extension (CRE) machine. 2. Minimum value measured in machine and cross machine direction. 3. Tension testing machine with a 1.75-inch diameter ring clamp, the steel ball being replaced with a 0.31-inch diameter solid steel cylinder with flat tip centered within the ring clamp. 4. All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table). 				

[END OF SECTION]

SECTION 02716 PROTECTIVE SOIL LAYER

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the construction of the protective soil layer component of the secure cell. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02223 - Granular Leachate Collection Layer
- B. Section 02225 - Sump and Pipe Bedding Gravel and Road Base Aggregate
- C. Section 02710 - Geocomposite Detection or Collection Layer
- D. Section 02712 - Geonet Detection or Collection Layer
- E. Section 02714 - Geotextile Filter, Cushion, or Sacrificial Layer
- F. Section 02775 - Geomembrane Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. Work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all testing activities outlined in the CQA Plan, and the Contractor shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. Soil testing (both field and laboratory testing) required by the CQA Plan will be the responsibility of the CQA Engineer. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. The Contractor shall cooperate with the CQA Engineer during all testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling. The Contractor shall provide access to all areas requiring testing. The Contractor shall repair any damage to finished work caused by the CQA Engineer sampling or testing activities.

- D. The CQA Engineer will coordinate independent surveying required by the CQA Plan. Surveying by the CQA Engineer does not relieve the Contractor of his responsibility to lay out, control, and document the work.
- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Protective soil layer material shall be obtained from secure cell or surface impoundment excavation or from on-site borrow sources identified by the Owner.
- B. Protective soil layer material shall classify as CL, ML, SC, GC, SM, or GM according to the Unified Soil Classification System (ASTM D 2487) and shall have a maximum particle size not exceeding 3 inches.

PART 3 EXECUTION

3.01 PROTECTIVE SOIL LAYER COMPACTION CRITERIA

- A. The Contractor shall place and compact the soil as described in of this Section.

3.02 PLACEMENT AND COMPACTION

- A. Protective soil layer material shall be placed above the leachate collection system (including the geotextile filter layer above the leachate collection system) at the locations and to the thicknesses shown on the Construction Drawings.
- B. The Contractor shall not place the protective soil layer until the CQA Engineer confirms that the constructed grades and elevations of the granular leachate collection system meet the requirements of the Construction Drawings, all field testing is complete, and the geotextile filter layer above the leachate collection system has been installed, tested, and approved in accordance with the requirements of the CQA Plan.
- C. Prior to placing the protective soil layer, the CQA Engineer will verify that the underlying geosynthetic components are free of holes, tears, excessive wrinkles, or foreign objects. As instructed by the Owner, the Contractor shall "work out" or repair all excessive wrinkles to the satisfaction of the CQA Engineer prior to placement of the protective soil layer. In all cases, wrinkles in the primary geomembrane liner on the secure cell side slopes shall not be of a size that they could fold back on themselves.
- D. The final in-place thickness of the protective soil layer shall be not less than 24 inches on floor areas and 18 inches on slope areas.

- E. The protective soil material shall be spread in one lift using a low ground-pressure dozer (Caterpillar D6H-LGP, or other equipment approved by the Owner), low-ground pressure tracked front-end loader, or belt conveyor. Equipment shall operate only over previously-placed protective soil layer material. The Contractor shall not operate equipment directly on geomembranes, geotextiles, geonets, or geocomposites.
- F. Unless otherwise specified by the Owner, the equipment used to haul and spread the protective soil layer shall not exert ground pressures exceeding the following:

<u>Allowable Equipment Ground Pressure (psi)</u>	<u>Minimum Thickness of Protective Soil Layer Above the Primary Geomembrane Liner (inches)</u>
<5	12
<10	18
<20	24
>20	36

The maximum allowable equipment ground pressure shall be 65 psi. The acceptability of equipment operating at ground pressures greater than 65 psi will be evaluated by the Owner at the Contractor's expense.

- G. Protective soil layer material shall be compacted by two passes of tracked equipment such as a Caterpillar D6H-LGP or other equipment approved by the Owner.
- H. In areas of heavy traffic, the thickness of the protective soil layer shall be increased at the direction of the Owner to satisfy the requirements of this Section. Heavy traffic areas shall be compacted with a smooth drum roller or other equipment approved by the Owner.
- I. The Contractor shall operate equipment in a manner that is protective of underlying geosynthetics. If it is suspected that any damage to the underlying geosynthetics may have occurred, the Owner will instruct the Contractor to remove overlying protective soil layer material to expose the geosynthetics. The Contractor shall repair, at his own expense, any damage of the underlying geosynthetics in accordance with these General Specifications.
- J. The Contractor shall minimize to the extent possible the generation of dust during placement of the protective soil layer. Water may be used for dust control if approved by the Owner. Chemical dust suppressants shall not be used.
- K. No protective soil layer material shall be placed or compacted during a sustained period of temperature below 32°F that results in frozen material, either in-place or in the borrow area. With the approval of the Owner, protective soil layer material may be placed and compacted during periods of early morning freezing temperatures if above-freezing temperatures are anticipated during the day.

- L. The Contractor shall not place frozen protective soil layer material nor shall he place protective soil layer material on frozen ground.
- M. Protective soil layer material shall not be placed during periods of precipitation or unfavorable weather conditions.

3.03 SURVEY CONTROL

- A. The Surveyor shall survey the final location and elevation of the top of the protective soil layer installed by the Contractor. Surveying shall be performed in accordance with Section 01010 of these General Specifications.
- B. The Surveyor shall provide a Record Drawing of the location and elevation of the top of the protective soil layer to the Owner in accordance with the requirements of Section 01010 of these General Specifications.

3.04 FIELD QUALITY CONTROL

- A. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.
- B. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at his own expense until acceptable test results are obtained.

3.05 PROTECTION OF WORK

- A. After the protective soil layer has been placed, the Contractor shall maintain it free of ruts, depressions, and damage resulting from the hauling and handling of any material, equipment, tools, etc.
- B. The Contractor shall use all means necessary to protect all materials and partially-completed and completed work of these General Specifications.
- C. In the event of damage, the CQA Engineer will identify any areas requiring repair, and the Contractor shall make repairs and replacements necessary, to the approval of the Owner and at no additional cost to the Owner.

[END OF SECTION]

SECTION 02718 POLYETHYLENE PIPE AND FITTINGS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary for the installation of all high density polyethylene (HDPE) pipes, pipe fittings, and appurtenances required for secure cell or surface impoundment construction. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02222 - Primary Clay Liner
- B. Section 02224 - Granular Leachate Collection Layer
- C. Section 02225 - Sump and Pipe Bedding Gravel and Road Base Aggregate
- D. Section 02710 - Geocomposite Detection or Collection Layer
- E. Section 02712 - Geonet Detection or Collection Layer
- F. Section 02714 - Geotextile Filter or Cushion Layer
- G. Section 02775 - Geomembrane Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. All work will be monitored and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all activities outlined in the CQA Plan, and the Contractor shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. The CQA Engineer will coordinate independent surveying as required by the CQA Plan. Surveying by the CQA Engineer does not relieve the Contractor of his responsibility to lay out, control, and document the work.
- D. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 HIGH DENSITY POLYETHYLENE (HDPE) RESIN PROPERTIES

- A. The HDPE pipe and fittings shall be manufactured from new, high molecular weight, high density polyethylene (HDPE) resin conforming to ASTM D 1248 (Type III, Class C Category 5, Grade P 34), ASTM D 3350 (Cell Classification PE 345434C), and having a Plastic Pipe Institute (PPI) Rating of PE 3408. The resin shall be pre-compounded. In plant blending of non-compounded resins shall not be permitted. Pipe and fittings shall be manufactured from the same resin and by the same manufacturer.
- B. The polyethylene compound shall contain a minimum of 2 percent carbon black to withstand outdoor exposure without loss of properties.
- C. The polyethylene compound shall have minimum resistance of 5,000 hours when tested for environmental stress crack in accordance with requirements of GRI-GM5.

2.02 HIGH DENSITY POLYETHYLENE PIPE AND FITTINGS PROPERTIES

- A. The Contractor shall provide pipe having the nominal diameters shown on the Construction Drawings.
- B. All HDPE pipe and fittings shall have a minimum Standard Diameter Ratio (SDR) of 11 unless otherwise indicated on the Construction Drawings.
- C. All HDPE pipe and fittings shall have a minimum hydrostatic design basis (HDB) of 1,600 pounds per square inch when determined in accordance with ASTM D 2837 unless otherwise indicated on the Construction Drawings.
- D. All HDPE pipe and fittings shall comply with ASTM F 714.
- E. HDPE pipe shall be supplied in standard laying lengths not exceeding 50 feet.
- F. HDPE pipe shall be furnished non-perforated or perforated to meet the requirements of the Construction Drawings. Perforations, if required, shall be drilled into the pipe after manufacture.
- G. HDPE pipes and fittings shall be homogeneous throughout and free of visible cracks, holes (other than intentional manufactured perforations), foreign inclusions, or other deleterious effects, and shall be uniform in color, density, melt index, and other physical properties.
- H. Fittings at the ends of pipes shall be HDPE end caps unless otherwise indicated on the Construction Drawings.

- I. Geomembrane boots shall be either field or shop-fabricated to the dimensions shown on the Construction Drawings. Pipe boots shall be fabricated from the same resin as the polyethylene geomembrane to which they are welded. Pipe boots shall be installed as indicated on the Construction Drawings.

2.03 MANUFACTURING QUALITY CONTROL

- A. The Contractor shall submit to the Owner for approval within 14 days prior to the start of pipe work a complete list of materials to be furnished and the name of the pipe Manufacturer.
- B. The Contractor shall submit to the Owner the pipe Manufacturer's certification of compliance with the product requirements of Part 2 of this section, including certification that stress regression testing has been performed in accordance with ASTM D 2837 on the pipe products representative of that delivered to the site. The Manufacturer's Certification must be based on a QC testing frequency of one sample per lot.
- C. The Contractor shall submit to the Owner in writing the following documentation from the pipe Manufacturer on the raw materials used to manufacture the pipe and fittings:
 1. Certificate identifying the specific resin used, its source, and the information required by ASTM D 1248.
 2. Certificate stating that no recycled resin was used in manufacturing the pipe except for a small percentage (15 percent or less) of resin generated in the pipe Manufacturer's own plant from production using the same resin as the recycled material.
- D. If requested by the Owner, the Contractor shall require the pipe manufacturer to retain one section of pipe (at least 5 feet in length) provided for the project for every 1,500 lineal feet of pipe produced for the project until the work is accepted by the Owner.
- E. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor.

2.04 LABELING

- A. The following shall be continuously indent-printed on the polyethylene pipe, or spaced at intervals not exceeding 10 feet:
 1. Name and/or trademark of the pipe Manufacturer.
 2. Nominal pipe size.
 3. Standard dimension ratio (SDR).
 4. The letters PE followed by the polyethylene grade per ASTM D 1248, followed by the hydrostatic design stress in 100's of psi (i.e., PE 3408).
 5. Manufacturing Standard Reference (e.g., ASTM F 714-1).

6. A production code from which the date and place of manufacture can be determined.

2.05 TRANSPORTATION

- A. Transportation of polyethylene pipe and fittings shall be the responsibility of the Contractor. The Contractor shall be liable for all damage to the polyethylene pipe and fittings incurred prior to and during transportation to the site.

2.06 HANDLING AND STORAGE

- A. Handling, storage, and care of the polyethylene pipe and fittings, prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for all damage to the material incurred prior to final acceptance by the Owner.
- B. The Contractor shall be responsible for storage of polyethylene pipe and fittings at the site. Pipe and fittings shall be stored on clean level ground, preferably turf or sand, free of sharp objects which could damage the pipe. Stacking shall be limited to a height that will not cause excessive deformation of the bottom layers of pipe under anticipated temperature conditions. Where necessary due to ground conditions, the pipe shall be stored on wooden sleepers that are spaced suitably and of such width as not to allow deformation of the pipe. The pipe shall be stored to minimize bowing.

2.07 PIPE BEDDING MATERIAL

- A. Pipe bedding material shall meet the requirements of Section 02224 of this General Specification as well as any other requirements of the Construction Drawings.

2.08 HDPE FLAT STOCK

- A. HDPE flat stock installed below polyethylene pipe shall consist of layers of high density polyethylene (HDPE) furnished at the dimensions shown on the Construction Drawings.

2.09 PORTLAND CEMENT CONCRETE

- A. Portland cement concrete used in the pads around the riser pipes shall be Class B, as specified in Section 601.02 of the Colorado Highway Specifications.

PART 3 EXECUTION

3.01 HANDLING AND PLACEMENT

- A. Pipe, fittings, and HDPE flat stock shall be installed as indicated on the Construction Drawings. These locations include sumps, collection laterals, mains, and/or riser pipe for the permanent sump, leachate collection system and leak detection system.

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- B. The Contractor shall exercise care when transporting, handling and placing pipe and fittings, such that they will not be cut, kinked, twisted, or otherwise damaged.
 - C. The Contractor shall comply with the pipe Manufacturer's recommendations for handling, storage, and installation of all polyethylene pipe fittings.
 - D. Ropes, fabric, or rubber-protected slings and straps shall be used when handling pipe. Slings, straps, etc. shall not be positioned at butt-fused joints. Chains, cables or hooks shall not be inserted into the pipe ends as a means of handling pipe.
 - E. Pipe or fittings shall not be dropped onto rocky or unprepared ground. The pipe and fittings shall not be dropped into trenches or dragged over sharp objects.
 - F. The maximum allowable depth of cuts, gouges, or scratches on the exterior surface of pipe or fittings is 10 percent of the wall thickness. The interior of the pipe and fittings shall be free of cuts, gouges and scratches. The CQA Engineer will inspect the pipes in accordance with the CQA Plan. Sections of pipe with excessive cuts, gouges, or scratches will be rejected and the Contractor will be required to remove and replace the rejected pipe, at no additional cost to the Owner.
 - G. Whenever pipe laying is not actively in progress, the open end of pipe that has been placed shall be closed using a watertight plug.
 - H. Where pipes penetrate through geomembranes, an effective seal shall be established in accordance with these General Specifications as well as the details shown on the Construction Drawings.

3.02 INSTALLATION

- A. All pipe and fittings shall be installed in accordance with these General Specifications and the pipe Manufacturer's instructions.
- B. The Contractor shall carefully examine all pipe and fittings for cracks, damage or defect before installation. Defective materials shall be removed from the site and replaced with non-defective material at no additional cost to the Owner.
- C. The interior of all pipe and fittings shall be inspected, and any foreign material shall be completely removed from the pipe interior before it is moved into final position.
- D. Field cutting of pipe shall be carefully made, without damage to pipe or lining system components, so as to leave a smooth end at right angles to the axis of pipe. The method and device used to cut the pipes shall be approved of by the Owner. Sharp edges of cut ends shall be filed off smooth. Flame cutting will not be allowed.
- E. All pipe and fittings shall be laid or placed to the grades and elevations shown on the Construction Drawings with bedding and backfill as shown on the Construction Drawings.

- F. Placement of overlying pipe bedding gravel shall be carried out in accordance with Section 02224 of these General Specifications.
- G. No pipe shall be laid until the CQA Engineer has observed the condition of the pipe.
- H. Blocking under piping shall not be permitting unless specifically accepted by the Owner.
- I. The Contractor shall provide all necessary adapters and/or connection pieces required when connecting different types and sizes of pipe or when connecting pipe made by different manufacturers.
- J. Concrete installed in the pads around the riser pipes shall be installed in accordance with the applicable requirements of Sections 601.05 through 601.14 of the Colorado Highway Specifications, and as shown on the construction Drawings. The Contractor shall be responsible for testing of the concrete, and shall provide the results to the Owner as soon as possible. As a minimum one slump test shall be performed, in accordance with ASTM C 143, for the concrete crest pad. One air entrainment test for the concrete crest pad shall be performed, in accordance with either ASTM C 173 or C 231. Three concrete cylinders shall be obtained, in accordance with ASTM C 31, from the concrete crest pad. The cylinders shall be tested after 28 days in accordance with ASTM C 39 and shall meet the requirements of these General Specifications or the Construction Drawings. Exposed surfaces of concrete shall be broom-finished.

3.03 JOINTS AND CONNECTIONS

- A. HDPE pipe shall be joined with thermal butt-fusion joints. All joints shall be made in accordance with ASTM D 2657 and the pipe Manufacturer's recommendations, and shall be made by trained personnel authorized by the pipe Manufacturer.
- B. Mechanical connections of HDPE pipe to auxiliary equipment such as valves, flow meters, pumps and tanks shall consists of the following unless indicated otherwise on the Construction Drawings:
 - 1. An HDPE flange connection, called a stub end, shall be butt-fused to the HDPE pipe. Outside diameter and drilling shall comply with the requirements indicated on the Construction Drawings.
 - 2. A Type 316 stainless steel back-up flange. Outside diameter and drillings shall comply with the requirements indicated on the Construction Drawings.
 - 3. Other mechanical couplings, such as 360 degree full circle clamps, shall only be used if approved by the Owner.
 - 4. The stub ends shall be connected with corrosion-resistant bolts and nuts of Type 316 stainless steel, as specified in ASTM A 726 and ASTM A 307.

- C. Polyethylene stub ends and flanges shall be at the ambient temperature of the surrounding soil at the time they are bolted tight to prevent relaxation of the flange bolts and loosening of the joint due to thermal contraction or expansion of the polyethylene pipe. Bolts shall be drawn up evenly and in line.
- D. Pipe adjacent to joints and joints themselves shall be rigidly supported for a distance of at least one pipe diameter beyond the backup flanges.
- E. Pipe boot connections shall be made in the field using viton rings and stainless steel clamps, as shown on the Construction Drawings. The viton ring material shall have a thickness of 3/16 inch and shall have an inner diameter equal to the outer diameter of the pipe on which the viton ring is to be placed. The stainless steel clamps shall be made of 3/16 inch thick, 2 inch wide, Type 316 stainless steel. The clamps shall be joined around the pipe boot using a Type 316 stainless steel clasp, not thicker than 3/8 inch. These materials shall be chosen by the Contractor and approved by the Owner.

3.04 SURVEY CONTROL

- A. The Surveyor shall survey the location and final elevation of the invert of all polyethylene leachate collection pipes (excluding laterals). The pipe shall be surveyed at its ends and at approximate 50-foot intervals between the ends. In addition, all joints, etc. shall be located horizontally and vertically and overall length measured. Surveying shall be performed in accordance with Section 01010 of these General Specifications.
- B. The Surveyor shall provide a Record Drawing of the location and final elevation of all leachate collection pipes.

3.05 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and all partially-complete and completed work of these General Specifications.
- B. In the event of damage, the Contractor shall make all repairs and replacements necessary, to the approval of the Owner and at no additional cost to the Owner.
- C. The CQA Engineer will issue an approval of pipe installation and inspection to the Owner prior to completely covering the pipe in accordance with the CQA Plan.

[END OF SECTION]

SECTION 02775 GEOMEMBRANE LINERS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment supervision, transportation, and installation services necessary for the installation of the primary and secondary geomembrane liners of the secure cell or surface impoundment. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02221 - Secondary Clay Liner
- B. Section 02222 - Primary Clay Liner
- C. Section 02224 - Granular Leachate Collection Layer
- D. Section 02225 - Sump and Pipe Bedding Gravel and Road Base Aggregate
- E. Section 02710 - Geocomposite Detection or Collection Layer
- F. Section 02712 - Geonet Detection or Collection Layer
- G. Section 02714 - Geotextile Filter, or Cushion, Layer
- H. Section 02716 - Protective Soil Layer
- I. Section 02718 - Polyethylene Pipe and Fittings
- J. Section 02780 - Geosynthetic Clay Liners

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan. The Contractor shall require the geomembrane manufacturer to comply with the submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. All work will be constructed, monitored, and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all activities outlined in the CQA Plan, and the Contractor shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. The Contractor shall deliver geomembrane to the site at least 14 calendar days prior to installation to allow sufficient time for testing required by the CQA Plan.

- D. Geomembrane rolls that do not meet the requirements of this General Specification will be rejected. The Contractor shall replace rejected material with new material that conforms to the specification requirements, at no additional cost to the Owner.
- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 RESIN

- A. Reclaimed polymer shall not be added to the resin; however, the use of polymer recycled during the manufacturing process will be permitted if the recycled polymer does not exceed 2 percent by weight of the total polymer weight. The product shall be manufactured specifically for use in geomembranes, using new, first-quality polyethylene resin.
- B. The resin shall comply with the following properties for high density polyethylene (HDPE):
 - 1. Specific Gravity:0.94 to 0.96 (ASTM D 792 Method A or ASTM D 1505)
 - 2. Melt Index:0.1 - 0.3 g/10 min. (ASTM D 1238 Condition E 190/C, 2.16 kg)
 - 3. Water absorption:0.1% max (ASTM D 570)

2.02 GEOMEMBRANE PROPERTIES

- A. The geomembrane Manufacturer shall be either Gundle Lining Systems, Inc., Houston, Texas, SLT North America, Inc., Conroe, Texas, or other Manufacturer making geomembrane meeting the requirements of this section. The Owner (based on concurrence with regulatory authorities) may approve an alternate material if sufficient evidence is submitted to verify that the alternate material has been tested (EPA Method 9090) by exposure to leachates with characteristics similar to those expected to be produced by the Owner and the tests verify that the alternate material's performance is satisfactory. The Owner will furnish test leachate, if available, upon request.
- B. Smooth or textured HDPE geomembrane shall be used based on the requirements of the Construction Drawings.
- C. The Contractor shall require that the geomembranes Manufacture furnish geomembrane with minimum average roll values, as defined by the Federal Highway Administration (FHWA), meeting or exceeding the criteria specified in Table 02775-1 and that meet the manufacturing quality control requirements of this section. The Contractor shall require the geomembrane Manufacturer to certify in writing as well as

provide test results that demonstrate that the geomembrane delivered to the site complies with the properties listed in Table 02775-1.

- D. In addition to the property values listed in Table 02775-1, the geomembrane material shall:
1. Contain a maximum of 1 percent by weight of additives, fillers, or extenders (not including carbon black).
 2. Not have striations, roughness (except in the case of textured HDPE geomembranes where a roughened surface is characteristic), pinholes, or bubbles on the surface.
 3. Be produced so as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter.
 4. Be manufactured in a single layer or coextruded.

2.03 MANUFACTURING QUALITY CONTROL

A. Resin:

1. The Contractor shall require the geomembrane Manufacturer to certify in writing that the resin used to manufacture the geomembrane delivered to the project site complies with the product specifications of this section. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. Any geomembrane manufactured from non-complying resin will be rejected.
2. The Contractor shall require the Manufacturer to supply quality control certificates from the resin Supplier that includes the origin (resin production plant), identification (brand name, number) the production date of the resin used in the manufacturer of the geomembrane shipped to the site, and the results of test conducted to verify that the resin used to manufacturer the geomembrane rolls assigned to the project meets the specifications of Part 2.01 of this section.

B. Rolls:

1. The Contractor shall require that the geomembrane Manufacturer continuously monitor the geomembrane during the manufacturing process for inclusions, bubbles, or other defects. Geomembrane that exhibits defects will not be accepted.

2. The Contractor shall require that the geomembrane Manufacturer monitor the geomembrane thickness during the manufacturing process. Geomembrane that fails to meet the specified minimum thickness will not be accepted.
3. The Contractor shall require that the geomembrane Manufacturer sample and test the geomembrane, at a minimum, once every 40,000 ft² and perform the following tests to demonstrate that the geomembrane properties conform to the values specified in this section. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. Samples shall be taken across the entire width of the roll and shall not include the first wrapping or outer layer of the roll (about 3.3 feet).

Test Procedure

Specific gravity	ASTM D 1505
Thickness (Smooth)	ASTM D 1593
Thickness (Textured)	ASTM D 751
Yield strength	ASTM D 638
Yield elongation	ASTM D 638
Tensile strength	ASTM D 638
Tensile elongation	ASTM D 638
Carbon black content	ASTM D 1603
Carbon black dispersion	ASTM D 3015 and ASTM D 2663

4. Geomembrane rolls that do not have acceptable manufacturing quality control test results shall be rejected by the Owner.
5. In the case of the rejection of a roll of geomembrane, the Contractor shall require that the geomembrane Manufacturer sample and test each roll manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established in accordance with the CQA Plan.
6. Additional testing may be performed at the geomembrane Manufacturer's discretion and expense, to more closely identify the non-complying rolls and/or to qualify individual rolls.
7. If requested by Owner, one coupon of geomembrane (at least 10 feet by 2 feet) for every 40,000 ft² of membrane produced shall be retained intact by the geomembrane Manufacturer until construction of landfill or surface impoundment components, for which the geomembrane is used, is complete and the Owner has accepted the completed work.

C. Manufacturing Plant Visit:

1. The Manufacturer shall permit the Owner or Owner's representative(s) to visit the manufacturing plant. Visits may be during the manufacturing of the geomembrane rolls for the specific project.
2. During the visit, the Owner or Owner's representative(s) may:
 - a. Review the manufacturing process, quality control procedures, laboratory facilities, and testing procedures;
 - b. Verify that properties guaranteed by the Manufacturer comply with the specifications;
 - c. Verify that the measurements of properties by the Manufacturer are properly documented and the test methods used are acceptable;
 - d. Inspect select geomembrane rolls for evidence of holes, blisters, or any sign of contamination by foreign matter;
 - e. Review packaging and transportation procedures;
 - f. Verify that roll packages are labeled in compliance with this Section; and
 - g. Take conformance samples from geomembrane rolls that are assigned to the project.

2.04 LABELING

- A. The geomembrane shall be labeled with the following information:
 1. Thickness of the material;
 2. Length and width of the roll or factory panel;
 3. Name of Manufacturer;
 4. Product identification;
 5. Lot number; and,
 6. Roll or factory panel number.

2.05 TRANSPORTATION

- A. Transportation of the geomembrane is the responsibility of the Contractor. The Contractor shall be liable for all damage to materials prior to and during transportation to the site. The Contractor shall replace any damaged rolls at no additional cost to the Owner.

2.06 HANDLING AND STORAGE

- A. Handling, storage, and care of the geomembrane prior to and following incorporation in the work is the responsibility of the Contractor. The Contractor shall be liable for all damage to the material incurred prior to final acceptance of the installation by the Owner. The Contractor shall repair any damage in accordance with this Section and at no additional cost to the Owner.
- B. The Contractor shall be responsible for storage of the geomembrane at the site. The geomembrane shall be protected from dirt, excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. The geomembrane shall also be stored in accordance with any additional requirements of the geomembrane Manufacturer.

PART 3 EXECUTION

3.01 EARTHWORK

- A. Surface Preparation
 - 1. Geomembrane liner shall be installed at all locations shown on the Construction Drawings.
 - 2. For secure cells (or significant portions thereof), the primary and secondary geomembrane liners and the cover geomembrane shall be installed as soon as practical after construction and CQA testing of the secondary clay liners and the clay cover. In areas where geosynthetic clay liner is used to cover the primary clay, primary geomembrane liner shall be installed as required by Section 2780. For surface impoundments (or significant portions thereof), the primary and secondary geomembrane liners shall be installed as soon as practical after the completion and CQA testing of the secondary clay liner and leak detection layer. Prior to geomembrane liner installation, the Contractor shall verify, by surveying, that the elevations, thicknesses, and grades of the clay liners conform to the requirements of the Construction Drawings. Installation of the geomembranes shall not begin until the CQA Engineer completes conformance testing and surveying of the appropriate portions of the clay liners in accordance with the CQA Plan.
 - 3. Areas to receive geomembrane liner shall be smooth and even, and free of ruts, voids, and protrusions or wrinkles in the clay or in the geosynthetic clay liner. Any surface features, as determined by the CQA Engineer or Owner, which could damage the geomembrane shall be removed by the Contractor. For slopes of 3:1 (horizontal:vertical) or flatter, the final surface of the clay liner prior to receiving geomembrane shall be rolled smooth using a smooth drum roller. For slopes steeper than 3H:1V, dressing of the slopes shall be accomplished by back-dragging the surface with a dozer blade or by other methods approved by the Owner (such as raking the surface by hand) until the Owner is satisfied that the surface is smooth and even, and free of ruts, voids, obstructions, etc.. No vehicles shall be allowed on the final dressed surface without the approval of the Owner.

4. The Contractor shall provide written certification that the surface on which the geomembrane will be installed is acceptable. The certificate of acceptance for each area under consideration shall be given to the Owner as part of geomembrane installation in that area.
5. Special care shall be taken to maintain the prepared surface of the clay liner.
6. No geomembrane shall be placed in an area which has been softened by precipitation or which has excessively cracked due to desiccation.

7. Any damage to the surface of the clay liner or geosynthetic clay liner caused by weather, installation activities, or other activities shall be repaired by the Contractor at no expense to the Owner.

B. Anchor Trenches:

1. The anchor trench shall be excavated prior to geomembrane placement to the elevations, grades, and width shown on the Construction Drawings.
2. No loose soil shall be allowed beneath the geomembrane in the anchor trench.
3. The anchor trench shall be backfilled as shown on the construction drawings after the secondary geomembrane and geocomposite drainage layers and the primary geomembrane and geocomposite drainage layer, have been installed. If necessary, a small amount of backfill (about 6 inches) may be placed in the trench immediately after geomembrane installation. Care shall be taken when backfilling the anchor trench to prevent any damage to the geomembrane or other geosynthetics.
4. Clay fill shall be placed in the anchor trench to the limits shown on the Construction Drawings. The clay fill shall be compacted using suitable hand-operated compaction equipment. Clay shall be compacted to the requirements in the Construction Drawings. In the absence of additional requirements, the moisture content of the clay fill in the anchor trenches shall be not less than the optimum moisture content, nor more than four percent wet of the optimum moisture content. The optimum moisture content will be obtained from the standard Proctor compaction test (ASTM D 698). The minimum allowable dry unit weight of clay fill in the anchor trench shall be 90 percent of the maximum dry unit weight obtained from the standard Proctor compaction test (ASTM D698).
5. Slightly rounded corners shall be provided at the top in-board side of the anchor trench to avoid sharp bends in the geomembrane.

3.02 GEOMEMBRANE DEPLOYMENT

A. Layout Drawings:

1. The Contractor shall provide at least 2 sets of geomembrane panel layout drawings to the Owner at least 14 days prior to geomembrane deployment. Drawings shall indicate the geomembrane panel configuration, dimensions, details, seam locations, etc. Field seams shall be differentiated from factory seams (if any). The layout drawings must be approved by the Owner prior to the installation of any geomembranes. These drawings shall not be modified without the prior approval of the Owner.

2. Field Panel Identification:

- a. A geomembrane field panel is defined as a roll or a portion of a roll cut in the field.
- b. Each field panel must be given an identification code (number or letter-number) consistent with the layout plan. This identification code shall be agreed upon by the Owner, and Contractor. The field panel identification code shall be related, through a table or chart, to the original resin, and the constituent rolls and factory panels.

C. Field Panel Placement:

1. Field panels shall be installed at the location and positions indicated in the layout drawings.
2. Field panels shall be placed one at a time, and each field panel shall be seamed shortly after its placement.
3. Geomembrane shall not be placed when the ambient temperature is below 40°F unless the Contractor has previously submitted a geomembrane cold-weather placement and seaming plan and such plan has been approved by the Owner.
4. Geomembranes shall not be placed during a precipitation event, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.
5. The Contractor shall employ placement methods which ensure that:
 - a. No vehicular traffic shall be allowed on the geomembrane.
 - b. Equipment used shall not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means.
 - c. Personnel working on the geomembrane shall not smoke, consume food or beverages (except for body fluid replenishment), wear damaging shoes, have cans, glass containers, or tools not required for liner placement on the geomembrane, or engage in other activities which could damage the geomembrane.
 - d. The method used to unroll the panels shall not scratch or crimp the geomembrane and shall not damage the supporting soil.
 - e. The method used to place the panels shall minimize wrinkles (especially differential wrinkles between adjacent panels).

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- f. Temporary loads and/or anchors (e.g., sand bags), not likely to damage the geomembrane, shall be placed on the geomembrane to prevent uplift by wind.
 6. On slopes, geomembranes shall be installed from the top of the slope to the bottom. The geomembrane shall be temporarily anchored at the top of the slope prior to deployment. Unrestrained release of the geomembrane from the top of the slope is not acceptable.
 7. Any field panel or portion thereof which becomes seriously damaged (torn, twisted, or crimped) shall be replaced with new material at no expense to the Owner. Less serious damage may be repaired with the approval of the Owner. Damaged panels or portions of damaged panels which have been rejected shall be removed from the work area at no expense to the Owner.
 8. Adjacent geomembrane panels shall be overlapped as described in this Section. Larger overlaps shall be used if thermal contraction of the geomembrane is anticipated prior to seaming. Adjacent panels shall be placed under similar temperature conditions, preferably early in the day when temperatures are cooler, to minimize the potential for differential contraction.
 9. If a textured geomembrane is placed over the GCL, a slip sheet (such as 20-mil smooth HDPE) shall first be placed over the GCL in order to allow the geomembrane to slide into its proper position. Once the overlying geomembrane is properly positioned, the slip-sheet shall be carefully removed paying close attention to avoiding any movement to the geomembrane.

3.03 FIELD SEAMING

A. Seam Layout:

1. In general, seams shall be oriented parallel to the line of maximum slope, i.e., oriented down, not across, the slope. In corners and at odd-shaped geometric locations, the number of field seams shall be minimized. No horizontal seam shall be permitted less than 10 feet from the toe of the slope, except where approved by the Owner. No panels shall be seamed in the field without the Owner's approval.

B. Personnel:

1. All personnel performing seaming operations shall be qualified as required by the CQA Plan. At least one seamer shall have a minimum of 1,000,000 ft² of HDPE geomembrane experience. Seamers who don't have a minimum of 1 million ft² HDPE geomembrane experience will be considered unexperienced. Qualifications of the seamers shall be provided to the CQA Engineer prior to the start of construction. All personnel performing field seaming shall be qualified by experience or by passing seaming tests. The seaming tests shall require all inexperienced seamers to make 5 trial seams on-site prior to any

actual field seams. The trial seams shall be tested according to this section and shall be performed under the supervision of an experienced seamer. The CQA Engineer, or a designated representative, will observe and record the results of the tests. No seaming shall be performed unless a "master seamer" is present.

C. Weather Conditions for Seaming:

1. Seaming shall not be attempted at ambient temperatures below 40°F. At ambient temperatures between 40°F and 50°F, seaming will be allowed if the geomembrane is preheated either by the sun or a hot air device, and if there is no excessive cooling from wind. At ambient temperatures above 50°F, no preheating will be required. In all cases, the geomembrane shall be dry and protected from excessive wind.
2. If the Contractor wishes to perform seaming at ambient temperatures below 40°F, he shall demonstrate that the seam so produced is equivalent to those produced under normally-approved conditions, and that the overall quality of the geomembrane is not adversely affected. The Contractor shall submit to the Owner for approval a geomembrane cold-weather placement and seaming plan that details all aspects of the cold-weather seaming operation.
3. To minimize geomembrane contraction stresses, seaming should ideally be carried out in the morning and late evening when the geomembrane is relatively contracted, and during the middle of the day if overcast conditions prevail. If the geomembrane is to be seamed in the middle of a sunny day, the Contractor shall ensure that there is sufficient slack in the geomembrane to prevent excessive stresses or trampolining when the geomembrane contracts as cooler temperatures prevail. The required amount of slack shall be determined by the Contractor and it should not be so much so as to cause excessive wrinkling of the geomembrane. If excessive trampolining or wrinkling of the geomembrane is observed, the Contractor will be required to make repairs to eliminate the problem at no additional cost to the Owner.
4. Ambient temperatures shall be measured near the crest of the secure cell or surface impoundment.

D. Overlapping and Temporary Bonding:

1. Geomembrane panels shall be overlapped a minimum of 3 inches for extrusion welding and 4 inches for fusion welding or a greater amount if recommended by the geomembrane Manufacturer, but in any event, sufficient overlap shall be provided to allow peel tests to be performed on the seam.

3. The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane. The temperature of the air at the nozzle of a spot welding apparatus shall be controlled such that the geomembrane is not damaged.
3. No solvent or adhesive shall be used for cleaning or bonding of the geomembrane liner material.

E. Seam Preparation:

1. Prior to seaming, the seam area shall be cleaned so that it is free of moisture, dust, dirt, debris of any kind, and foreign material.
2. If seam overlap grinding is required, the process shall be completed according to the geomembrane Manufacturer's instructions and in a manner that does not damage the geomembrane.
3. Seams shall be aligned with the fewest possible number of wrinkles and "fishmouths".

F. General Seaming Requirements:

1. All geomembrane overlaps shall be continuously seamed using approved procedures.
2. Seaming shall extend to the outside edge of panels to be placed in the anchor trench.
3. If required, a firm substrate shall be provided by using a flat board, a conveyor belt, or similar hard surface, directly under the seam overlap to achieve proper support.
4. If seaming operations are carried out at night, adequate illumination shall be provided.
5. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane that extends a minimum of 6 inches beyond the cut in all directions.
6. At the end of each day or installation segment, all exposed geomembrane edges shall be anchored by sandbags or other approved means. Sandbags securing the geomembrane on side slopes should be connected by a rope fastened at the top of the slope by a temporary anchor. If high winds are expected, boards with weighted sand bags on top may be used to keep wind from getting under the exposed edge of the geomembrane.

G. Seaming Process:

1. Approved processes for field seaming are extrusion welding and fusion welding using equipment that the Owner has approved by make and model. Alternate processes shall not be used unless a plan for their use has been submitted by the Contractor and approved by the Owner. Seaming equipment shall not damage the geomembrane.
2. Extrusion Equipment and Procedures:
 - a. The Contractor shall maintain at least one spare operable seaming apparatus on site.
 - b. The extrusion welding apparatus shall be equipped with gauges indicating the temperature in the apparatus and at the nozzle.
 - c. Prior to beginning a seam, the extruder shall be purged until all heat-degraded extrudate has been removed from the barrel. Whenever the extruder is stopped, the barrel shall be purged of all heat-degraded extrudate.
 - d. The Contractor shall provide documentation regarding the extrudate to the Owner and shall certify that the extrudate is compatible with the specifications, and consists of the same resin as the geomembrane.
 - e. The electric generator for the extrusion welders shall be placed either outside the area to be lined or on a smooth base or other such manner that no damage occurs to the geomembrane.
3. Fusion Equipment and Procedures:
 - a. The Contractor shall maintain at least one spare operable seaming apparatus on site.
 - b. The fusion-welding apparatus shall be an automated vehicular-mounted device equipped with gauges indicating the applicable temperatures and pressures
 - c. The edges of cross seams shall be abraded to a smooth incline (top and bottom) prior to welding.
 - d. A movable protective layer shall be used directly below each geomembrane overlap to be seamed if deemed necessary by the Owner.

- e. The electric generator for the fusion welders shall be placed either outside the area to be lined or on a smooth base or other such manner that no damage occurs to the geomembrane.
- f. All fusion-welded seam intersections shall be patched in accordance with this Section.

H. Trial Seams:

1. Trial seams shall be made on fragment pieces of geomembrane to verify that seaming conditions are adequate. Such trial seams shall be made at the beginning of each seaming period (morning and afternoon). Each seamer shall make at least one trial seam each day. Trials seams shall also be made in the event that the ambient temperature varies more than 20° F since the last passing trial seam. Trial seams shall be made under the same conditions as actual seams. The trial seam sample shall be at least 5 feet long by 1 foot wide (after seaming) with the seam centered lengthwise for fusion trial seams and at least 3 feet long by 1 foot wide for extrusion trial seams. Seam overlap shall be as indicated in Part 3.03.D. of this Section.
2. Five specimens, each 1 inch wide, shall be cut from the trial seam sample by the Contractor. Two specimens shall be tested for shear strength and three specimens shall be tested for peel strength using a field tensiometer. Both tracks of double fusion welds will be tested for peel strength on each of the three specimens unless otherwise approved by the Owner. The test specimens shall not fail in the seam and shall meet or exceed the strength requirements in Table 02775-2. If a specimen fails, the entire operation shall be repeated. If the second trial seam fails, the seaming apparatus or seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. Trial seam failure is defined as failure of any one of the five specimens.
3. The CQA Engineer will observe trial seam testing procedures. Successful trial seam samples will be assigned a number and marked accordingly by the CQA Engineer, who will also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description. The sample itself will be retained only until the construction of the liner is complete, and the liner has been accepted by the Owner.

I. Nondestructive Seam Continuity Testing:

1. Except as noted below the Contractor shall nondestructively test for continuity all field seams over their full length, using the vacuum test (primarily for extrusion seams), or air pressure test (for double fusion seams only) methods. All other test methods must be approved by the Owner. These tests shall be carried out as the seaming work progresses, not at the completion of all field seaming. The Contractor shall complete any required repairs in accordance with this Section at no additional cost to the Owner.
2. If the seam cannot be nondestructively tested after final installation, the following procedures shall apply:
 - a. Prior to seaming, the seamer shall make a new trial seam.

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- b. The seam shall be capped with the same type of geomembrane if the seams of the cap can be nondestructively tested.
 - c. If the seam is accessible to nondestructive testing prior to final installation but not after final installation, the seam shall be nondestructively tested prior to final installation.
 - d. At the discretion of the Owner, vacuum testing of fusion welded seams may be allowed in lieu of capping fusion welded seams which cannot be air pressure tested.
 - e. If none of the above techniques are practical the CQA Engineer will closely observe and document the seaming process.
3. Vacuum Testing
- a. The equipment for vacuum box testing shall comprise the following:
 - i. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.
 - ii. A steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections.
 - iii. A rubber pressure/vacuum hose with fittings and connections.
 - iv. A bucket and applicator.
 - v. A soapy solution.
 - b. The following procedures shall be followed:
 - i. Energize the vacuum pump and reduce the tank pressure to approximately 5 psi gauge.
 - ii. Wet a strip of geomembrane seam approximately 4 inches by one and one half times the length (minimum) of the vacuum box with the soapy solution.
 - iii. Place the box over the wetted area.
 - iv. Close the bleed valve and open the vacuum valve.
 - v. Ensure that a leak tight seal is created as evidenced by a negative box pressure of a minimum 5 psi gauge.

- vi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than 10 seconds.
 - vii. If no bubbles appear after 10 seconds, close the vacuum valve and open the bleed valve, move the box to the next adjoining area with a minimum 3 inches overlap, and repeat the process.
 - viii. All areas where soap bubbles appear shall be marked with a marker that will not damage the geomembrane and repaired in accordance with Part 3.03.K. of this Section with no additional cost to the Owner.
4. Air Pressure Testing (For Double-Fusion Seams Only):
- a. The following procedures are applicable to those processes which produce a double seam with an enclosed space.
 - b. The equipment shall comprise the following:
 - i. An air pump (manual or motor driven), equipped with a pressure gauge, capable of generating and sustaining a pressure between 25 and 30 psi, and mounted on a cushion to protect the geomembrane.
 - ii. A rubber hose with fittings and connections.
 - iii. A sharp hollow needle, or other approved pressure feed device.
 - c. The following procedures shall be followed:
 - i. Seal both ends of the seam to be tested.
 - ii. Insert needle, or other approved pressure feed device, into the tunnel created by the fusion weld.
 - iii. Insert a protective cushion between the air pump and the geomembrane.
 - iv. Energize the air pump to a gauge pressure between 25 and 30 psi, close valve, and sustain the pressure for not less than 5 minutes.
 - v. If the loss of pressure exceeds 2 psi, or does not stabilize, locate faulty area and repair in accordance with Part 3.03.K. of this Section.

- vi. At the end of the test, cut the air channel at the end of the seam opposite the needle and verify air flow to ensure that the entire seam length was tested.
- vii. Remove the needle, or other approved pressure feed device, and repair all test penetrations in accordance with Part 3.03.K. of this Section.

J. Destructive Testing:

1. Destructive seam tests shall be performed on samples collected from selected locations to evaluate seam strength and integrity. Destructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.
2. Sampling:
 - a. Destructive test samples shall be collected at a minimum average frequency of one test location per 500 feet of seam length. Test locations shall be determined during seaming, and may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming. The CQA Engineer will be responsible for choosing the locations of destructive seam samples. The Contractor shall not be informed in advance of the locations where the seam samples will be taken. The CQA Engineer may increase the sampling frequency.
 - b. Samples shall be cut by the Contractor at the locations designated by the CQA Engineer as the seaming progresses in order to obtain laboratory test results before the geomembrane is covered by another material. Each sample shall be numbered and the sample number and location identified on the panel layout drawing. All holes in the geomembrane resulting from the destructive seam sampling shall be immediately covered to prevent desiccation of the underlying clay. The holes shall be repaired in accordance with Part 3.03.K. of this Section. The continuity of the new seams in the repaired areas shall be tested according to this Section.
 - c. Two test specimens, each 1 inch wide and 6 to 12 inches long with the seam centered parallel to the width, shall be taken. The test specimens shall be spaced a clear distance of approximately 42 inches apart. These specimens shall be tested in the field in accordance with Part 3.03.J.3 of this Section. If these samples pass the field test, a laboratory sample shall be taken. The removed destructive sample shall be at least 12 inches wide by 42 inches long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

- i. One 12-inch long portion to the Contractor.
 - ii. One 18-inch long portion to the CQA Engineer for laboratory testing.
 - iii. One 12-inch long portion to the CQA Engineer for archive storage.
3. Field Testing:
 - a. The two 1 inch wide test specimens shall be tested in the field, using a tensiometer, for peel adhesion. Field testing shall be the responsibility of the Contractor and shall be observed by the CQA Engineer. The test specimens shall not fail in the weld more than 10 percent and shall meet the peel strength requirements of Table 02775-2. Both tracks of double-fusion welded seams shall be tested in peel on each test specimen unless otherwise approved by the Owner. If any field test sample fails to pass, then the procedures outlined in Part 3.03.K. of this Section shall be followed.
4. Laboratory Testing:
 - a. Laboratory testing by the CQA Engineer, in accordance with the CQA Plan, shall include seam shear strength and shear strain at yield (ASTM D 3083) and peel adhesion (ASTM D 413). The minimum acceptable values to be obtained in these tests are those indicated in Table 02775-2. At least 5 specimens shall be tested for each test method. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear...). A sample passes the laboratory tests when at least 4 out of 5 of the test specimens meet or exceed all of the test criteria. Both tracks of double-fusion welded seams shall be tested in peel.
5. Destructive Test Failure:
 - a. The following procedures shall apply whenever a sample fails a destructive test, whether the test is conducted by the CQA Engineer's laboratory, the Contractor's laboratory, (if used) or by a field tensiometer. The Contractor shall have two options:
 - i. The Contractor can reconstruct the seam(s) (e.g., remove the old seam(s) and reseam, or cap the seam(s)) between any two passed test locations.
 - ii. The Contractor can trace the welding path to an intermediate location, a minimum of 10 feet from the location of the failed test (in each direction) and take test specimens for an additional

field destructive tests at each location. If these field destructive tests pass, then full laboratory samples shall be taken. If these laboratory samples pass the tests, then the seam(s) shall be reconstructed between these locations. If either sample fails, then the process shall be repeated to establish the zone in which the seam shall be reconstructed. This will be done by following the chronological order in which the seaming apparatus welded the seam(s) prior to and after it welded the failing test location.

In any case, all acceptable seams must be bounded by two locations from which samples passing laboratory destructive tests have been obtained. In cases exceeding 150 feet of reconstructed seam(s), a sample taken from within the reconstructed zone must pass destructive testing. Whenever a sample fails, the CQA Engineer may require additional tests for seams that were formed by the same seamer and/or seaming apparatus or seamed during the same time shift at no additional cost to the Owner.

- iii. Should three consecutive failing destructives be performed on a single welding apparatus, the apparatus shall not be permitted to weld until the machine has been repaired and successfully passed three consecutive trial seams.

K. Defects and Repairs:

1. The geomembrane will be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Contractor if surface contamination inhibits inspection.
2. Each suspect location, both in seam and non-seam areas shall, at the discretion of the CQA Engineer, be either repaired or nondestructively tested using the methods described Part 3.03.I. of this section, as appropriate. Each location which fails nondestructive testing shall be marked by the CQA Engineer and repaired by the Contractor.
3. When geomembrane seaming is completed (or when seaming of a significant area of a geomembrane is completed) and prior to placing overlying materials, the CQA Engineer shall identify all excessive geomembrane wrinkles. The Contractor shall cut and reseam all wrinkles so identified. The seams thus produced shall be tested like any other seams.
4. Repair Procedures:

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- a. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired by the Contractor. Repairs to the geomembrane shall be completed to the base of the anchor trench but are not required across the base of the anchor trench. Several repair procedures exist. The final decision as to the appropriate repair procedure shall be agreed upon between the CQA Engineer and the Contractor. The procedures available include:
- i. patching, used to repair holes, tears, intersections of fusion-welded seams, and undispersed raw materials;
 - ii. abrading and spot extrusion welding, used to repair small sections of extruded seams and air pressure test needle holes;
 - iii. spot seaming, used to repair areas where the geomembrane has been scratched, the geomembrane thickness has been reduced, or other minor, localized flaws exist;
 - iv. capping, used to repair failed seams; and,
 - v. removing failing seams and replacing them with strips of new material seamed into place (used with long lengths of fusion seams).
- b. In addition, the following shall be satisfied:
- i. surfaces of the geomembrane which are to be repaired shall be abraded prior to the repair;
 - ii. all surfaces must be clean and dry at the time of repair;
 - iii. all seaming equipment used in repair procedures must be approved by the Owner;
 - iv. the repair procedures, materials, and techniques shall be approved in advance, for the specific repair, by the CQA Engineer;
 - v. patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 inches; and,
 - vi. the geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.
5. Repair Verification:

- a. Each repair shall be located, logged, and nondestructively tested using the methods described in Part 3.03.I. of this Section, as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair. Failed tests will require the repair to be redone and retested until a passing test results. At the discretion of the CQA Engineer, destructive testing may be required on large repairs.

3.04 MATERIALS IN CONTACT WITH THE LINER

- A. The Contractor shall not leave any tools or equipment on the geomembrane.
- B. The Contractor shall take all necessary precautions to ensure that the geomembrane is not damaged during its installation or during the installation of other components of the liner system or by other construction activities. Installation on rough surfaces shall be performed carefully. If approved by the Owner, additional loosely placed geotextile sections may be used by the Contractor to protect the geomembrane.
- C. The CQA Engineer will provide monitoring of the placement and spreading of soil materials over the geomembrane as required by the CQA Plan.
- D. Placement of granular leachate collection material on top of a geomembrane liner shall be carried out in accordance with Section 02224 of these General Specifications.
- E. Equipment shall not be driven directly on the geomembrane. Unless otherwise specified by the Owner, all equipment operating on materials overlying the geomembrane shall comply with the following:

<u>Maximum Allowable Equipment Ground Pressure (psi)</u>	<u>Thickness of Soil Above Geomembrane (inches)</u>
<5	12
<10	18
<20	24
>20	36

The maximum allowable equipment ground pressure shall be 65 psi. The acceptability of equipment operating at ground pressures greater than 65 psi will be evaluated by the Owner at the Contractor's expense.

These equipment ground pressure requirements do not apply to any equipment used to construct the secondary or primary clay liners. The Owner may restrict the use of equipment that may potentially damage the geomembrane.

- F. Appurtenances:

1. Installation of the geomembrane in sump areas, and connection of the geomembrane to appurtenances shall be made according to the specifications. Extreme care shall be taken while seaming around sumps and appurtenances since neither nondestructive nor destructive testing may be feasible in these areas.
2. All clamps, slips, bolts, nuts, or other fasteners used to secure the geomembrane to each appurtenance shall be at least as durable as the geomembrane.
3. Geomembrane boots for pipe penetrations shall be factory fabricated and tested where practical. Geomembrane boots shall be installed as shown on the Construction Drawings and in accordance with any geomembrane Manufacturer recommendations.

3.05 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and partially completed and completed work.
- B. In the event of damage, the Contractor shall make repairs and replacements necessary to the approval of the Owner and at no additional cost to the Owner.
- C. The CQA Engineer will issue an approval of the geomembrane liner installation to the Owner in accordance with the CQA Plan prior to placement of any material over the geomembrane.

3.06 RECORD DRAWINGS

- A. Within 7 days of the completion of installation of any layer of geomembrane liner and unless otherwise approved by the Owner, the Contractor shall provide 2 copies of a complete "as-built" record drawing to the Owner. This record drawing shall be prepared by the Contractor and shall be at a scale of no less than 1 inch = 30 feet.
- B. Record drawings shall include the following:
 1. The surveyed locations, dimensions, and elevations of anchor trenches.
 2. The identification, size, and surveyed location of all deployed field panels of geomembrane liner (with date of deployment).
 3. The identification, length, and surveyed location of all seams (both factory and field seams).
 4. The location, and type of all repairs to seams and field panels.
 5. The destructive test sample locations and pass/fail results.

- C. The Owner will review the record drawing and either approve it or return it to the Contractor for revision. If the drawing is returned to the Contractor, he shall revise the drawing as requested by the Owner. No additional construction that would cover the installed geomembrane may be performed until the record drawing is approved by the Owner. The Contractor may submit a partial record to obtain approval for a portion of work.

TABLE 02775-1 REQUIRED GEOMEMBRANE			
Property	Test Method	80 mil HDPE⁽¹⁾	40 mil HDPE
Thickness	ASTM D1593 Para 8.1.3 (Smooth)	80 mil	40 mil
	ASTM D751 (Textured)	72 mil (min.)	36 mil (min.)
Specific Gravity	ASTM D1505	0.940	0.940
Elongation @ Yield	ASTM D638	13%	13%
Elongation @ Break	ASTM D638 Speed C	500% Smooth 100% Textured	500% Smooth 100% Textured
Tensile Strength @ Yield	ASTM D638 Test Specimen Type IV	160 lb/in	80 lb/in
Tensile Strength @ Break	ASTM D638	270 lb/in Smooth 100 lb/in Textured	135 lb/in Smooth 46 lb/in Textured
Carbon Black Content	ASTM D1603	2% to 3%	2% to 3%
Carbon Black Dispersion	ASTM D3015 and ASTM D2663	A-1, A-2, B-1	A-1, A-2, B-1
Environmental Stress Crack	ASTM D1693	1,500 hrs	1,500 hrs
Low Temperature Brittleness	ASTM D746 Procedure B	-94°F	-94°F
Dimensional Stability	ASTM D1204	.2% (max)	.2% (max)
Puncture Resistance	FTMS 101C	96 lb Smooth 95 lb Textured	48 lb Smooth 45 lb Textured
Note: ⁽¹⁾ Values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table). Where ranges of values are given, the average roll values must be within the specified range. The specified dimensional stability is a maximum average roll value.			

TABLE 02775-2 REQUIRED GEOMEMBRANE SEAM PROPERTIES			
PROPERTY	TEST METHOD	80 MIL HDPE⁽¹⁾	40 MIL HDPE
1. Shear strength at yield	ASTM D3083	FTB, 90% of Parent Mat'l	FTB, 90% of Parent Mat'l
2. Shear Strain at Yield	ASTM D3083	10%	10%
3. Peel Strength	ASTM D413	FTB, 60% of Parent Mat'l	FTB, 60% of Parent Mat'l
NOTE: ⁽¹⁾ Specified properties are minimums.			

[END OF SECTION]

SECTION 02780 GEOSYNTHETIC CLAY LINERS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all labor, materials, tools, equipment supervision, transportation, and installation services necessary for the installation of the primary geosynthetic clay liner (GCL) of the secure cell or surface impoundment. The work shall be carried out in accordance with these General Specifications, Supplemental Specifications, the CQA Plan, and the Construction Drawings.

1.02 RELATED SECTIONS

- A. Section 02221 - Secondary Clay Liner
- B. Section 02222 - Primary Clay Liner
- C. Section 02224 - Granular Leachate Collection Layer
- D. Section 02225- Sump and Pipe Bedding Gravel and Road Base Aggregate
- E. Section 02710 - Geocomposite Detection or Collection Layer

1.03 QUALIFICATIONS AND SUBMITTALS

- A. The Contractor shall abide by all qualification and submittal requirements of the CQA Plan. The Contractor shall require the GCL manufacturer to comply with the submittal requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

- A. All work will be constructed, monitored, and tested in accordance with the requirements of the CQA Plan.
- B. The Contractor shall be aware of all activities outlined in the CQA Plan, and the Contractor shall account for these activities in the construction schedule. No additional costs to the Owner shall be allowed by the Contractor as a result of the performance of the CQA activities.
- C. The Contractor shall deliver GCL to the site at least 14 calendar days prior to installation to allow sufficient time for testing required by the CQA Plan.
- D. GCL rolls that do not meet the requirements of this General Specification will be rejected. The Contractor shall replace rejected material with new material that conforms to the specification requirements, at no additional cost to the Owner.
- E. If the CQA Engineer's tests indicate work does not meet the requirements of the specifications, the CQA Engineer will establish the extent of the nonconforming area.

The nonconforming area shall be reworked by the Contractor at no cost to the Owner until acceptable test results are obtained.

PART 2 PRODUCTS

2.01 GCL PROPERTIES

The GCL material shall be in accordance with the test methods, test frequencies and material physical properties as listed in Table 02780-1.

- A. In addition to the property values listed in Table 02780-1, the GCL material shall:
1. The GCL shall be manufactured by mechanically bonding the geotextiles using a needle punching process to create frictional and shear strength characteristics.
 2. In order to maintain these characteristics, no glues, adhesives or other non-mechanical bonding processes shall be used in lieu of the needle punch process. Their use to enhance the physical properties of the GCL is permitted.
 3. Acceptable GCLs for this project include the Bentofix Thermal Lock, or any other needle punched GCLs which meet the requirements of this specifications.
 4. The GCL supplied in accordance with this project shall be manufactured by needle punching as described below.
 - i. The needle punched GCL shall be thermally locked. The thermal lock process must heat set the nonwoven fibers where they protrude from the second geotextile (woven or nonwoven depending upon produce) to more permanently secure the reinforcement in place.
 - ii. To demonstrate the uniformity of the manufacturing process, no delamination of the geotextile components from the bentonite core shall occur when the GCL is exposed to 70 degree tap water for one hour.
 5. Interface Shear Testing of Proposed Equal Materials

Interface shear tests (ASTM D 5321) shall be performed by the Geosynthetic Laboratory under the direction of the Design Engineer for any GCL material proposed as an equal for Bentofix Thermal Lock GCL. Interface shear testing will be performed on fully hydrated GCL samples using a 12 inch by 12 inch shear box under test conditions described in LF13, Appendix B. The number of tests to be performed is based on a ratio of one test per 100,000 ft² of material. A proposed equal material must demonstrate a strength envelop which is equivalent to the materials previously tested (see Figure LF13, Appendix B). All costs related to testing and evaluation of proposed equal materials are the responsibility of the Contractor.

6. Interface Shear Testing for QA Conformance Samples

Interface shear tests (ASTM D 5321) shall be performed by the Geosynthetic Laboratory under the direction of the CQA Engineer using the same test procedures described in LF13, Appendix B. Tests will be performed at a frequency of one test per 100,000 ft² of material. All costs related to testing and evaluation of conformance samples is the responsibility of the CQA Engineer.

2.02 MANUFACTURING QUALITY CONTROL

- A. The Contractor shall require that the GCL Manufacturer sample and test the GCL, at the frequencies outlined in Table 02780-1 the tests shall demonstrate that the GCL properties conform to the values specified in Table 02780-1. All Quality Control testing required by these General Specifications and/or conducted at the discretion of the Contractor shall be the responsibility of the Contractor. GCL rolls that do not have acceptable manufacturing quality control test results shall be rejected by the Owner.
- B. Quality Control certificates shall be issued by the GCL manufacturer to the project engineer, CQA inspector or other designated party for each delivery of material. The certifications shall be signed by the quality control manager of the GCL manufacturer or other responsible party and shall include the following information:
1. Shipment Packing List - A list indicating the rolls shipped on a particular truckload.
 2. Bill of Lading - A list indicating the rolls shipped on a particular truckload.
 3. Letter of Certification - The letter indicating the material is in conformance with the physical properties specified.
 4. Physical Properties Sheet - The material specification for the GCL supplied in accordance with this specification.
- C. Quality Control submittals shall be issued by the GCL manufacturer to the project engineer, CQA inspector or other designated party for each lot of material if necessary. The submittals shall include the following information:
1. Bentonite Manufacturer Certification - Bentonite manufacturer quality documentation for the particular lot of clay used in the production of the rolls delivered.
 2. Geotextile Manufacturer Certification - Geotextile manufacturer quality control documentation for the particular lots of geotextiles used in the production of the rolls delivered.

3. GCL Manufacturer Tracking List - Cross referencing list delineating the corresponding geotextile and bentonite lots for the materials used in the production of the rolls delivered.

4. Manufacturing Quality Control Data - The manufacturing quality control test data indicating the actual test values obtained when tested at the appropriate frequencies for the properties specified in Table 02780-1.

D. Manufacturing Plant Visit:

1. The Manufacturer shall permit the Owner or Owner's representative(s) to visit the manufacturing plant. Visits may be during the manufacturing of the GCL rolls for the specific project.
2. During the visit, the Owner or Owner's representative(s) may:
 - a. Review the manufacturing process, quality control procedures, laboratory facilities, and testing procedures;
 - b. Verify that properties guaranteed by the Manufacturer comply with the specifications;
 - c. Verify that the measurements of properties by the Manufacturer are properly documented and the test methods used are acceptable;
 - d. Inspect select GCL rolls for evidence of holes, delamination, or any sign of contamination by foreign matter;
 - e. Review packaging and transportation procedures;
 - f. Verify that roll packages are labeled in compliance with this Section; and,
 - g. Take conformance samples from GCL rolls that are assigned to the project.

- E. Any accessory bentonite used for sealing seams, penetrations, or repairs, shall be the same granular bentonite as used in the production of the GCL itself.

2.03 LABELING

A. The geomembrane shall be labeled with the following information:

1. Length and width of the roll or factory panel;
2. Name of Manufacturer;
3. Product identification;
4. Lot number; and,
5. Roll or factory panel number.

2.04 TRANSPORTATION

- A. Transportation of the GCL is the responsibility of the Contractor. The Contractor shall be liable for all damage to materials prior to and during transportation to the site. The Contractor shall replace any damaged rolls at no additional cost to the Owner.

2.05 HANDLING AND STORAGE

- A. Handling, storage, and care of the GCL prior to and following incorporation in the work is the responsibility of the Contractor. The Contractor shall be liable for all damage to the material incurred prior to final acceptance of the installation by the Owner. The Contractor shall repair any damage in accordance with this Section and at no additional cost to the Owner.
- B. The Contractor shall be responsible for storage of the GCL at the site. The GCL shall be protected from water, dirt, puncture, cutting, or other damaging or deleterious conditions. The GCL shall also be stored in accordance with any additional requirements of the GCL Manufacturer, Owner, or CQA Engineer.
1. GCL should be stored no higher than three to four rolls high or limited to the height at which the handling apparatus may be safely handled by installation personnel. Stacks or tiers of rolls should be situated in a manner that prevents sliding or rolling by Achocking@ the bottom layer of rolls.
 2. Rolls shall not be stacked on uneven or discontinuous surfaces as this may cause bending or deformation of the rolls and in turn damage the GCL or cause difficulty inserting the core pipe.
 3. An additional tarpaulin or plastic sheet shall be used over the stacked rolls to provide extra protection for GCL material stored outdoors.
 4. Bagged bentonite material shall be stored and tarped next to GCL rolls unless other more protective measures are available. Bags shall be stored on pallets or other suitably dry surface which will prevent undue prehydration.
- C. GCL must be supported during handling to ensure worker safety and prevent damage to the liner. Under no circumstances should the rolls be dragged, lifted from one end, lifted with only the forks of a lift truck or pushed to the ground from the delivery vehicle.

The CQA inspector shall verify that suitable handling equipment exists which does not pose any danger to installation personnel or risk of damage or deformation to the GCL material itself. Typical handling equipment is described below:

1. Spreader Bar Assembly - A spreader bar assembly shall include both a core pipe or bar and a spreader bar beam. The core pipe shall be used to uniformly

support the roll when inserted through the GCL core while the spreader bar beam will prevent chains or straps from chafing the roll edges.

2. Stinger - A stinger is a rigid pipe or rod with one end directly connected to a forklift or other handling equipment. If a stinger is used, it should be fully inserted to its full length into the roll to prevent excessive bending of the roll when lifted.
3. Roller Cradles - Roller cradles consist of two larger diameter rollers spaced approximately 3 inches apart which both support the GCL roll and allow it to be freely unrolled. The use of roller cradles shall be permitted if the rollers support the entire width of the GCL roll.
4. Straps - Straps may be used to support the ends of the spreader bars *but are not recommended as the primary support mechanism*. As straps may damage the GCL where around the roll and generally do not provide sufficient uniform support to prevent roll bending or deformation, great care must be exercised when this option is used.

PART 3 EXECUTION

3.01 EARTHWORK

Earthen Subgrade - The surface upon which the GCL material will be installed shall be inspected by the CQA inspector and certified by the Earthwork Contractor to be in accordance with the requirements of this specification.

- A. Site specific compaction requirements should be followed in accordance with the project drawings and specifications. At a minimum, the level of compaction should be such that no rutting is caused by installation equipment or other construction vehicles which traffic the area of deployment.
- B. The surfaces to be lined shall be smooth and free of any debris, vegetation, roots, sticks, sharp rocks, or other deleterious materials larger than two inches as well as free of any voids, large cracks or standing water or ice.
- C. Directly prior to deployment of the GCL, the subgrade shall be final graded to fill remaining voids or desiccation cracks, and smooth drum rolled to eliminate sharp irregularities or abrupt elevation changes. The surfaces to be lined shall be maintained in this smooth condition.

3.02 GEOSYNTHETIC SUBGRADE

Prior to GCL deployment on another geosynthetic surface shall be inspected and approved by the third party CQA inspector in accordance with the requirements of the project specification documents.

3.03 ANCHOR TRENCH

An anchor trench shall be excavated by the earthwork contractor or liner installer to the lines and grades shown on the project drawings.

- A. The anchor trench shall be constructed free of sharp edges or corners and maintained in a dry condition. No loose soil shall be permitted beneath the GCL within the trench.
- B. The anchor trench shall be inspected as well as approved by the CQA inspector prior to the GCL placement, back-filling and compaction of the anchor key material.

3.04 SUBGRADE INSPECTION

The earthen or geosynthetic subgrade shall be continuously inspected, approved and certified by the CQA inspector prior to GCL placement.

Upon approval by the CQA inspector, it shall be the installer's responsibility to indicate to the Engineer any change in the condition of the subgrade that could cause it to be out of compliance with any of the requirements of this section or the project specific specification.

3.05 GCL DEPLOYMENT

- A. GCL Orientation - In the absence of specific guidelines, GCL panels should be placed with the non-woven side up on slopes to maximize the shear strength characteristics.
- B. GCL Panel Position - Where possible, all slope panels should be installed parallel to the maximum slope while panels installed in flat areas require no particular orientation. No horizontal GCL panel seams shall be allowed on slopes steeper than 5%.
- C. Panel Deployment - GCL materials shall be installed in general accordance with the procedures set forth in this section, subject to site specific conditions which would necessitate modifications.

Reinforced GCL shall be used on both slopes as well as the flat areas to ensure the GCL withstands the rigors of the installation and subsequent low load hydration.

1. Deployment should proceed from the highest elevation to the lowest to facilitate drainage in the event of precipitation.
2. The GCL may be deployed on slopes by pulling the material from a suspended roll, or securing a roll end into an anchor trench and unrolling each panel as the handling equipment slowly moves backwards.
3. Deployment on flat areas shall be conducted in the same manner as that for the slopes, however, care should be taken to minimize dragging@ the GCL. Slip-sheet may be used to facilitate positioning of the liner while ensuring the GCL is not damaged from underlying sources.
4. Overlaps shall be a minimum of 6 inches and be free of wrinkles, folds or "fishmouths".

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5. The Contractor shall only install as much GCL that can be covered at the end of the day. No GCL shall be left exposed overnight. The exposed edge of the GCL shall be covered by a temporary tarpaulin or other such water resistant sheeting until the next working day.
- D. Anchoring - All GCL material installed on slopes greater than 7H:1V shall be anchored to prevent potential GCL panel movement.
1. Standard Anchor - The GCL shall be placed into and across the base of the excavated trench, stopping at the back wall of the excavation as shown on the drawing.
- E. Seaming - A 6-inch lap line and a 9-inch match line shall be imprinted on both edges of the upper geotextile component of the GCL to assist in installation overlap quality control. Lines shall be printed as continuous dashes in easily observable non-toxic ink.
1. Overlap seams shall be a minimum of six inches on panel edges and one foot on panel ends.
 2. Loose granular bentonite should be placed between panels at a rate of 1/4 pound per linear foot of seam.
- F. Detailing - Detail work, defined as the sealing of the liner to pipe penetrations, foundation walls, drainage structures, spillways, and other appurtenances, shall be performed as recommended by the Design Engineer and the GCL Manufacturer.
- G. Damage Repair - Prior to geomembrane material placement, damage to the GCL shall be identified and repaired by the installer. Damage is defined as any rips or tears in the geotextiles, delamination of geotextiles or a displaced panel.
1. Rip and Tear Repair (Flat Surfaces) - Rips or tears may be repaired by completely exposing the affected area, removing all foreign objects or soil and by then placing a patch cut from unused GCL over the damage (damaged material may be left in place), with a minimum of overlap of 12 inches on all edges.
 2. Rip and Tear Repair (Slopes) - Damaged GCL material on slopes shall be repaired by the same procedures above. The minimum overlap of 12 inches on all edges may be increased as recommended by the CQA Engineer.
 3. Displaced Panels - Displaced panels shall be adjusted to the correct position and orientation. The adjusted panel shall then be inspected for any geotextile damage or bentonite loss. Damage shall be repaired by the above procedure.
 4. Premature Hydration - If the GCL is subjected to premature hydration, the GCL installer shall notify the QA/QC technician and project engineer for a site specific determination as to whether the material is acceptable or if alternative measures

must be taken to ensure the quality of the design-dependent upon the degree of damage.

3.06 MATERIALS IN CONTACT WITH THE GCL

- A. The Contractor shall not leave any tools or equipment on the GCL.
- B. The Contractor shall take all necessary precautions to ensure that the GCL is not damaged during its installation or during the installation of other components of the liner system or by other construction activities. Installation on rough surfaces shall be performed carefully.
- C. The CQA Engineer will provide monitoring of the placement and spreading of soil materials over the GCL. Equipment shall not be driven directly on the GCL. Unless otherwise specified by the Owner, all equipment operating on materials overlying the GCL shall comply with the following:

<u>Maximum Allowable Equipment Ground Pressure (psi)</u>	<u>Thickness of Soil Above Geomembrane (inches)</u>
<5	12
<10	18
<20	24
>20	36

The maximum allowable equipment ground pressure shall be 65 psi. The acceptability of equipment operating at ground pressures greater than 65 psi will be evaluated by the Owner at the Contractor's expense.

- D. Installation of the overlying geosynthetic component can be accomplished through the use of *lightweight*, rubber-tired equipment such as a 4-wheel all-terrain vehicle (ATV). This vehicle can be driven directly on the GCL, provided the ATV makes no sudden stops, starts, or turns.
- E. Smooth HDPE may be dragged across the GCL surface with equipment or by hand labor during positioning. Similarly, the HDPE may be unrolled with the use of low ground pressure equipment.
- F. If a textured geomembrane is placed over the GCL, a slip sheet (such as 20-mil smooth HDPE) shall first be placed over the GCL in order to allow the geomembrane to slide into its proper position. Once the overlying geomembrane is properly positioned, the slip-sheet shall be carefully removed paying close attention to avoiding any movement to the geomembrane.

3.07 PROTECTION OF THE WORK

- A. The Contractor shall use all means necessary to protect all materials and partially completed and completed work.
- B. In the event of damage, the Contractor shall make repairs and replacements necessary to the approval of the Owner and at no additional cost to the Owner.
- C. The CQA Engineer will issue an approval of the GCL liner installation to the Owner in accordance with the CQA Plan prior to placement of any material over the GCL.

TABLE 02780-1 REQUIRED GCL PROPERTIES⁽⁴⁾				
Geotextile Properties	Test Method	Manufacturer's QC Minimum Test Frequency	Value -English-	Value -SI-
Nonwoven Mass/Unit Area	ASTM D 5261	1/200,000 sq. ft (1/200,000 sq.m)	7.4 oz./yd ² Typical 6.0 oz./yd ² MARV	250 g/m ² Typical 200 g/m ² MARV
Woven	ASTM D 5261	1/200,000 sq. ft (1/20,000 sq. M)	3.4 oz./yd ² Typical 3.1 oz./yd ² MARV	115 g/m ² Typical 105 g/m ² MARV
BENTONITE				
Swell Index	ASTM D 5890	1/100,000 lbs. (50,000 kg)	24 ml/2g min.	24 ml/2g min.
Moisture Content	ASTM D 4643	1/100,000 lbs. (50,000 kg)	12% max.	12% max.
Fluid Loss	ASTM D 5891	1/100,000 lbs. (50,000 kg)	18 ml max.	18 ml max.
FINISHED GCL ⁽⁴⁾				
Bentonite Mass Per Unit Area ¹	ASTM D 5261	1/40,000 sq. ft (1/4,000 sq.m)	0.90 lb./sq. Ft MARV	4.39 kg/m ² MARV
Grab Strength ²	ASTM D 4362	1/40,000 sq. ft (1/4,000 sq.m)	95 lbs MARV	422 N MARV
Grab Elongation ²	ASTM D 4632	1/40,000 sq. ft (1/4,000 sq.m)	75% Typical	75% Typical
Peel Strength	ASTM D 4632	1/40,000 sq. ft (1/4,000 sq.m)	15 lbs. min.	66 N min.
Permeability ³	ASTM D 5084	1/100,000 sq. ft (1/10,000 sq. M)	5 x 10 ⁻⁹ cm/sec max	5 x 10 ⁻⁹ cm/sec max
Notes:				

TABLE 02780-1
REQUIRED GCL PROPERTIES⁽⁴⁾

- | | |
|----|--|
| 1. | Oven-dried measurement reflecting a moisture content of zero. |
| 2. | Measured at maximum peak, in the weakest principal direction. |
| 3. | De-Aired Tap Water @ 5 psi maximum effective confining stress and 2 psi head. |
| 4. | Internal shear strength testing (ASTM D 5321) of QA conformance samples or proposed equal material will be performed by the CQA Engineer as described in this specification. |

[END OF SECTION]