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SECTION 02105

EROSION CONTROL

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for erosion control measures associated with lining materials for drainage channels.

PART 2 PRODUCTS

2.01 EROSION CONTROL BLANKET

Permanent Turf Reinforcement Mat shall be SI Geosolutions Landlok 450, or equivalent. To be used in Type IB, II and IV channels.

Temporary Erosion Control Mat shall be SI Geosolutions ECB CS2, or equivalent. To be used in Type IA channels.

PART 3 EXECUTION

3.01 GENERAL

A. Grade and compact area of installation and remove all rocks, clods, vegetation or other obstructions so that the installed mat will have direct contact with soil surface. Prepare seedbed by loosening 2-3 inches of topsoil. Incorporate amendments such as fertilizer into soil.

B. For temporary erosion control mat, apply seed to soil surface before installing blanket/mat. For permanent erosion control mat, apply seeding after installation and prior to filling mat with soil.

C. The CONTRACTOR shall install the permanent and temporary control mats in accordance with the manufacturer's recommendations. In general the installation should include:

1. Anchor trenches or check slots (6-inches deep) at 30 foot intervals along the trench.

2. Longitudinal anchor trenches (4-inches deep) to secure outside edges.

3. Anchor erosion control mat with U-shaped wire staples. Staples shall be a minimum of 6-inches in length and have sufficient ground penetration to resist pullout. Longer anchors may be required. Anchors for the permanent erosion control mat shall be installed with a minimum of 2 anchors per square yard. Temporary erosion control mats shall be installed with a minimum of 1.5 anchors per square yard.

4. After installation of permanent erosion control mat, apply seed and apply ½ to ¾ inches of fine soil into the mat to completely fill the voids. Use backside of rake, or similar, to smooth soil fill in order to just expose the top netting.

END OF SECTION

SECTION 02110

SITE CLEARING, GRUBBING AND STRIPPING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for site clearing, grubbing and stripping associated with final closure construction of Landfill B19 at the Kettleman Hills Facility

B. Clearing, grubbing and stripping shall be performed to remove organic, soft, loose, and deleterious materials and expose a firm, unyielding subgrade.

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork

B. Section 02751 - HDPE Geomembrane

PART 2 PRODUCTS

A. Organic, soft, loose and deleterious materials includes, but is not limited to, vegetative growth, non-engineered fills, alluvial deposits, soft, loose, or saturated subgrade soils, refuse, and construction debris.

PART 3 EXECUTION

3.01 PROTECTION

A. Locate, identify, and protect utilities that remain from damage.

B. Protect groundwater monitoring wells and piezometers, and landfill gas extraction wells and monitoring probes from damage or displacement.

3.02 CLEARING

A. Clear areas required for access to site and execution of work.

B. Earthwork CONTRACTOR shall remove all organic and deleterious material, and trash from the subgrade surface. Vegetative growth greater than 1 inch in dimension shall be removed to a depth of 6 inches below the subgrade surface.

C. The Earthwork CONTRACTOR shall consider that clearing, grubbing, and stripping will necessitate the use of manual labor to remove all organic and deleterious material from the subgrade surface.

D. The Earthwork CONTRACTOR shall remove soft, loose, or saturated materials as approved by the CQA CONSULTANT. The materials shall be removed until a firm, unyielding subgrade, approved by the CQA CONSULTANT, is exposed.

E. All removed materials shall be disposed of onsite in an area designated by the PROJECT MANAGER. No accumulation of flammable material shall remain on or adjacent to the construction area.

F. The Earthwork CONTRACTOR shall expose existing liner terminations as required on the Drawings. The Work may require hand excavation to avoid damage to the existing liner. Any damage to the existing liner shall be repaired by the Earthwork CONTRACTOR at no additional cost to the OWNER.

END OF SECTION

SECTION 02200

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. This section describes the general requirements for earthworks associated with the final closure construction of Landfill B19 at the Kettleman Hills Facility.

B. The Earthwork CONTRACTOR shall furnish all labor, materials, equipment and incidentals necessary to perform all excavation, backfilling, compaction and grading required to complete the work shown on the Drawings and specified herein. The Work shall include, but not necessarily be limited to, survey and staking, borrow excavation and hauling, excavation for trenches, fill placement and compaction, grading, and all related work.

C. The Earthwork CONTRACTOR shall comply with the safety procedures given in Section 01016 of these Specifications.

1.02 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 01400 - Construction Quality Control

C. Section 02110 - Site Clearing, Grubbing and Stripping.

D. Section 02720 – Drainage Facilities

E. Section 02751 - HDPE Geomembranes

1.03 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM), latest editions:

1. ASTM D422 - Test Method for Particle Size Analysis of Soils.
2. ASTM D1556 - Test Method for Density of Soil In-Place by the Sand Cone Method.
3. ASTM D1557 - Test Methods for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lb. Rammer and 18-inch Drop.
4. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
5. ASTM D2419 - Test Method for Sand Equivalent Value of Soil/Fine Aggregate.
6. ASTM D2497 - Standard Test Method for Classification of Soils for Engineering Purposes.

7. ASTM D2922 - Test Methods for Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth).
8. ASTM D2937 - Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
9. ASTM D3017 - Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

B. Standard Specifications for Public Works Construction (SSPWC).

1.04 QUALITY ASSURANCE/CONTROL

A. The Earthwork CONTRACTOR shall adhere to the requirements of Section 01400 of these Specifications.

B. Compaction testing of engineered fill and backfill shall be performed by the CQA CONSULTANT. Testing shall be performed at locations to be determined by the CQA CONSULTANT, in order to determine if the soils meet the compaction requirements. Costs for testing to verify compaction and soil moisture content will be assumed by the OWNER. The cost of retesting, should corrections to construction be required, shall be the responsibility of the Earthwork CONTRACTOR.

C. The OWNER shall have complete authority to order immediate stoppage of work due to use of improper construction procedures, or for any reason that in his sole opinion, may result in a defective work.

1.05 DEFINITIONS

A. Excavation: Consists of the removal of material encountered to subgrade elevations and the reuse or disposal of materials removed.

B. Subgrade: The surface upon which structures/systems/fills are constructed.

C. Borrow: Soil material obtained from other than the excavation.

D. Unauthorized excavation consists of removing materials beyond indicated subgrade elevations or dimensions without direction by the PROJECT MANAGER. Unauthorized excavation, as well as remedial work directed by the PROJECT MANAGER, shall solely be at the Earthwork CONTRACTOR's expense.

E. Utilities include on-site above ground and underground pipes, conduits, ducts, and cables, as well as underground services.

1.06 SAFETY

A. CONTRACTOR is solely responsible for performing work in a safe manner and complying with all applicable local, state and federal codes, ordinances, laws, and regulations.

B. CONTRACTOR shall comply with the requirements of the Health and Safety Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural Fill

1. Structural Fill shall be removed from the on-site borrow area(s) designated by the OWNER. Material shall be predominantly free from roots, wood, organic matter, refuse or other deleterious matter, and shall not contain particles over 6 inches in greatest dimension.

2. The OWNER has designated on-site borrow source(s) for the CONTRACTOR. The CONTRACTOR shall be responsible for excavating, loading, hauling, placing and compacting the material from the designated borrow source(s).

B. Foundation Layer

1. Foundation Layer is structural fill placed within 1-foot of HDPE geomembrane.

2. In addition to the structural fill requirements, Foundation layer shall not contain particles over 1 inch in greatest dimension and have a hydraulic conductivity of less than or equal to 1×10^{-5} cm/sec as determined by ASTM D5084.

C. Vegetative Cover

1. Vegetative Cover shall be removed from the on-site borrow area(s) designated by the OWNER. Material shall contain no particles over 3 inches in greatest dimension.

2. The OWNER has designated on-site borrow source(s) for the CONTRACTOR. The CONTRACTOR shall be responsible for excavating, loading, hauling, placing and compacting the material from the designated borrow source(s).

D. Trench Backfill

1. Trench Backfill shall be removed from the on-site borrow area(s) designated by the OWNER. Material shall be predominantly free from roots, wood, organic matter, refuse or other deleterious matter, and shall not contain particles over 1 inch in greatest dimension.

2. The OWNER has designated on-site borrow source(s) for the CONTRACTOR. The CONTRACTOR shall be responsible for excavating, loading, hauling, placing and compacting the material from the designated borrow source(s).

E. Water

1. Water shall be potable water or reclaimed water approved for use by OWNER.

2. The OWNER will provide water for dust control and soil preparation to the Earthwork CONTRACTOR at no cost to the Earthwork CONTRACTOR.

3. The CONTRACTOR shall only obtain water from sources designated by the OWNER.

PART 3 EXECUTION

3.01 GENERAL

A. The Earthwork CONTRACTOR shall be solely responsible for the satisfactory completion of all earthwork in accordance with the Drawings and Specifications.

B. Equipment used in the excavation, transport, placement and compaction of all materials used in construction will be standard of practice grading machinery of known specifications suitable for performing the required work in a timely and efficient manner.

C. All material considered by the CQA CONSULTANT to be unsuitable for use in the construction of the earthwork shall be removed. All materials incorporated as part of engineered fill must be inspected and placement must be observed by the CQA CONSULTANT. Unsuitable material shall be disposed of in the designated area.

D. Where work is interrupted by heavy rains, earthwork operations shall not be resumed until observations and field tests by the CQA CONSULTANT indicate the moisture content and density of the in-place fills and/or materials intended for placement are within the specified requirements.

E. If any unanticipated earth conditions of an adverse or potentially adverse nature are encountered during grading, the Earthwork CONTRACTOR shall immediately notify the CQA CONSULTANT. The CQA CONSULTANT and DESIGN ENGINEER shall investigate, analyze, and make recommendations to mitigate these conditions.

F. Throughout construction, all excavated and/or fill areas shall be graded to provide positive drainage and prevent ponding of water. Surface water shall be controlled to avoid damage to adjoining properties or to finished work on the site.

G. No heavy equipment shall be permitted to operate within 3 feet of existing wellheads or piping. Compaction of material within these limits shall be completed with hand equipment.

H. The Earthwork CONTRACTOR shall apply water to any exposed earthen areas during construction to minimize airborne dust. This shall include active and inactive excavation areas, haul roads, and any nonvegetated stockpiles. The Earthwork CONTRACTOR shall be responsible for complying with all state and local regulations regarding dust and/or air quality.

I. Earthwork CONTRACTOR **shall not** use "paddle-wheel" (i.e., Caterpillar 613 or equivalent) equipment to excavate soils.

J. Earthwork CONTRACTOR shall provide manned traffic control (e.g., flagman) at locations identified by Owner and/or Contractor as being a potential safety hazard.

3.02 CONTROL OF WATER

A. The Earthwork CONTRACTOR shall excavate and backfill in a manner and sequence that will provide proper drainage at all times. The Earthwork CONTRACTOR shall remove all water, including runoff and run-on collected from rainwater encountered during excavation, to a location approved by the PROJECT MANAGER, by pumps, drains, and other approved methods.

B. The Earthwork CONTRACTOR shall take all necessary precautions to preclude the accidental discharge of fuel, oil, etc. and to prevent such accidents that may endanger the environment. The Earthwork CONTRACTOR will be responsible for the cost of remediating the results of any such discharges or accidents.

3.03 BORROW

A. CONTRACTOR shall submit the proposed limits of the borrow area to the OWNER for approval prior to the commencement of the Work. The maximum limits of the borrow area are shown on the Drawings.

B. The gradients of the borrow slopes and the depth of the borrow excavation should not exceed those specified on the Drawings. If the slopes are constructed steeper or the depth of the borrow excavation is greater than that specified on the Drawings, the CONTRACTOR shall reconstruct the slopes/refill the bottom to the gradients/depth specified by backfilling and compacting material in accordance with the requirements for engineered fill in this Section. The cost to reconstruct the slopes/refill the bottom will be borne solely by the CONTRACTOR.

C. The CONTRACTOR shall maintain a secure work site at all times.

3.04 STRUCTURAL FILL

A. Prior to placing structural fill, CONTRACTOR shall clear and grub the area in accordance with Section 02110 of these Specifications. CONTRACTOR shall also remove uncertified existing fills, disturbed soils and deleterious materials from the area to the satisfaction of the CQA CONSULTANT.

B. The ground surface (i.e. areas with less than 10% slope) to receive fill shall be over excavated a minimum of 2 feet. The base of the excavation shall be scarified to a depth of 8 inches. The scarified ground surface shall then be brought to within 3 percent of optimum moisture content, mixed as required, and compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM D1557. Excavated soil may be used for filling the excavation if placed in accordance with the structural fill requirements. If the scarified zone is greater than 12 inches in depth, the excess shall be removed, placed in loose lifts not to exceed 8 inches in loose thickness. Prior to fill placement, the ground surface to receive fill shall be stabilized and inspected by the CQA CONSULTANT.

C. Fill placed against existing slopes (i.e. areas with greater than 10% slope) shall be keyed into the slope. Keys shall extend a minimum of 6 feet horizontally into the existing slope. The keys shall form a series of steps in the existing fill.

D. Fill shall be placed in loose lifts not to exceed 8-inches thick, brought to a uniform moisture content within 4 percent of optimum (3 percent for Foundation Layer), and compacted to 90 percent of the maximum dry density as determined by ASTM D1557.

E. Where tests indicate the moisture content or density of any layer of fill or portion thereof is below the Project requirements, the particular layer or portion thereof shall be reworked until the required moisture or density has been attained. No additional fill shall be placed over an area until the prior fill lift has been tested and meets the present requirements to the satisfaction of the CQA CONSULTANT.

F. In the event of rain or other reason, if the moisture content of previously placed fill material or processed soils intended for placement is more than 4 percent above optimum as determined by ASTM D1557, the fill material shall be aerated by blading, disking, or other satisfactory method until the moisture content complies with the requirements of this Section. Any previously compacted materials which are disturbed (aerated, bladed, etc.) to reduce or increase the moisture content must be recompacted to the Specifications and to the satisfaction of the CQA CONSULTANT once specified moisture contents are attained.

3.05 VEGETATIVE COVER

A. Vegetative cover layer shall be placed as shown on the Drawings. Soils shall not be placed over geosynthetic materials at ambient temperatures below 41 degrees F nor above 100 degrees F unless otherwise specified. The soils shall be placed in a manner which does not cause excessive movement or wrinkling of the geosynthetics.

B. Vegetative cover layer shall be placed and compacted by tracking with the low ground-pressure pressure dozer used for placement or other relatively light-compaction equipment wherever the soil thickness is less than 3 feet. The equipment used to spread and compact the backfill shall not exert a ground pressure in excess of 6 psi on no less than 1 foot of material. Manually operated compaction equipment may be required in constricted locations and directly adjacent to sensitive structures.

C. Hauling and spreading equipment for the vegetative cover layer shall operate on a minimum of 3 feet of soil above a geosynthetic layer. Low-ground pressure (i.e., less than 6 psi) spreading equipment may operate on a minimum of one foot of soil above a geosynthetic layer.

D. Fill shall be placed in loose lifts not to exceed 8-inches thick, brought to a uniform moisture content within 3 percent of optimum, and compacted between 85 to 90 percent of the maximum dry density as determined by ASTM D1557.

E. Where tests indicate the moisture content or density of any layer of fill or portion thereof is below the Project requirements, the particular layer or portion thereof shall be reworked until the required moisture or density has been attained. No additional fill shall be placed over an area until the prior fill lift has been tested and meets the present requirements to the satisfaction of the CQA CONSULTANT.

F. In the event of rain or other reason, if the moisture content of previously placed fill material or processed soils intended for placement is more than 3 percent above

optimum as determined by ASTM D1557, the fill material shall be aerated by blading, disking, or other satisfactory method until the moisture content is within four percent of optimum moisture content as determined by ASTM D1557. Any previously compacted materials which are disturbed (aerated, bladed, etc.) to reduce or increase the moisture content must be recompacted to the Specifications and to the satisfaction of the CQA CONSULTANT once specified moisture contents are attained.

3.06 SURFACE PREPARATION

A. All surfaces to be overlain by geosynthetics shall be smooth, uniformly sloped (minimum 5%), firm, and free of rocks, protrusions, or depressions greater than 0.5-inch in maximum dimension. The Earthwork CONTRACTOR shall consider that manual removal/repair of unacceptable areas may be required and shall be considered inherent to the work described herein.

3.07 TRENCH EXCAVATION AND BACKFILL

A. All trenches shall be excavated to lines and grades and dimensions indicated on the Drawings. All trench excavation, backfill, and compaction shall be in accordance with pertinent provisions of this Section.

B. All pipe work placed inside the trenches shall have a minimum of 8-inch clearance from any protrusions from the trench side walls or bottom.

C. The Earthwork CONTRACTOR shall backfill excavated trenches as promptly as progress of the work permits and immediately after the pipe has been laid, jointed, and tested.

D. The trench bottom shall be compacted to provide a uniform bed for the pipe. Backfill material shall be placed around the pipe and shall be compacted by hand-tamping, or methods acceptable to the CQA CONSULTANT.

E. The Earthwork CONTRACTOR shall compact the select engineered fill for trench backfill to at least 90 percent of the maximum dry density and within 4 percent of the optimum moisture content as determined in accordance with ASTM D1557.

F. Trench backfill shall be placed as shown on the Drawings. The backfill shall not be placed at ambient temperatures below 41o F nor above 100o F unless otherwise specified. The material shall be placed in a manner that does not cause movement or excessive wrinkling of, or induce excessive wrinkling of the geosynthetics. The CONTACTOR shall not operate equipment directly on any geosynthetics.

3.08 TOLERANCES

A. All material limits shall be constructed within a tolerance of ±1.0 ft for horizontal state plan coordinates, 0 to +0.1 ft vertical for reference to mean sea level (MSL), and 0 to +0.1 ft where dimensions are shown or specified as a minimum. The plane of the surface shall not vary more than 0.10 feet when measured with a 10-foot straight edge.

3.09 EXCAVATION BELOW GRADE

A. All excavation shall be performed within the limits of the work to the lines, grades, and elevations indicated and specified herein. The Earthwork CONTRACTOR shall not excavate or remove materials beyond indicated subgrade elevations or dimensions without the approval of the PROJECT MANAGER. The Earthwork CONTRACTOR shall backfill and compact any unauthorized excavation to the satisfaction of the PROJECT MANAGER at no additional cost to the OWNER.

B. When acceptable to the PROJECT MANAGER, lean concrete may be used to bring the bottom elevation of excavations under footings or trenches to correct elevations.

END OF SECTION

SECTION 02270

RIPRAP

PART 1 GENERAL

1.01 SUMMARY

A. This section describes the general requirements for the placement of riprap associated with the final closure construction at the Kettleman Hills Facility Landfill B-19.

B. The CONTRACTOR shall furnish all labor, materials, tools, equipment, supervision, transportation, manufacturing and installation services necessary to furnish and/or place the riprap as shown on the Drawings including the excavation and backfill as required.

1.02 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 02200 - Earthwork

1.03 REFERENCES

A. State of California Department of Transportation (CALTRANS) Standard Specifications, latest editions.

B. American Society for Testing and Materials (ASTM) most current version, latest editions.

C. American Association of State Highway and Transportation Officials (AASHTO), latest editions.

1.04 SUBMITTALS

A. Submit the riprap gradation and durability certification from Supplier a minimum of 2 weeks prior to material placement for review by the CQA Consultant.

B. Submit the granular filter gradation and durability certification from Supplier a minimum of 2 weeks prior to material placement for review by the CQA Consultant.

C. Submit the manufacturer's quality control (QC) certificate(s) for the geotextile. QC certificates shall include roll numbers and identification, sampling procedures, and results of quality control tests verifying that each of the properties listed in Table 02270-2 is met.

D. Submittals shall be in accordance with Section 01300.

1.05 QUALITY ASSURANCE

A. Riprap Source

1. Set up riprap source location inspection meeting with the CQA CONSULTANT and source material owner prior to delivering materials to project site.

2. Identify stock piling procedure.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver and stockpile enough stone onsite for project.

B. Prevent contamination of the stone surfaces with clays or similar materials.

C. Remove any stone that does not conform to this specification.

1. The Engineer may reject any stones not conforming to this specification.

PART 2 PRODUCTS

2.01 RIPRAP

A. Riprap shall consist of material that is mechanically stable and chemically inert. In general, hard rock types such as basalt and granite are preferred; siltstones, mudstones, and carbonate rocks are not acceptable. Riprap shall be free from spoil and inorganic material.

B. Riprap material shall consist of sub-angular to angular material. Riprap shall conform to the gradation specified in Table 02270-1:

Table 02270-1
Riprap Gradation

Rock Size	D_{50} = 6 inch[1]	D_{50} = 12 inch[2]
24-inch	100% passing	90-100% passing
12-inch	90-100 % passing	30-50% passing
6-inch	30-50% passing	0-5% passing
3-inch	0-5% passing	-

Note: [1] Caltrans Facing Rip-rap may be substituted [2] Caltrans Light Riprap may be substituted.

2.02 BEDDING MATERIALS

A. Geotextile Filter

1. The rock slope protection geotextile shall be nonwoven fabric.

2. The geotextile shall be manufactured from polyester, nylon, polypropylene, or polyvinylidene material. The material shall have the following minimum properties:

Table 02270-2
Geotextile Filter Requirements

Property	Test Method	Requirement
Grab Tensile, lbs	ASTM D4632	160 - nonwoven
Tear Strength, lbs	ASTM D4533	55 -nonwoven
Puncture Strength, lbs.	ASTM D4833	55 -nonwoven
Permittivity, 1/sec	ASTM D4491	0.5
Apparent Opening Size (U.S. Sieve)	ASTM D4751	70 – 100
Ultraviolet Stability	ASTM D4355	50 percent

PART 3 EXECUTION

3.01 PREPARATION

A. Install surface and ground water control measures as needed to perform work in dry conditions. Water control measures include, but are not limited to diversions, culverts, sumps with pumps or other means necessary to maintain the level of groundwater below subgrade elevation and to divert surface water away from the work area.

B. Remove all topsoil, loose excavated materials, trees, timber debris, soft yielding material and concrete debris, and other objectionable materials from beneath the areas where the grouted riprap is to be placed and as shown on the Drawings. Do not block natural drainage layers or horizons within the channel bottom.

C. Notify the CQA CONSULTANT before placing riprap elements over geotextile.

3.02 PLACEMENT OF GEOTEXTILE

A. The geotextile shall be placed directly on the prepared surface prior to the placement of riprap. The geotextile shall be placed parallel to slope; horizontal seams on the slopes steeper than 5 horizontal to 1 vertical are not permitted.

B. Geotextile seams shall be joined by overlapping a minimum of 2 feet, in the direction of water flow, at the edges and pinning the overlapped strip with U-shaped wire pins or similar fasteners. Fasteners shall be inserted through both strips of overlapped fabric at increments approximately 4 feet along the overlap. Additional pins shall be installed as necessary to prevent displacement of the fabric.

C. The geotextile shall be anchored along the leading and trailing edges as shown on the Drawings.

D. The CONTRACTOR shall be responsible for field handling, storing, deploying, seaming or connecting, temporary restraining (against wind), anchoring, and other aspects of geotextile installation. The CONTRACTOR shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system.

E. No equipment shall operate directly on the geotextile.

F. Use sandbags or other acceptable anchorage to prevent wind uplift.

G. Repair damaged geotextile by placing a geotextile patch, extending 3 feet in all directions beyond the damaged area. Damaged geotextile shall be repaired or replaced at no expense to the OWNER.

H. After the geotextile has been installed, the riprap may be placed over the completed sections.

I. The CONTRACTOR shall use a placement method for the riprap that does not damage the underlying geotextile. The riprap shall be placed from the bottom of the slope to the top.

J. The riprap shall be placed to the extents and to the thickness shown on the Drawings.

3.03 PLACEMENT OF RIPRAP

A. The CONTRACTOR may place the riprap over completed sections of the geotextile. A geotextile section is considered complete once the CQA CONSULTANT verifies that the geotextile material meets the requirements of this Section of the Specifications.

B. The riprap shall be placed to the limits and thickness shown on the drawings.

C. The riprap need not be compacted, but shall be placed to grade as shown on the Drawings. The riprap shall be placed in such a manner as to ensure that the larger rock fragments are uniformly distributed and the smaller rock fragments fill the voids between the larger rock fragments to produce a well-keyed, densely-placed, uniform layer of riprap of the specified thickness. Hand placing will be required only to the extent necessary to secure the results specified above.

D. Place all stones in a dry condition beginning at the toe of the slope or other lowest point.

END OF SECTION

SECTION 02370

VEGETATION

PART 1 GENERAL

1.01 SUMMARY

A. This section describes the general requirements for vegetating areas associated with the final closure construction at the Kettleman Hills Facility Landfill B-19.

B. The CONTRACTOR shall furnish all labor, materials, tools, equipment, supervision, transportation, manufacturing and installation services necessary to vegetate areas of the final cover as required.

1.02 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 02200 - Earthwork

1.03 REFERENCES

A. State of California Department of Transportation (CALTRANS) Standard Specifications, latest editions.

1.04 SUBMITTALS

A. Submit the seed mix a minimum of 2 weeks prior to starting of vegetation work for review by the CQA Consultant.

B. Submittals shall be in accordance with Section 01300.

1.05 QUALITY ASSURANCE

CQA Consultant to verify adequate seed application.

PART 2 PRODUCTS

2.01 SEED/ FERTILIZER

A. The seed shall be a mixture of Zorro Fescue (Festuca megalura) at a rate of 4.0 lbs/acre and Panoche Red Brome (Bromus rubens) as a rate of 12.0 lbs/acre.

B. Fertilizer shall be either 15-15-15 or 16-20-0 applied at a rate of 500 lbs/acre.

PART 3 EXECUTION

3.01 PREPARATION

A. The area to be seeded should be weed fee and have a firm seed bed which has previously been roughened by scarifying, disking, harrowing, or otherwise worked to a depth of two to four inches. The seed bed may be prepared when earth moving work is completed..

B. The vegetated soil layer should be seeded with the seed mix listed in Section 2.01.

C. The vegetated soil layer should be fertilized with the fertilizer listed in Section 2.01. The fertilizer should be distributed uniformly over the seed bed and incorporated into the soil. Incorporation of the fertilizer may be done as part of the seedbed preparation or as part of the seeding operation unless the seed is broadcast. If fertilizing is a part of the seed bed preparation, it should not be performed more than 15 days prior to seeding.

D. A straw mulch shall be applied at a rate of 4,000 lbs/acre to stabilize the soil and retain moisture during seed germination. At least 50 percent of the applied straw should be more than six inches in length. The mulch should be applied immediately after seeding. To prevent removal of straw by wind, the mulch shall be anchored using either mulching rollers or disks. If disks are used for anchoring they should be dull and run straight.

END OF SECTION

SECTION 02720

CMP DOWNDRAINS

PART 1 - GENERAL

1.01 SUMMARY

A. This section shall apply to the materials and operations required for the installation of CMP downdrains.

B. The extent of the work is indicated on the contract drawings.

C. Related Sections: Refer to the following sections for related work:

1. Section 02200, "Earthwork".

2. Section 03300, "Cast-in-Place Concrete".

1.02 SUBMITTALS

A. Submit anchor detail with supporting documentation of spacing.

1.03 QUALITY ASSURANCE

A. The materials and practices comprising the work shall conform to this and other referenced standard specifications.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

Piping materials shall be unlined corrugated metal pipe (CMP) with 2-2/3 by 1/2-inch or 3 by 1-inch corrugations, or equivalent. The minimum wall thickness shall be 0.064 inches. Each section shall be marked with a permanent label which allows identification of class and type of material. In addition, pipe materials shall conform to the following requirements:

A. Corrugated Steel Pipe and Fittings: Materials for the CMP including base metal, rivets and spelter coating shall be as specified in AASHTO M 36. CMP shall be used for the construction of stormwater downdrains and shall be 36" in diameter, unless otherwise shown on the drawings.

B. Pipe anchors shall be as recommended by the manufacturer for the pipe size installed. Recommendations shall include type and spacing (not to exceed 10 feet).

C. Special sections, such as elbows, tees and wyes shall be of the same gage as the conduit to which they are joined, and shall conform to applicable requirements of ASTM M36.

2.02 JOINTS

Joints shall be supplied with the pipe or fitting. Gasket materials shall be stored in accordance with ASTM C 443. In addition, the joints shall conform to the following requirements:

A. Joints for corrugated steel pipe shall have joining bands which are the same gauge and material as the pipe.

B. When metal end sections are required, the following requirements shall pertain:

a. Metal end sections shall be of the same gage as the conduit.

b. The end of the pipe shall be furnished with annular corrugations to conform to metal end sections so the no leakage results from the connection; however, other designs may be used if approved by the Engineer.

c. When connector sections are used the connector section shall be helical or annular as required to match the type of pipe used.

PART 3 - EXECUTION

3.01 PIPE LAYING

A. General: Provide drainage pipe of the size, and class indicated and install at the locations and elevations indicated on the contract drawings.

B. Pipe installation shall be in accordance with the pipe manufacturer's written installation instructions and with the applicable provisions or requirements of the following referenced handbooks and standard specifications:

Corrugated Steel Pipe: "Handbook of Steel Drainage & Highway Construction Products".

C. Pipe shall be laid on a smoothly-graded, prepared subgrade soil foundation true to alignment and grade as indicated on the contract drawings. Bell holes shall be hand-excavated so that the bottom of the pipe is in continuous contact with the surface of the prepared subgrade material.

D. Pipe laying shall proceed upstream with the spigot ends pointing in the direction of flow. Pipe shall not be laid in standing water or when trench or weather conditions are deemed unsuitable by the Owner or CQA Engineer.

E. Approved backfill material shall be spaded and compacted into the "haunch" area under each side of the pipe so that all void spaces underneath the pipe are filled with compacted backfill material.

F. Approved backfill material shall be placed in the trench along the side of the pipe and compacted by hand up to the top of the pipe. Approved backfill material shall be placed and compacted a minimum of 12" above the top of the pipe.

3.02 CLEANING

A. Prior to laying pipe, the interior of each pipe section shall be cleaned of all soil and debris.

B. After laying and backfilling, all pipe interiors shall be free of all foreign material such as soil, cement mortar, joint compounds, etc. If large amounts of material have accumulated, the Owner may require flushing of the pipe. If flushing is required, any outlets into existing lines will be blocked so that no foreign material is discharged into existing lines.

3.03 INSPECTION

A. Upon arrival at the job site, each section of pipe shall be inspected for compliance with the applicable piping materials product requirements listed in Part 2 of this specification. Any section of pipe found to be defective shall be immediately removed from the job site and shall be replaced by the Contractor at no additional cost to the Owner.

B. Immediately prior to laying, each pipe section shall be visually inspected for defects or damage. Any damaged or defective pipe shall not be used.

C. Pipe roundness shall not vary from a true circle by more than 5% of the pipe's normal diameter and deviation from straight line parallel to pipe length shall not exceed 1/16" per linear foot measured on the concave side.

END OF SECTION

SECTION 02725

HDPE PIPE

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for the manufacture, supply, installation, and quality control (QC) of high density polyethylene (HDPE) pipes, fittings and connections.

1.02 SUBMITTALS

A. Prior to the delivery of any HDPE pipe to the site, Earthwork CONTRACTOR shall submit to ENGINEER for review and approval complete, detailed shop drawings of all HDPE pipe and fittings, a list of materials to be furnished, the name of the pipe manufacturer, and the manufacturer's recommendations for handling, storage, and installation.

B. Earthwork CONTRACTOR shall also submit the pipe manufacturer's certification of compliance with the Specifications, including certification that stress regression testing has been performed in accordance with ASTM D 2837, for all HDPE pipe materials delivered to the site.

C. In addition to the certification cited above, Earthwork CONTRACTOR shall submit in writing the following documentation of the pipe manufacturer on the raw materials used to manufacture the pipe and fittings:

1. certificate of compliance stating the specific resin, its source, and the information required by ASTM D 3350; if in-plant blending of the resin is performed, the pipe manufacturer shall provide a certificate of compliance stating that the blended resin meets the requirements of ASTM D 3350; and
2. certificate of compliance stating that no recycled resin was used in manufacturing the pipe except for a small percentage (i.e., less than 10 percent) of resin generated in the pipe manufacturer's own plan from production using the same resin as the recycled material.

1.03 REFERENCES

A. The American Society for Testing and Materials (ASTM), latest editions:

1. ASTM D 1603 – Standard Test Method for Carbon Black in Olefin Plastics

2. ASTM D 1693 – Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics

3. ASTM D 2657 – Standard Practice for Heat-Joining for Polyolefin Pie and Fittings

4. ASTM D 2837 – Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials

5. ASTM D 3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

6. ASTM F 714 – Standard Specification for Polyethylene (PE) Plastics Pipe (SDR-PR) Based on Outside Diameter

1.04 RELATED SECTIONS

A. Section 02220 - Earthwork

PART 2 PRODUCTS

2.01 MATERIALS

A. HDPE pipe shall be of the diameter and SDR rating (per ASTM F714) as indicated on the plans.

B. The HDPE pipe and fittings shall be manufactured from new, high molecular weight, high density polyethylene (HDPE) resin conforming to ASTM D 3350 (Type III, Class C Category 5, Grade P 64), pipe cell classification PE 345464C according to ASTM D 3350, 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 be permitted if the manufacturer provides a certificate of compliance that the blended resin conforms to the requirements of the Specifications. Pipe and fittings shall be manufactured from the same resin and by the same manufacturer.

C. The polyethylene compound shall contain a minimum of 2 percent carbon black (per ASTM D1603) to withstand outdoor exposure without loss of properties.

D. The polyethylene compound shall have a minimum resistance of 5,000 hours when tested for environmental stress crack in accordance with requirements of ASTM D1693.

2.02 HDPE PIPE AND PIPE FITTINGS

A. Earthwork CONTRACTOR shall provide HDPE pipe having the nominal diameters specified herein and shown on the Drawings.

B. HDPE pipe and fittings shall have a minimum hydrostatic design basis (HDB) of 1,600 pounds per square inch (psi) when determined in accordance with ASTM D 2837 unless otherwise indicated herein or on the Drawings.

C. HDPE pipe shall be supplied in standard laying lengths not exceeding 50 feet.

D. HDPE pipes and fittings shall be homogeneous throughout and free of visible cracks, holes, (i.e., other than intentional manufactured perforations), foreign inclusions, or other deleterious effects, and shall be uniform in color, density, melt index, and other physical properties.

E. Fittings at each end of pipes shall consist of HDPE end caps unless indicated otherwise herein or on the Drawings.

2.03 LABELING

A. The following shall be continuously indent-printed on the HDPE pipe, or spaced at intervals not exceeding 5 feet:

1. name and/or trademark of the pipe manufacturer;
2. nominal pipe size;
3. pipe stiffness;
4. the letters PE followed by the polyethylene grade per ASTM D 3350, and by the Hydrostatic Design Basis in 100's of psi (e.g., PE 3408);
5. test method references (e.g., ASTM D 2412); and
6. a production code from which the date and place of manufacture can be determined.

PART 3 EXECUTION

3.01 GENERAL

A. Transportation of HDPE pipe and fittings shall be the responsibility of Earthwork CONTRACTOR. Earthwork CONTRACTOR shall be liable for all damage incurred prior to and during transportation to the site.

B. Handling, storage, and care of the HDPE pipe and fittings prior to and following installation at the site is the responsibility of Earthwork CONTRACTOR. Earthwork CONTRACTOR shall be liable for all damage to the material incurred prior to final acceptance of the project by OWNER.

C. Earthwork CONTRACTOR shall be responsible for storage of HDPE pipe and fittings at the site. Pipe and fittings shall be stored on clean level ground, preferable 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, spaced suitable and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports. The pipe shall be stored out of direct sunlight (i.e., to minimize pipe bowing). Earthwork CONTRACTOR shall also comply with the pipe manufacturer's recommendations for handling, storage, and installation of HDPE pipe and fittings.

D. Earthwork CONTRACTOR shall exercise care when transporting, handling and placing HDPE pipe and fittings such that they will not be cut, kinked, twisted, or otherwise damaged. 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. Pipe or fittings shall not be dropped onto rocky or unprepared ground. Under no circumstances shall pipe or fittings be dropped into trenches, or dragged over sharp objects.

E. Earthwork CONTRACTOR shall carefully examine all pipe and fittings for cracks, damage, or defects before installation. Defective or damaged materials shall be immediately removed from the site and replaced at no additional cost to OWNER.

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. CQA CONSULTANT will inspect all pipes. Sections of pipe with excessive cuts, gouges or scratches will be rejected and Earthwork CONTRACTOR shall be required to remove and replace the rejected pipe, at no additional cost to 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 cap.

H. 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.

I. Field-cutting of pipes, when required, shall be made with a machine specifically designed for cutting pipe. Cuts shall be carefully made, without damage to pipe or lining, so as to leave a smooth end at right angles to the axis of pipe. Cutter ends shall be tapered and sharp edges filed off smooth. Flame cutting will not be allowed.

J. No pipe shall be laid until CQA CONSULTANT has observed the condition of the pipe.

K. No pipe shall be brought into position until the preceding length has been bedded and secured in its final position.

L. Blocking under piping shall not be permitted unless specifically accepted by PROJECT MANAGER for special conditions or as indicated on the Drawings.

M. Pipe will be inspected in the field before and after placement in the trench. If upon inspection, pipe is found not to be in compliance with the Specifications, it shall be subject to rejection. Any corrective work shall be approved by CQA CONSULTANT. The costs for the corrective work shall be at Earthwork CONTRACTOR's sole expense. Pipe shall be laid to the line and grade shown on the Drawings, with uniform bearing under the full length of the barrel of the pipe. Any pipe which is not in true alignment or shows any undue settlement after laying shall be taken up and relaid at Earthwork CONTRACTOR's sole expense. The joining of the pipe shall be in accordance with the manufacturer's written instructions and the Specifications, as approved by PROJECT MANAGER.

N. All placed pipes shall be surveyed along the top of the pipe to complete the record drawings prior to backfilling. All start points, angle joints, junctions, connections, and end points of the pipe shall be surveyed. All survey work shall conform to the quality and practice required by CQA CONSULTANT, specified herein, and in the CQA Plan.

O. Both during the construction period and immediately prior to acceptance of the construction work by OWNER, Earthwork CONTRACTOR shall keep the pipe free-draining and free of rocks, soil, and debris.

P. Earthwork CONTRACTOR shall provide all necessary adapters and/or pipe connection pieces required when connecting different types and sizes of pipe or when connecting pipe made by different manufacturers. Earthwork CONTRACTOR shall weld flanges to existing Stainless Steel pipes in Phase II for connection of new HDPE pipe.

Q. HDPE pipe shall be jointed with butt fusion joints or eletro-fusion couplers. All joints shall be made in strict compliance with the pipe manufacturer's recommendations and ASTM D2657. Use of adhesives or solvents in the joints will not be allowed.

R. Testing of the HDPE pipe after backfilling and compaction shall be required. Testing shall be performed by Earthwork CONTRACTOR and shall include pulling a test mandrel through the pipe, as specified in Section 306-1.2.12 of the SSPWC. This test will be used to ensure that the pipe has not been excessively deformed, crushed, or blocked during backfilling. Alternative test procedures will require approval by PROJECT MANAGER. Any corrections required due to test failure as evaluated by CQA CONSULTANT, shall be at Earthwork CONTRACTOR's sole expense.

END OF SECTION

SECTION 02751

HDPE GEOMEMBRANES

PART 1 GENERAL

1.01 SUMMARY

A. This section describes the requirements for the manufacture, supply, installation, and quality control (QC) of high density polyethylene (HDPE) geomembrane associated with the final closure construction at the Kettleman Hills Facility, Landfill B-19.

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork

1.03 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D638 - Test Method for Tensile Properties of Plastics
2. ASTM D792 - Specific Gravity (Relative Density) and Density of Plastics
3. ASTM D1004 - Test Method for Initial Tear Resistance of Plastic File and Sheeting
4. ASTM D1238 - Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
5. ASTM D1505 - Test Method for Density of Plastics by Density-Gradient Technique
6. ASTM D1603 - Test Method for Carbon Black in Olefin Plastics
7. ASTM D3895 - Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
8. ASTM D4218 - Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
9. ASTM D4833 - Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
10. ASTM D5199 - Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
11. ASTM D5321 - Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

12. ASTM D 5397 - Procedure to Perform a Single Point Notched Content Tensile Load – Appendix (SP-NCTL) Test

13. ASTM D5596 - Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

14. ASTM D5721 - Practice for Air-Oven Aging of Polyolefin Geomembranes

15. ASTM D5885 - Test Method of Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Colorimetry

16. ASTM D5994 - Test Method for Measuring Core Thickness of Textured Geomembranes

B. Geosynthetics Research Institute (GRI):

1. GRI-GM 10 - Specification for the Stress Crack Resistance of Geomembrane Sheet

2. GRI-GM11 - Accelerated Weathering of Geomembranes Using a Fluorescent UVA – Condensation Exposure Device

3. GRI-GM12 - Measurement of the Asparity Height of Textured Geomembranes Using a Depth Gage.

4. GRI-GM13 - Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

1.04 PRE-QUALIFICATION

A. The Geosynthetic CONTRACTOR shall pre-qualify for geomembrane installation by providing the following documentation:

1. The Geosynthetic CONTRACTOR shall have a minimum of 10,000,000 square feet (sf) of polyethylene geomembrane cumulative installation experience.

2. The Geosynthetic CONTRACTOR shall provide at least three references from prior installation projects in excess of 500,000 sf including the following information:

a. Client's name, address, phone number and contact or representatives name.

b. Project site and description.

c. Geomembrane type and quantity installed.

1.05 SUBMITTALS

A. Submittals shall be provided in general accordance with Section 01300.

B. HDPE Resin: Furnish the following in writing to the CQA CONSULTANT a minimum of seven calendar days prior to geomembrane shipment to the site:

1. Statement of production dates and origin of resin used to manufacture the geomembrane for the project.

2. Certification stating all resin is from the same manufacturer and that no reclaimed polymer was added to the resin during the manufacturing of the geomembrane and that recycled polymer does not exceed 2 percent by weight.

3. Copies of the quality control certificates issued by the manufacturer and resin supplier indicating that the resin used to manufacture the geomembrane meets these specifications. These shall contain manufacturing quality control test results including specific gravity (ASTM D792 or D1505) and melt index (ASTM D1238, Condition E).

C. Manufacturing Quality Control: A copy of the manufacturer's quality control program shall be submitted to the CQA CONSULTANT a minimum of seven calendar days prior to geomembrane shipment to the site. Quality control testing shall be performed by the manufacturer in accordance with GRI-GM13 and as approved by the CQA CONSULTANT. Prior to delivery the following shall be submitted to the CQA CONSULTANT for review:

1. Certificates for each shift's production of geomembrane.

2. Copies of quality control certificates issued by the manufacturer. The quality control certificates shall include:

   a. Roll numbers and identification:

   b. Sampling procedures; and

   c. Results of quality control tests, including descriptions of the test methods used.

3. The results of the manufacturing quality control tests shall meet or exceed the property values listed in Table 02751-1.

4. Geomembrane delivery, storage, handling and installation instructions.

5. Extrudate Beads and/or Rod:

   a. Statement of production dates.

   b. Certification stating all extrudate is from one manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane rolls.

   c. Copies of quality control certificates issued by the manufacturer including test results for specific gravity ASTM D792 and melt index ASTM 1288 Condition E.

D. Geomembrane Installer: Prior to mobilization of the Geosynthetic CONTRACTOR to the site, the following information shall be submitted:

1. Shop drawings indicating panel layout and field seams 14 calendar days prior to installation of geomembrane.

2. Installation schedule.

3. Copy of Geosynthetic CONTRACTOR's letter of approval or license by the geomembrane manufacturer.

4. Installation capabilities, including:

   a. Information on equipment proposed for this project;

   b. Average daily production anticipated for this project; and

   c. Quality control procedures.

5. Provide copies of the quality control/quality assurance program for the manufacturer of the geomembrane liner.

6. Resume of the superintendent to be assigned to this project, including dates and duration of employment.

7. Resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment.

8. The installation crew shall have the following experience.

   a. The superintendent shall have supervised the installation of a minimum of 2,000,000 ft^2 of polyethylene geomembrane and 500,000 ft^2 of geotextile.

   b. The master seamer shall have experience seaming a minimum of 1,000,000 ft^2 of polyethylene geomembrane using the same type of seaming apparatus to be used at this site.

   c. All other seaming personnel shall have seamed at least 100,000 ft^2 of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less than 100,000 ft^2 of polyethylene geomembrane shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.

E. During the installation, the Geosynthetic CONTRACTOR shall be responsible for the timely submission to the CQA CONSULTANT of subgrade acceptance certificates, signed by the Installer, for each area to be covered by geomembrane.

F. The Geosynthetic CONTRACTOR shall furnish the OWNER upon completion of the project:

1. A warranty provided by the manufacturer in accordance with GRI-GM13 against defects in material. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the OWNER.

2. A 1-year warranty provided by the Geosynthetic CONTRACTOR against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the OWNER.

3. As-built panel drawings in compliance with Section 01400.

E. Certificate of calibration less than 12 months old shall be submitted prior to installation for all field tensiometers.

1.06 QUALITY ASSURANCE

A. Perform work in accordance with Section 01400, the Geosynthetic CONTRACTOR's Quality Control Program, and CQA Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. The geomembrane shall be comprised of high density polyethylene (HDPE) material as indicated on the drawings, manufactured of new, first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures.

B. The geomembrane shall be produced free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defect shall be repaired in accordance with the repair procedures in Article 3.06.

C. The geomembrane shall be manufactured with a minimum of 15.0 feet seamless width. There shall be no factory seams.

D. The geomembrane shall be HDPE 80-mil thick and textured on both sides as indicated on the Drawings.

E. The geomembrane shall be supplied in rolls. Folds will not be permitted.

F. Specifications for the HDPE geomembrane properties are presented in Table 02751-1.

G. Resin:

1. Shall be HDPE, new, first quality, compounded and manufactured specifically for producing HDPE geomembrane.

2. Do not intermix resin types.

3. Shall meet the following additional requirements:

Test	Test Designation	Minimum Frequency	Requirements
Specific Gravity[1]	ASTM D 792 Method A	(2)	≥ 0.932
Melt Index	ASTM D 1238 Condition E	(2)	≤ 1.0 g per 10 minutes
Notes: (1) Resin without carbon black (2) 1 test per resin batch			

H. Extrudate Rod or Bead:

1. Shall be made from same resin as the geomembrane.

2. Additives shall be thoroughly dispersed.

3. Shall be free of contamination by moisture or foreign matter.

4. Shall meet the following requirements:

Test	Test Designation	Minimum Frequency	Requirements
Specific Gravity	ASTM D 792 Method A	(1)	≥ 0.940
Carbon Black Content	ASTM D 1603	(1)	2-3%
Melt Index	ASTM D 1238 Condition E	(1)	≤ 1.0 g per 10 minutes
Notes: (1) 1 test per resin batch.			

2.02 DELIVERY, STORAGE AND HANDLING

A. Handling, storage, and care of the geomembrane following transportation to the site shall be the responsibility of the Geosynthetic CONTRACTOR. The Geosynthetic CONTRACTOR shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the CQA ENGINEER.

B. Conform to the manufacturer's requirements to prevent damage to geomembrane.

C. Delivery:

1. Deliver materials to the site only after the CQA CONSULTANT and the OWNER approve required submittals.

2. All rolls of geomembrane delivered to the site shall be identified at the factory with the following:

a. Manufacturer's name

b. Product identification and thickness

c. Lot number

d. Roll number

e. Roll dimensions

3. Separate damaged rolls from undamaged rolls and store at locations designated by the OWNER until proper disposition of material is determined by the OWNER the CQA CONSULTANT.

4. The OWNER will be the final authority regarding damage.

5. Separate rolls without proper documentation and store until CQA CONSULTANT approval is received.

D. On-Site Storage:

1. Store in space allocated by the OWNER.

2. Protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage.

3. Store on level prepared surface (not on wooden pallets).

4. Stack per manufacturer's recommendation but no more than three rolls high.

E. On-Site Handling:

1. Use appropriate handling equipment to load, move or deploy geomembrane rolls. Appropriate handling equipment includes cloth chokers and spreader bar for loading, spreader and roll bars for deployment. Dragging panels on ground surface will not be permitted.

2. Do not fold geomembrane material; folded material shall be rejected.

3. The Geosynthetic CONTRACTOR is responsible for storage, and transporting material from storage area to liner facility.

F. Damaged Geomembrane:

1. Geomembrane damage will be documented by the CQA CONSULTANT.

2. Damaged geomembrane shall be repaired, if possible, in accordance with these specifications or shall be replaced at no additional cost to the OWNER.

2.03 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:

1. Equipped with gauges showing temperatures both in apparatus and at nozzle (extrusion welder) or at wedge (fusion welder).

2. Maintain adequate number of welding apparatus to avoid delaying work.

3. Use power source capable of providing constant voltage under combined-line load.

4. Provide secondary containment to catch spilled fuel under electric generator, if located on geomembrane.

B. Provide calibrated tensiometer capable of quantitatively measuring geomembrane strength:

1. Equipped with gauge accurate to ± 2 lbs per inch of geomembrane width and capable of pulling at 2 inches per minute and 20 inches per minute.

2. Provide one inch die for cutting sample specimens.

3. Provide certificate of tensiometer calibration within the past 12 months.

PART 3 EXECUTION

3.01 EXAMINATION

A. The Geosynthetic CONTRACTOR shall document in writing that the surface on which the geomembrane will be installed is acceptable. In so doing the Geosynthetic CONTRACTOR shall assume full liability for the accepted surface.

B. The beginning of installation means acceptance of existing conditions. The Geosynthetic CONTRACTOR shall be responsible for maintenance of the geomembrane covered subgrade once installation of geomembrane begins.

3.02 PREPARATION

A. Maintain the surface suitability and integrity until the lining installation is completed and accepted.

B. Repair rough areas and any damage to the subgrade caused by installation of the lining and fill any ruts in subgrade caused by equipment prior to geomembrane deployment.

C. To avoid sharp bends in the geomembrane, bevel the leading edges of the anchor trench.

D. Subgrade shall be smooth, uniform, firm and free from rocks or other debris. For deployment over soil subgrade, no rocks or protrusions greater than 0.5 inch in diameter shall be exposed at the subgrade surface.

3.03 DEPLOYMENT

A. Geomembrane shall not be deployed:

1. During precipitation:

2. In the presence of excessive moisture;

3. In areas of ponded water;

4. In the presence of excessive winds (i.e., greater than 20 mph); and

5. In excessive heat (i.e., greater than 110° F) or cold (i.e., less than 40° F).

B. Each panel shall be marked with an "identification code" (number or letter) consistent with the layout plan. The identification code shall be simple and logical. The number of panels deployed in one day shall be limited by the number of panels which can be seamed on the same day. All deployed panels shall be seamed to adjacent panels by the end of each day.

C. The following is the acceptable method of deployment:

1. Use equipment which will not damage geomembrane by handling, trafficking, leakage of hydrocarbons or other means.

2. Do not allow personnel working on geomembrane to wear damaging shoes, or engage in activities that could damage geomembrane.

3. Smoking on the liner is prohibited.

4. Round sharp corners of clamps and other metal tools used in the work area.

5. Do not allow clamps and other metal tools to be tossed or thrown.

6. Unroll panels with a method that protects geomembrane from scratches and crimps and protects soil surface and underlying geotextile from damage.

7. Use a method to minimize wrinkles, especially differential wrinkles between adjacent panels.

8. Place adequate hold-downs to prevent uplift by wind.

9. Use hold-downs that will not damage geomembrane such as sandbags.

10. Use continuous hold-downs along leading edges to minimize risk of wind flow under panels.

11. Panels shall be deployed perpendicular to slope elevation contours and the generation of seams shall be minimized.

12. Protect geomembrane in heavy traffic areas by geotextile, extra geomembrane or other suitable materials.

13. Do not allow vehicular traffic on geomembrane surface.

14. Panels deployed on grades steeper than 12% shall extend a minimum of 3 feet beyond the crest or toe of that grade.

15. Shingles or overlap panels in a downward direction to facilitate drainage.

16. Rub sheets used during installation shall be removed prior to placement of subsequent panels.

D. Visually inspect sheet surface during unrolling of geomembrane and mark faulty or suspect areas for repair or test. Replace faulty (requires more than one patch per 200 square feet) geomembrane stock at no additional cost to the OWNER.

3.04 FIELD SEAMING

A. Orient seams perpendicular to slope elevation contours, i.e., orient down (not across) slope and use seam numbering system compatible with panel number system.

B. Minimize the number of field seams in corners, odd-shaped geometric locations, sumps, and outside corners.

C. Overlap panels by a minimum of 3 inches for extrusion welding and 4 inches for fusion welding. Use procedures to temporarily bond adjacent panels together that do not damage the geomembrane and that are not detrimental to seam weld material for extension welding.

D. Do not use solvent or adhesive unless product is approved in writing by the OWNER.

E. No horizontal seams shall be allowed on grades steeper than 12% or within 3 feet of the crest or toe of slopes. A horizontal seam is defined as more than half of the panel width.

F. Clean surface of grease, moisture, dust, dirt, debris or other foreign material.

G. Prior to any extrusion welding, the geomembrane seam or repair shall be prepared as follows:

1. Clean surface of oxidation by disc grinder or equivalent not more than one hour before seaming; use number 80 grit sandpaper for the disc grinder. Bevel edges of geomembrane before bonding and provide continuous tacking in repair areas.

2. Repair area where excessive grinding substantially reduces sheet thickness by more than 4 mils beyond extent of weld.

3. Clean grinding dust around weld area after grinding.

4. The following procedure shall be followed for wrinkles and fishmouths.

   a. Cut along the ridge of the wrinkle or fishmouth.

   b. Overlap a minimum of 3 inches and seam.

c. Any portion where the overlap is less than 3 inches shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 inches beyond the cut in all directions.

5. If required, a firm, dry substrate (piece of geomembrane or other material) may be placed directly under the seam overlap to achieve proper support.

6. Keep water from intercepting the weld during and immediately after welding the seam.

7. For existing welds, or welds that are over 3 minutes old, grind the existing weld two inches back from point of termination and restart welding on ground weld.

H. At least one spare operable seaming apparatus shall be maintained for every three seaming teams. Place protective fabric or piece of geomembrane beneath hot welding apparatus when resting on geomembrane lining and use an electric generator capable of providing constant voltage under combined line load. The electric generator shall generally be located outside of liner. Provide protective lining and secondary containment large enough to catch spilled fuel under electric generators when located on the liner. The welding apparatus shall be equipped with gauges giving temperatures in apparatus and at nozzle.

I. For extrusion welding, purge welding apparatus of heat-degraded extrudate before welding if extruder is stopped for longer than five minutes. All purged extrudate shall be disposed of off the geomembrane. Each extruder shoe shall be inspected daily for wear to assure that its offset is the same as the geomembrane thickness. Repair or replace worn shoes, damaged or misaligned armature brushes, nozzle contamination, or other worn or damaged parts. Avoid stop-start welding. Remove extrudate rod from welder when not using welder for long period (over two hours). No welding may commence on the liner until the field trial seam sample, made by that equipment and seamer, passes destructive testing.

J. Test and set "hot air system" using scrap material at least each day prior to commencing seaming and adjust hot air velocity to preclude wind effects. Adjust contact pressure rollers to prevent surface ripples in sheet. No equipment shall be used for welding the geomembrane until a field trial seam sample made by that equipment has passed destructive testing.

K. In performing hot wedge welding, the welding apparatus shall be automated vehicular mounted devices equipped with gauges giving applicable temperatures and pressures. The edge of cross seams shall be ground to a smooth incline (top and bottom) prior to welding. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage. Protect against moisture buildup between sheets. If welding across cross seams, conduct field test seams at least every two hours, otherwise once prior to start of work and once at mid-day. No equipment is allowed to commence welding on geomembrane until the field trial seam sample made by that equipment has passed destructive testing.

L. Field trial seams shall be conducted, per seaming apparatus and per seamer, on pieces of geomembrane liner to verify adequate seaming conditions at the following frequency:

1. At beginning of each seaming period.

2. At least once every five hours.

3. At the discretion of the CQA CONSULTANT.

M. Make the trial seams at area of seaming and in contact with subgrade or GCL (same condition as the liner to be seamed). The seam sample shall be at least 42-inches long and 12-inches wide with the seam centered lengthwise. A one foot length of each trial seam sample shall be submitted to the CQA CONSULTANT for archive. Cut three 1-inch wide specimens and test two for peel adhesion, and one for bonded seam strength (shear). Each double wedge fusion seam specimen shall be tested for peel on both sides of the weld. A specimen passes when:

1. The break is film tearing bond (FTB) conforming to National Sanitation Foundation (NSF) Standard 54, Definition 2.15.

2. The break is ductile.

3. The strength of breaks for the trial seam testing shall conform to the values listed in Table 02751-1, included at the end of this section.

N. A trial seam sample passes when all specimens have passing results in peel and shear tests. If a specimen fails (one of the specimens fails in either peel or shear mode), the trial seam procedure shall be repeated in its entirety. If the repeated trial seam fails, the seaming apparatus or operator may not weld until the deficiencies or conditions are corrected and two consecutive passing field trial seams are achieved.

O. The following procedures shall by followed during cold weather conditions.

1. Geomembrane surface temperatures shall be determined by the CQA CONSULTANT at intervals of at lease once per 100 feet of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32° F.

2. For fusion welding, preheating may be waived by the OWNER based upon a recommendation by the CQA CONSULTANT, if the Geosynthetic CONTRACTOR demonstrates to the CQA CONSULTANT's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

3. If preheating is required, the CQA CONSULTANT will observe all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.

4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.

5. All preheating devices shall receive approval by the CQA CONSULTANT prior to use.

6. Additional destructive tests will be taken at an interval between 250 and 500 feet of seam length, at the discretion of the CQA CONSULTANT.

7. Sheet grinding may be performed before preheating, if applicable.

8. Trial seaming shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 10° F from the initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during the temperature drop.

P. The following procedures shall by followed during warm weather conditions.

1. At ambient temperatures above 104° F, no seaming of the geomembrane shall be permitted unless the Geosynthetic CONTRACTOR can demonstrate to the satisfaction of the CQA CONSULTANT that the geomembrane seam quality is not compromised. Trial seaming shall be conducted under the same ambient temperature conditions as the production seams. At the option of the CQA CONSULTANT, additional destructive testing may be required for any suspected areas.

3.05 FIELD QUALITY CONTROL

A. The Geosynthetic CONTRACTOR shall designate a full-time quality control (QC) technician who shall be responsible for supervising and/or conducting the field quality control program. The QC technician may not be replaced without written authorization by the OWNER.

B. Non-Destructive Seam Testing

1. The Geosynthetic CONTRACTOR shall non-destructively test field welds for continuity over their full length using vacuum test units. The non-destructive testing shall be performed concurrently with seaming work progress, not at the completion of all seaming. Any defects located in the seam shall be repaired in accordance with Article 3.06. The following non-destructive testing procedures shall be used to test the field seams for continuity.

a. Vacuum box testing for extrusion welds.

b. Air pressure testing for double fusion seams.

2. Vacuum Box Testing

a. The vacuum box testing equipment shall comprise the following.

i. Rigid housing; transparent viewing window; a soft rubber gasket attached to bottom of housing; porthole or valve assembly; and a vacuum gauge.

ii. A vacuum pump capable of applying 5 psi gage pressure of vacuum to the box.
iii. A bucket of soapy solution and applicator.

b. The procedure for vacuum testing is as follows:

i. Clean window, gasket surfaces, and check for leaks.
ii. Energize vacuum pump and reduce tank pressure to approximately 5 psi.
iii. Wet a strip of geomembrane approximately 12 inches by 30 inches (length of box) with soapy solution.
iv. Place box over wetted area and compress.
v. Close bleed valve and open vacuum valve.
vi. Ensure that a leak tight seal is created.
vii. Examine length of weld through viewing window for presence of soap bubbles for a period of not less than 10 seconds.
viii. If no bubbles appear after 10 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three inches overlap and repeat process.
ix. Areas where soap bubbles appear will be marked by the CQA CONSULTANT with a defect code. The Geosynthetic CONTRACTOR shall then repair the area in accordance with Article 3.06 and retest the repaired area.

3. Air Pressure Testing (Double Fusion Seams Only)

a. The air pressure testing equipment shall comprise the following.

i. An air pump, equipped with pressure gauge with an accuracy of 1 psi, capable of generating and sustaining a pressure between 25 to 30 psi and mounted on a cushion to protect geomembrane.
ii. Rubber hose with fittings and connections.
iii. Sharp hollow needle or other pressure feed device approved by the OWNER.

b. To perform the test:

i. Seal both ends of the seam to be tested.
ii. Insert a needle or other approved pressure feed device into tunnel created by double hot wedge seaming and insert a protective cushion between air pump and geomembrane.
iii. Energize air pump to 25 to 30 psi, close valve, and sustain pressure for a minimum of five minutes.
iv. If loss of pressure exceeds 2 psi or does not stabilize, locate faulty area and repair in accordance with Article 3.06.
v. Release pressure at opposite end of seam from gauge to verify that the seam is not blocked.
vi. Remove approved pressure feed device and seal penetration holes by extrusion welding.

C. Destructive Seam Testing

1. For destructive seam testing, the CQA CONSULTANT shall be provided with a minimum of one sample per 500 feet of seam length by each welding apparatus. The location will be selected by the CQA CONSULTANT and the Geosynthetic CONTRACTOR will not be informed of the sample location in advance. The Geosynthetic CONTRACTOR shall visually observe, mark and repair suspect welds before release of a section to the CQA CONSULTANT for destructive sample marking. Cut destructive samples as seaming and nondestructive testing progresses, prior to completion of liner installation. The CQA CONSULTANT will mark destructive samples with consecutive numbering, location, apparatus I.D., technician I.D., Engineer I.D., and apparatus settings and date. Record, in written form, weld and test date, time, location, seam number, ambient temperatures, machine settings, technician I.D., apparatus I.D., and pass or fail description. The Geosynthetic CONTRACTOR shall immediately repair holes in geomembrane resulting from obtaining destructive samples and vacuum test patches. The size of destructive samples shall be 12 inches wide by 44 inches long with seam centered lengthwise.

2. Two 1-inch wide specimens shall be taken from each side of the sample and tested by the Geosynthetic CONTRACTOR for peel and shear in the field prior to CQA destructive testing. If any of these specimens fail, the Geosynthetic CONTRACTOR shall track the failure immediately. The remaining sample shall be cut into three 14-inch long by 12 inches wide pieces and distributed as follows:

   a. To the CQA CONSULTANT for destructive testing.

   b. To the CQA CONSULTANT for archive.

   c. To the Geosynthetic CONTRACTOR for its use.

3. Ten 1-inch wide specimens shall be taken from one piece. Five specimens shall be tested for peel and five for shear in accordance with the CQA Plan, with test results meeting the requirements of Table 02751-1, included at the end of this section. In the event of failure, the procedures for failed seam tracking are:

   a. Retrace welding path a minimum of 10 feet in both directions from the failed test location and remove (at these locations) a one inch wide specimen for testing. Repeat tracking procedures until the Geosynthetic CONTRACTOR is confident of seam quality.

   b. Obtain destructive samples from each side of the welding path and give samples to the CQA CONSULTANT for destructive testing.

   c. Repeat process if additional tests fail.

   d. Reconstruct seam between passing test locations to satisfaction of the CQA CONSULTANT.

   e. Reconstruction may be one of the following:

i. Cut out old seam, reposition panel and re-seam.
ii. Add cap strip.

f. Cut additional destructive samples from reconstruction at discretion of CQA CONSULTANT.

g. If additional destructive sample results are not acceptable, repeat process until reconstructed seam is judged satisfactory by the CQA CONSULTANT.

D. For final seaming inspection, check the seams and surface of geomembrane for defects, holes, blisters, undispersed raw materials, or signs of contamination by foreign matter. Brush, blow, or wash geomembrane surface if dirt inhibits inspection. The CQA CONSULTANT shall decide if cleaning of geomembrane surface and welds is needed to facilitate inspection. Distinctively mark repair areas and indicate required type of repair.

3.06 REPAIR PROCEDURES

A. 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 Geosynthetic CONTRACTOR if surface contamination inhibits inspection. The Geosynthetic CONTRACTOR shall ensure that an inspection of the geomembrane precedes any seaming of that section.

B. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

C. Repair, removal and replacement shall be at the Geosynthetic CONTRACTOR's expense.

D. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. The Geosynthetic CONTRACTOR shall be responsible for repair of damaged or defective areas. Agreement upon the appropriate repair method shall be decided between the CQA CONSULTANT and the Geosynthetic CONTRACTOR. Procedures available include:

1. Patching: Used to repair holes (over 1/4-inch diameter), tears (over 1/4 inch long), undispersed raw materials, and contamination by foreign matter.

2. Grinding and welding: Used to repair pinholes, blemishes and over-grinding.

3. Capping: Used to repair large lengths of failed seams.

4. Removing the seam and replacing with a strip of new material.

E. In addition, the following procedures shall be observed.

1. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.

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

3. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA CONSULTANT.

4. Extend patches or caps at least 6 inches beyond the edge of the defect, i.e., be a minimum of 12 inches in diameter, and round all corners of material to be patched.

5. Bevel the edge of the patch and do not cut patch with repair sheet in contact with geomembrane. Temporary bond the patch to the geomembrane with an approved method, extrusion weld the patch and then vacuum test the repair.

F. Repair Verification:

1. Number and log each patch repair (performed by the CQA CONSULTANT).

2. Non-destructively test each repair using methods specified in this Section.

3. Provide daily documentation of non-destructive and destructive testing to the CQA CONSULTANT. The documentation shall identify seams that initially failed the test and include the evidence that these seams were repaired and retested successfully.

3.07 ACCEPTANCE

A. The Geosynthetic CONTRACTOR shall retain OWNERSHIP and responsibility for the geomembrane until acceptance by the OWNER.

B. Acceptance Criteria: The following shall be completed:

1. Verification of adequacy of field seams, repairs and testing by the CQA CONSULTANT.

2. All submittals.

3. "As-built" drawings, approved and final drawings submitted.

4. Construction area cleaned.

5. Final field inspection

6. Warranty signed over to the OWNER.

C. Field Inspections: Inspect the completed work with the OWNER; defects, wrinkles, suspicious looking welds shall be noted and marked; document, correct and arrange further field inspections until no corrective action is necessary.

TABLE 02751-1
REQUIRED PHYSICAL PROPERTIES OF 40 and 60-MIL
TEXTURED HDPE GEOMEMBRANE

PROPERTY	METHOD	40 mil	60 mil
Thickness, mil.	ASTM D 5994	- 38 minimum average - 36 lowest indiv. value for 8 out of 10 specimens - 34 lowest indiv. value for any of the 10 specimens	- 57 minimum average - 54 lowest indiv. value for 8 out of 10 specimens - 51 lowest indiv. value for any of the 10 specimens
Sheet Density (min.)	ASTM D 792 or ASTM D 1505	0.940	0.940
Asperity Height (min. ave.)	GM12	10 mil	10 mil
Min. Ave. Tensile Properties [1] • Tension at Yield (lb/in) • Strain at Yield (%) • Tension at Break (lb/in) • Strain at Break (%)	ASTM D 6693	 84 12 60 100	 126 12 90 100
Tear Resistance, lbs. (min. ave.)	ASTM D1004, Die C	28	42
Oxidative Induction Time (OIT) (min. ave.) • Standard OIT, or • High Pressure OIT	 ASTM D3895 ASTM D5885	 100 minutes 400 minutes	 100 minutes 400 minutes
Oven Aging at 85°C • Standard OIT (min. ave.), % retained after 90 days, or • High Pressure OIT (min. ave.), % retained after 90 days	 ASTM D5721 ASTM D3895 ASTM D5885	 55% 80%	 55% 80%
UV Resistance • High Pressure OIT (min. ave.)	GRI-GM11 ASTM D5885	 50%	 50%
Stress Crack Resistance (min. hours with no failures)	ASTM D5397 (Appendix)	300	300
Puncture Resistance, lbs. (min. ave.)	ASTM D4833	60	90
Carbon Black Content (allowable range in percent)	ASTM D1603	2.0 – 3.0	2.0 – 3.0
Carbon Black Dispersion	ASTM D5596	- minimum 9 out of 10 specimens in category 1 or 2 - all 10 specimens in Category 1, 2, or 3	- minimum 9 out of 10 specimens in category 1 or 2 - all 10 specimens in Category 1, 2, or 3
Seam Strength • Peel (lb/in) (fusion/ ext.) • Shear (lb/in)	 ASTM D4437	 65 / 52 81	 98 / 78 121

Notes: (1) Elongation at yield and elongation at break shall be calculated using a gage length of 1.3 inches and 2.0 inches, respectively.

END OF SECTION

SECTION 02752

GEOTEXTILES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for the manufacture, supply, installation, and quality control (QC) of geotextiles.

1.02 RELATED SECTIONS

A. Section 02220 – Earthwork

B. Section 02751 – HDPE Geomembranes

1.03 REFERENCES

A. Latest version of the American Society for Testing and Materials (ASTM) standards:

1. ASTM D4355. Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.

2. ASTM D4632. Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)

3. ASTM D4833. Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products

4. ASTM D4873. Standard Guide for Identification, Storage, and Handling of Geotextiles.

5. ASTM D5199. Standard Test Method for Measuring Geotextiles

6. ASTM D5261. Standard Test Method for Measuring Mass Per Unit Area of Geotextiles.

1.04 SUBMITTALS

A. Quality Control Submittals:

1. A copy of the manufacturer's quality control (QC) plan.

2. Manufacturing QC certificates for each production run. The certificates shall identify the origin and the manufacturer of the resin. The certificates shall be signed by responsible parties employed by the manufacturer (such as the production manager). Tests shall be performed at the frequency indicated in the manufacturer's QC Plan.

3. The QC certificates shall include roll numbers and identification, sampling procedures, and results of quality control tests verifying that each of the properties

listed in Table 02752-1 is met. Samples shall be tested at a minimum frequency of once every 100,000 sf. The manufacturer quality control tests to be performed include the tests specified in Article 2.01 of this section.

4. Manufacturer's certification that the geotextile products meet or exceed specified requirements and are 100% free of needles.

B. The Geosynthetic CONTRACTOR shall submit the following.

1. Installation plan: and

2. Proposed seam stitching methods.

C. Submittals shall be in accordance with Section 01300.

1.05 QUALITY ASSURANCE

A. Perform work in accordance with the CQA Plan.

1.06 QUALIFICATIONS

A. Geotextile shall be supplied by a geotextile manufacturer meeting the following qualification requirements:

1. The geotextile manufacturer shall be responsible for the production and delivery of geotextile rolls and shall be a well-established firm with more than two years experience in the manufacture of geotextiles. The geotextile manufacturer shall submit a statement to the CQA CONSULTANT listing:

a. Certified minimum average roll property values of the proposed geotextiles and the test methods used to determine those properties.

b. Projected delivery date of the material for this project.

B. The Geosynthetic CONTRACTOR shall meet the requirements of the CQA Plan.

PART 2 PRODUCTS

2.01 MATERIALS

A. Non-woven geotextiles shall have the following minimum average roll value (MARV) properties:

TABLE 02752-1

REQUIRED PHYSICAL PROPERTIES OF GEOTEXTILE

Fabric Property	ASTM Test Method	Manufacturer QC Test Frequency [1]	Required Test Values
Mass Per Unit Area (min. ave.)	D-5261	1 per 100,000 sf	12 oz/sy
Grab Strength (min. ave.)	D-4632	1 per 100,000 sf	300 lbs
Puncture Strength (min. ave.)	D-4833	1 per 100,000 sf	180 lbs
UV Resistance	D-4355	1 per resin formulation	70 percent [2]

Notes: (1) Manufacturer may elect to provide certification of values for geotextiles.
(2) After 500 hours of exposure.

B. Geotextile shall be non-woven, needle-punched polyester or polypropylene fabric free from needles or other foreign material.

2.02 DELIVERY, STORAGE, AND HANDLING

A. Handling, storage, and care of the geotextiles following transportation to the site shall be the responsibility of the CONTRACTOR. The CONTRACTOR shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the CQA CONSULTANT.

B. The CONTRACTOR shall be responsible for storage of the geotextile at the site after the material is delivered. The geotextile shall be stored off the ground and out of direct sunlight, and shall be protected from mud, dirt, dust, and any additional storage procedures required by the Geotextile manufacturer.

C. All rolls of geotextile shall be identified at the factory with the following:

1. Manufacturer's name
2. Product identification
3. Lot Number
4. Roll number
5. Roll dimensions

D. Geotextiles shall be handled in a manner as to ensure they are not damaged in any way.

E. Precautions shall be taken to prevent damage to underlying materials during placement of the geotextile.

F. After unwrapping the geotextile from its cover, the geotextile shall not be left exposed for a period in excess of 30 days.

PART 3 EXECUTION

3.01 INSTALLATION

A. Geotextile seams shall be continuously sewn or heat bonded. Geotextile seams shall be overlapped a minimum of 6 inches prior to sewing. No horizontal seams shall be allowed on slopes steeper than 5 horizontal to 1 vertical.

B. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile, shall be used for all sewing. The seams shall be sewn using Stitch Type 401. The seam type shall be Federal Standard Type SSa-1.

C. The CONTRACTOR shall examine the entire geotextile surface after installation to ensure that no potentially harmful foreign objects are present. Such foreign objects shall be removed and damaged geotextile shall be repaired or replaced at no cost to OWNER.

D. Use care not to damage underlying materials during installation.

E. Prevent the geotextile from accumulating excessive dust.

F. The CONTRACTOR shall be responsible for field handling, storing, deploying, seaming or connecting, temporary restraining (against wind), anchoring, and other aspects of geotextile installation. Specifically, the CONTRACTOR shall follow the guidelines in ASTM D 4873 regarding the placement, handling and storage or geotextiles.

G. The CONTRACTOR shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system.

H. No equipment shall operate directly on the geotextile.

I. Use sandbags or other acceptable anchorage to prevent wind uplift.

3.02 REPAIRS

A. Any holes or tears in the geotextile shall be repaired using a geotextile patch consisting of the same geotextile.

1. On slopes inclined steeper than 10 horizontal to 1 vertical, patches shall be sewn into place with a minimum 6-inch overlap.

2. On slopes inclined at 10 horizontal to 1 vertical or less, patches may be heat-bonded with a 6-inch overlap in all directions.

END OF SECTION

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. This section covers all cast-in-place concrete, including reinforcing steel, finishing, curing, and other appurtenant work.

B. The Earthwork CONTRACTOR shall furnish all labor, equipment, materials and incidentals necessary to complete all concrete work as shown on the Drawings and specified herein.

C. All concrete designs shall be based on 4000 psi concrete. The minimum allowable concrete strength shall be 4000 psi.

1.02 REFERENCE STANDARDS AND DOCUMENTS

A. Except as otherwise indicated on the Drawings or stated in these Specifications, materials, equipment, details, and construction methods shall comply with the applicable provisions of the Standard Specifications for Public Works Construction (SSPWC).

B. All concrete work shall be in conformance with the recommended practices of American Concrete Institute (ACI-301). All concrete design and details shall conform to requirements of latest publication of ACI-318. All steel reinforcements shall comply with the Concrete Reinforcing Steel Institute (CRSI) "Manual of Standard Practices."

1.03 SUBMITTALS

A. The source and quality of concrete materials and the concrete proposed for the work shall be submitted to the CQA CONSULTANT for review prior to any concrete placement.

B. Submit written reports to CQA CONSULTANT of each proposed mix for each class of concrete at least 15 days prior to start of Work. Do not begin concrete production until proposed mix designs have been reviewed by CQA CONSULTANT.

C. Submittals shall be in accordance with Section 01300 of these Specifications.

1.04 QUALITY ASSURANCE/CONTROL

A. The Earthwork CONTRACTOR shall adhere to Section 01400 of these Specifications.

B. The CQA CONSULTANT shall monitor the placement of the reinforcing steel and concrete. CONTRACTOR shall prepare and test three (3) test cylinders for every 50 cubic yard of concrete delivered to the site. One (1) test cylinder shall be tested at 7 days and two (2) test cylinders shall be tested at 28 days, in accordance with ASTM C39. The average of the 28-day results shall not be less than the specified strength.

PART 2 MATERIALS

2.01 MATERIAL REQUIREMENTS

A. Cement - ASTM C150, Type II.

B. Fine Aggregate - Clean natural sand, ASTM C33.

C. Coarse Aggregate - Crushed rock, washed gravel, or other inert granular material conforming to ASTM C33.

D. Water - Potable, clean and free from deleterious substances, ASTM C94

E. Reinforcing Steel - ASTM A615, deformed, Grade 60. Wire fabric shall conform to ASTM A185.

F. Membrane Curing Compound - Federal Specification TT-C-800, Type I, Class 1; minimum 18 percent solids; non-yellowing; unit moisture loss 0.039 gm/cm2 mas; Gifford-Hill "Sealco 800," ProSoCo "Kure and Seal," Protex "Acrychlor," or Sonneborn "Kure-N-Seal."

G. Polyethylene Film - PS17; 6 mil.

H. Fly Ash – ASTM C618, Type F.

I. Water Reducing Admixture: ASTM C494, Type A.

J. Tie Wire: Minimum 16 gauge, annealed type.

2.02 MIX DESIGN

A. Prepare and submit design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 310. For the trial batch method, use an independent testing agency acceptable to CQA CONSULTANT for preparing and reporting proposed mix designs.

B. Use water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete, as required, for placement and workability, as approved by Construction Manager.

C. Unless otherwise specified, concrete mix shall be controlled within the following limiting requirements:

1. Cement Content - Not less than 550 pounds per cubic yard.
2. Water to Cement Ratio – Not to exceed 0.50.
3. Consistency - Workable, without segregation, with slump not more than 5 inches when concrete is placed.
4. Mixing - Thoroughly in a batch mixer for not less than 4 minutes at high speed.
5. Compressive Strength - 3000 psi at 28 days in accordance with ASTM C39.
6. Maximum Aggregate Size – 1-inch.

2.03 CONCRETE FORMS

A. Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions indicated on the drawings. Forms shall be substantial and sufficiently tight to prevent leakage and shall be maintained in proper position and accurate alignment. Forms shall be thoroughly cleaned and oiled before concrete is placed and shall not be removed until the concrete has hardened sufficiently to support all loads without damage.

B. Forms for Exposed Finish Concrete: Plywood, metal, metal-framed plywood faced, or other acceptable panel-type materials to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings.

1. Use plywood complying with U. S. Product Standard PS-1 "B-B Concrete Form) Plywood," Class I, Exterior Grade or better, mill-oiled and edge-sealed, with each piece bearing legible inspection trademark.

C. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.

D. Form Release Agent: Provide commercial formulation form release agent with a maximum of 350 mg/l volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

PART 3 EXECUTION

3.01 FORMS

A. Construct forms to sizes, shapes, lines, and dimensions shown and to obtain accurate alignment, location, grades, level, and plumb work in finished structures.

B. Fabricate forms for easy removal without hammering or prying against concrete surfaces.

C. Chamfer exposed corners and edges as indicated, using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.

D. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before placing

concrete. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

3.02 PLACING REINFORCEMENT

A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports and as specified.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as approved by Construction Manager.

D. Place reinforcement to maintain minimum coverage as indicated for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

E. All concrete slabs and foundations shall have a minimum steel content of ½-inch diameter bar at 18-inches on center unless otherwise shown on the Drawings.

3.03 PLACEMENT OF CONCRETE

A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. General: Comply with ACI 304, "Guide for Measuring, Mixing, Transporting, and Placing Concrete", and as specified.

C. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened sufficiently to cause seams or planes of weakness.

D. Concrete shall be conveyed to the point of final deposit and placed by methods which will prevent the separation or loss of the ingredients.

E. Re-tempering of concrete or mortar which shows evidence of initial set shall not be permitted. Such concrete or mortar materials are unacceptable and shall be disposed away from the work site or as directed by the ENGINEER.

F. Appropriate mechanical vibration shall be used in order to thoroughly work concrete around reinforcement and embedded fixtures and into corners of the forms during placing operations.

G. Unless otherwise authorized, compaction shall use immersion-type vibrators. Compaction shall result in concrete free of voids. Exercise care to compact concrete vigorously and thoroughly to obtain maximum density. Concrete shall be consolidated within 15 minutes after its placement in the forms.

H. Where depositing concrete by chute, provide equipment of such size and design as to ensure a continuous flow in the chute. Provide the discharge end of the chute with a baffle plate to prevent segregation. Position the chute so that the concrete will not need to flow more than 5 feet horizontally.

Do not drop concrete from the end of a chute a distance greater than 3 times the horizontal thickness of the layer being deposited, with a maximum distance of 5 feet. Where the distance from the end of the chute to the surface of the concrete exceeds these distances, use a spout (tremie) and maintain the lower end as near to the surface of deposits as practical. When the operation is intermittent, discharge the chute into a hopper.

I. Concrete shall be discharged at the job within 1.5 hours after the cement has been added to the water or the aggregates, except when the air temperature exceeds 85° F, the time shall be reduced to 45 minutes.

J. Immediately after completion of trowel finish, surfaces shall be slightly roughened by brushing with a fiber-bristle brush in the directing of drainage.

K. Immediately following completion of finishing operations and after concrete has taken initial set, the floor shall be covered to prevent evaporation of water from the concrete, curing shall be accomplished by the following methods.

L. "Curing Compound" - When ponding or wetting method is not possible because of essential construction operations, the use of a colorless curing compound conforming to ASTM C309 will be acceptable. Application shall be in accordance with the manufacturer's instructions.

M. All footings shall be placed in undisturbed native soil or approved compacted fill.

3.04 FINISHING

A. Fins and other surface projections shall be removed from all formed surfaces except surfaces that will be in contact with earth backfill. Surface voids and recesses resulting from removal of form ties shall be filled with mortar. Forms shall not damage the concrete when removed.

3.05 CURING

A. Concrete shall be maintained in a moist condition and protected from loss of moisture for at least seven days by polyethylene film or membrane curing compound. Membrane curing compound shall be applied as recommended by the manufacturer. Concrete shall not be permitted to freeze for at least seven days following placement.

3.06 JOINTS

A. Construction Joints: Locate and install construction joints so they do not impair strength or appearance of the structure, as acceptable to Construction Manager.

B. Place construction joints perpendicular to main reinforcement.

C. Expansion joints between structural concrete and drainage channels shall be 1/2-inch thick closed cell neoprene or cork. Surface of expansion joint shall be sealed to prevent intrusion of water.

3.07 INSTALLING EMBEDDED ITEMS

A. General: Set and build into formwork anchorage devices and other embedded items required for other work that is attached to or supported by cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of items to be attached.

B. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and contours in finished surfaces. Provide and secure units to support screed strips using strike-off templates or compacting-type screeds.

END OF SECTION

Part 1 GENERAL

1.01 Scope

A. This specification covers the requirements for the upright 6,100 gallon leachate collection and removal system (LCRS) tank. The tank shall be molded in one-piece seamless construction by rotational molding. The tanks shall be designed for above-ground, vertical installation and be capable of containing chemicals at atmospheric pressure. The tank shall be single-walled with an open top. Included are requirements for materials, properties, design, construction, dimensions, tolerances, workmanship, and appearance.

1.02 References

A. ASTM (American Society for Testing and Materials) Standards:

D618 Conditioning Plastics and Electrical Insulating Materials for Testing
D638 Tensile Properties of Plastics
D790 Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D883 Definitions of Terms Relating to Plastics
D1505 Density of Plastics by the Density-Gradient Technique
D1525 Test Method for Vicat Softening Temperature of Plastics
D1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics
D1998 Standard Specification for Polyethylene Upright Storage Tanks
D2765 Degree of Crosslinking in Crosslinked Ethylene Plastics as Determined by Solvent Extraction
D2837 Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials

B. ARM (Association of Rotational Molders) Standards:

Low Temperature Impact Resistance (Falling Dart Test Procedure)

C. ANSI Standards:

B-16.5 Pipe Flanges and Flanged Fittings

D. OSHA Standards:

29 CFR 1910.106 Occupational Safety and Health Administration, Flammable and Combustible Liquids

E. UBC CODE:

Uniform Building Code 1997 Edition

1.03 Classification

A. Tanks shall be classified as follows: Type I - Tanks molded from cross-linkable polyethylene resin.

Part 2 Products

2.01 Materials

A. The material used shall be virgin polyethylene resin as compounded and certified by the manufacturer. Type I tanks shall be made from crosslinked polyethylene resin as manufactured by ExxonMobil Chemical, or resin of equal physical and chemical properties.

B. All polyethylene resin material shall contain a minimum of a U.V. 8 stabilizer as compounded by the resin manufacturer. Pigments may be added at the purchaser's request, but shall not exceed 0.25% (dry blended) of the total weight.

C. Mechanical Properties of Type I tank material:

PROPERTY	ASTM	VALUE
Density (Resin)	D1505	0.938-0.946 g/cc
Tensile (Yield Stress 2"/min)	D638	3000 PSI
Elongation at Break (2"/min.)	D638	>300%
ESCR (100% Igepal, Cond. A, F50)	D1693	>1000 hours
ESCR (10% Igepal, Cond. A, F50)	D1693	>1000 hours
Vicat Softening Degrees F. Temperature	D1525	250
Flexural Modulus	D790	100,000 PSI

2.02 Design Requirements

A. The minimum required wall thickness of the cylindrical shell at any fluid level shall be determined by the following equation, but shall not be less than 0.187 in. thick.

T = P x O.D./2 SD = 0.433 x S.G. x H x O.D./2 SD

T = wall thickness
SD = hydrostatic design stress, PSI
P = pressure (.433 x S.G. x H), PSI
H = fluid head, ft.
S.G. = specific gravity, g/cm^3
O.D. = outside diameter, in.

1. The hydrostatic design stress shall be determined by multiplying the hydrostatic design basis, determined by ASTM D2837 using rotationally molded samples, with a service factor selected for the application. The hydrostatic design stress is 600 PSI at 73 degrees Fahrenheit for Type I and Type II materials. In accordance with the formula in 6.1, the tank shall have a stratiform (tapered wall thickness) wall.

2. The hydrostatic design stress shall be derated for service above 100 degrees Fahrenheit and for mechanical loading of the tank.

3. The standard design specific gravity shall be 1.5 or 1.9.

B. The minimum required wall thickness for the cylinder straight shell must be sufficient to support its own weight in an upright position without any external support. Flat areas shall be provided to allow locating large fittings on the cylinder straight shell.

C. The top head must be integrally molded with the cylinder shell. The minimum thickness of the top head shall be equal to the top of the straight wall. The top head of tanks with 2000 or more gallons of capacity shall be designed to provide a minimum of 1300 square inches of flat area for fitting locations.

D. Tanks with 2000 or more gallons of capacity shall have a minimum of 3 lifting lugs integrally molded into the top head. The lifting lugs shall be designed to allow erection of an empty tank.

E. The tank shall be designed to provide a minimum of 4 tie-down lugs integrally molded into the top head. The tie-down lugs shall be designed to allow tank retention in wind and seismic loading situations without tank damage. Refer to section 2.06 for tank tie-down accessories.

2.03 Dimensions and Tolerances

A. All dimensions will be taken with the tank in the vertical position, unfilled. Tank dimensions will represent the exterior measurements.

1. The tolerance for the outside diameter, including out of roundness, shall be per ASTM D1998.

2. The tolerance for fitting placements shall be +/- 0.5 in. in elevation and 2 degrees radial at ambient temperature.

2.04 Test Methods

A. Test specimens shall be taken from fitting location areas or piggy-back test molds.

B. Low Temperature Impact Test

1. Test specimens shall be conditioned at -40 degrees Fahrenheit for a minimum of 2 hours.

2. The test specimens shall be impacted in accordance with the standard testing methods as found in ASTM D1998. Test specimens < 1/2" thickness shall be tested at 100 ft.-lb. Test specimens > 1/2" thickness shall be tested at 200 ft.-lb.

C. Degree of Crosslinking Test (% Gel - Type I Only)

1. The test method used is to be the o-xlene insoluble fraction (gel test) per ASTM D2765 Method C. This test method is for determination of the ortho-xlene insoluble fraction (gel) of crosslinked polyethylene.

2. The percent gel level for Type I tanks on the inside 1/8 in. of the wall shall be a minimum of 65%.

D. Ultrasonic Tank Thickness Test

1. All tanks 2000 gallons or larger shall be measured for tank wall thickness at 6", 1ft., 2ft. and 3ft. on the tank sidewall height at 0° and 180° around the tank circumference with 0° being the tank manway and going counter-clockwise per ANSI standard drafting specifications. All tanks shall meet design thickness requirements and tolerances.

E. The tank shall be visually inspected to determine such qualities as are discussed in Section 2.05.

2.05 Workmanship

A. The finished tank wall shall be free, as commercially practicable, of visual defects such as foreign inclusions, air bubbles, pinholes, pimples, crazing, cracking and delaminations that will impair the serviceability of the vessel.

B. All cut edges where openings are cut into the tanks shall be trimmed smooth.

2.06 Tank Accessories

A. Tank Accessories - Tie Down Systems

1. The tie down system shall be designed to withstand 110 MPH wind loads. Tie down systems must meet seismic zone 4 requirements per UBC 1997 code. Any anchor bolts shall be provided by the CONTRACTOR per the instructions and the base plates for the system.

2. The tie down system shall be mild steel.

3. Mild steel parts shall be deburred and galvanized.

2.07 Marking, Packing and Packaging

A. The tanks shall be marked to identify the product, date (month and year) of manufacture, capacity, and serial number. The tank shall be shipped with a 3 of 9, HRI bar code label containing tank description, manufacturing order number, part number, serial number, manufacturer, and date.

B. The proper caution or warning signs as prescribed by OSHA standard 29 CFR 1910.106 shall be customer determined and supplied.

C. All packing, packaging, and marking provisions of ASTM Practice D3892 shall apply to this standard.

D. All fittings that do not interfere with tank shipment shall be installed unless otherwise specified. Fittings and accessories that interfere with tank shipment or could be broken during shipment are shipped separately.

PART 3 EXECUTION

3.01 GENERAL

A. The placement and installation of the tank shall be the responsibility of the CONTRACTOR.

B. Handling, storage and care of the tank prior to and following installation at the site is the responsibility of the Earthwork CONTRACTOR. Earthwork CONTRACTOR shall be liable for all damage incurred prior to final acceptance of the project by the OWNER.

C. Earthwork CONTRACTOR shall exercise care when transporting, handling and placing tank such that the tank will not be kinked, twisted, nicked or otherwise damaged.

D. Install tank and tie-downs in accordance with Manufacturer's instructions.

END OF SECTION

APPENDIX E

HELP MODEL RESULTS

Golder Associates	Kettleman Hills Facility Landfill B-19 Closure Plan Update	
	Proj. No.: 053-1910	Made By: JB
	Date: 10-18-2006	Checked By: RH
	Sheet: 1 of 2	Reviewed By: SGS

Objective:

To estimate the leachate generation rate and infiltration through the separation liner overlying the Class I waste in Landfill B-19.

Method:

The Hydrologic Evaluation of Landfill Performance (HELP) Model Version 3.07 will be used to estimate the leachate generation and infiltration through the separation liner. The HELP model will be used to evaluate the 12-acre "control unit" of the Class II/III Landfill which will be operated in a "dry" state. Golder also reviewed the analysis be Shaw/Emcon (2006) for the Joint Technical Document (JTD) for the bioreactor to evaluate the leachate generation and flow through the geocomposite, including head on the separation liner. Based on Shaw's calculations Golder estimated infiltration for the 4 acre portion of the bioreactor that overlies the separation liner.

The relevant portions of the Leachate Collection and Removal Calculations report prepared by Shaw (2006) are attached. This report evaluates the impact of the bioreactor on the separation liner as well as the Class II/III LCRS. The conclusions of this report are summarized below.

Assumptions:

The HELP model was setup in a similar manner to the analysis used in the RUST 1997 Closure Plan where a 40 foot layer of waste was modeled over the separation liner. This is the control unit of the bioreactor. The model was setup to use synthetically generated climate data for Bakersfield, California. The model was setup to run a 30-year simulation. The layers of the model also used default parameters for the soil cover and waste, as follows:

Layer 1 – 1' cover soil – Soil Type 10
Layer 2 – 20' waste – Material Type 19
Layer 3 – 1' cover soil – Soil Type 10
Layer 4 – 20' waste – Material Type 19
Layer 5 – 2' operations layer – Soil Type 10
Layer 6 – Geocomposite Drainage Layer Material Type 20, k = 10 cm/sec
Layer 7 – 60 mil HDPE geomembrane – Material Type 35, conservatively assumed to have 4 pin holes per acre and 4 installation defects per acre.
Layer 8 – 2' foundation layer, k = 1x10E-5 cm/sec

For the control portion of the landfill the base grades were assumed to be 4% (constructed at 5%) with a 350 foot long flow path to the LCRS gravel in Phase 1A.

Results:

The computer simulation indicates that for the 12 acre area an annual average of 32,154 cubic feet (241,000 gallons) of leachate will be generated from the control cell. The separation liner will have a head of approximately 0.02 inches. The liner will percolate/leak an average of 0.172 cubic feet per year or 1.3 gallons/year to the Class I waste.

Based on historic monitoring records Landfill B-19 is currently producing (for the entire Class II/III landfill) less than 20,000 gallons per year, significantly less than predicted by HELP.

Conclusions:

The control unit of the Class II/III landfill has historically produced less leachate than estimated by the HELP model. Even with the higher flows estimated by HELP the estimated percolation/leakage through the separation liner is less than 1 gallon per year.

The bioreactor portion of the site that overlies the separation liner will generate significantly higher volumes of leachate. Shaw/Emcon (2006) have performed calculations for this portion of the separation liner. Based on the modeling, up to 10,000 gallons per acre per day of leachate may be generated (conservative). Assuming this volume of leachate is generated, the geocomposite drainage layer would be able to convey the flow without development of greater than 0.25 inches of head. The head level within the geocomposite remains very low and therefore Golder estimated the percolation/leakage through the separation liner would also remain very low (estimated to be less than 1 gallon per year) to the Class I waste.

Once the bioreactor has ceased and the final cover has been constructed the amount of leachate and subsequently the amount of percolation/leakage through the separation liner will diminish.

Based on the analysis, the amount of leachate percolating from the Class II/III waste to the Class I waste is very minimal.

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**************************************************************************************
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**                                                                                  **
**                                                                                  **
**                HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                     **
**                  HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                      **
**                    DEVELOPED BY ENVIRONMENTAL LABORATORY                         **
**                     USAE WATERWAYS EXPERIMENT STATION                            **
**               FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                    **
**                                                                                  **
**                                                                                  **
**************************************************************************************
**************************************************************************************

PRECIPITATION DATA FILE:     C:\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\DATA1060.D10
OUTPUT DATA FILE:            C:\HELP3\khf30.OUT

TIME:  12:18      DATE:  10/18/2006

**************************************************************************************

     TITLE:  Landfill B-19 Modified Closure - Separation Liner (Control)

**************************************************************************************

     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.
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Note: Items in **Bold** Text have been added by Golder to the HELP model output file. Boxes placed around text have also been added by Golder to emphasize key output data.

```
                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER  10
     THICKNESS                     =     12.00   INCHES
     POROSITY                      =      0.3980 VOL/VOL
     FIELD CAPACITY                =      0.2440 VOL/VOL
     WILTING POINT                 =      0.1360 VOL/VOL
     INITIAL SOIL WATER CONTENT    =      0.1644 VOL/VOL
     EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	240.00	INCHES
POROSITY	=	0.1680	VOL/VOL
FIELD CAPACITY	=	0.0730	VOL/VOL
WILTING POINT	=	0.0190	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0730	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	240.00	INCHES
POROSITY	=	0.1680	VOL/VOL
FIELD CAPACITY	=	0.0730	VOL/VOL
WILTING POINT	=	0.0190	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0730	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2476	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

LAYER 6

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.30	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0132	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	4.00	PERCENT
DRAINAGE LENGTH	=	350.0	FEET

LAYER 7

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	4.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 - EXCELLENT	

LAYER 8

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4190	VOL/VOL
FIELD CAPACITY	=	0.3070	VOL/VOL
WILTING POINT	=	0.1800	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4190	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 350. FEET.

SCS RUNOFF CURVE NUMBER	=	93.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	12.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.973	INCHES

UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	52.972	INCHES
TOTAL INITIAL WATER	=	52.972	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
BAKERSFIELD CALIFORNIA

STATION LATITUDE	=	35.42	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	44	
END OF GROWING SEASON (JULIAN DATE)	=	331	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	6.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	42.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	38.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	63.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BAKERSFIELD CALIFORNIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.98	1.07	0.87	0.70	0.24	0.07
0.01	0.05	0.13	0.30	0.65	0.65

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BAKERSFIELD CALIFORNIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
48.20	53.20	57.10	62.70	70.80	78.30
84.50	82.40	77.30	68.00	56.20	48.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BAKERSFIELD CALIFORNIA
AND STATION LATITUDE = 35.42 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.15	0.78	0.99	0.62	0.24	0.02
	0.00	0.03	0.09	0.25	0.97	0.50
STD. DEVIATIONS	0.70	0.61	0.61	0.42	0.32	0.06
	0.01	0.10	0.18	0.46	0.74	0.35
RUNOFF						
TOTALS	0.079	0.036	0.047	0.010	0.004	0.000
	0.000	0.000	0.001	0.019	0.092	0.009
STD. DEVIATIONS	0.107	0.058	0.091	0.014	0.010	0.000
	0.000	0.001	0.002	0.044	0.170	0.023
EVAPOTRANSPIRATION						
TOTALS	0.633	0.921	0.833	0.628	0.408	0.216
	0.127	0.088	0.081	0.088	0.276	0.272
STD. DEVIATIONS	0.502	0.631	0.568	0.422	0.152	0.090
	0.121	0.104	0.088	0.076	0.404	0.223
LATERAL DRAINAGE COLLECTED FROM LAYER 6						
TOTALS	0.0944	0.2039	0.2070	0.1009	0.0531	0.0047
	0.0024	0.0000	0.0001	0.0010	0.0062	0.0645
STD. DEVIATIONS	0.1695	0.2271	0.2015	0.1487	0.1105	0.0156
	0.0126	0.0001	0.0005	0.0053	0.0231	0.1382
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 7						
AVERAGES	0.0005	0.0011	0.0010	0.0005	0.0003	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
STD. DEVIATIONS	0.0008	0.0012	0.0010	0.0008	0.0006	0.0001
	0.0001	0.0000	0.0000	0.0000	0.0001	0.0007

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	5.64	(1.614)	245707.5	100.00
RUNOFF	0.296	(0.1962)	12881.98	5.243
EVAPOTRANSPIRATION	4.571	(1.1998)	199107.77	81.034
LATERAL DRAINAGE COLLECTED FROM LAYER 6 - Leachate to Phase 1A = 241,000 gallons/year (annual total)	0.73817	(0.45974)	32154.621	13.08655
PERCOLATION/LEAKAGE THROUGH LAYER 8 - Leachate to Class I Waste = 1.3 gallons/year	0.00000	(0.00000)	0.172	0.00007
AVERAGE HEAD ON TOP OF LAYER 7	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.036	(0.7537)	1562.89	0.636

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.54	67082.398
RUNOFF	0.762	33202.0156
DRAINAGE COLLECTED FROM LAYER 6	0.05111	2226.56738
Peak Daily Leachate to Phase 1A - 16,700 gallons		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.01057
Peak Daily Leachate to Class I - 0.1 gallons/day or 0.01 gallons/ac/day		
AVERAGE HEAD ON TOP OF LAYER 7	0.008	
MAXIMUM HEAD ON TOP OF LAYER 7	0.021	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.14	6112.1191

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3153
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	3.0934	0.2578
2	17.5200	0.0730
3	2.9280	0.2440
4	17.5200	0.0730
5	2.9280	0.2440
6	0.0030	0.0100
7	0.0000	0.0000
8	10.0560	0.4190
SNOW WATER	0.000	

****
****

Leachate Collection and Removal System Calculations

This section evaluates the adequacy of the existing primary leachate collection and removal system (LCRS) for the Class II/III waste disposal area to support the proposed bioreactor unit operations. No liquids will be added to the control unit of the Class II/III disposal area or the existing, inactive Class I disposal unit. This evaluation is based on experience from other bioreactor projects implemented by Waste Management, Inc. (WM) in terms of the flow of liquids through waste, and the theoretical analysis of the LCRS using the Hydrologic Evaluation of Landfill Performance (HELP) Model. The function of the leachate and liquids management system, including the LCRS is described in Section 8.1.

Existing LCRS System Background

The base liner and LCRS were constructed in 1998 to allow Class II/III waste disposal in Landfill B-19. The capacity of the LCRS was designed for "dry cell" conditions, where peak leachate production was based primarily on the percolation of storm water through the waste during the operating stages of the landfill. An analysis was performed for the northeastern sump serving 30[1] acres and the southeast sump serving the remaining proposed Class II/III area. The HELP analysis by Rust Environmental and Infrastructure estimated that the worst-case peak daily head on the liner would be less than 12 inches[2], and occur during the Phase 3 waste filling sequence. The estimated peak daily leachate production was calculated to be 17,209 gallons per day[3] for the 30 acres served by the northeastern sump (equating to an average of approximately 573 gallons per acre per day, (gpad)).

To date, Phase 3 filling operations have been completed. The actual leachate collection from the Class II/III LCRS (B191AP) has been much less than predicted by the HELP modeling performed by Rust in 1998. Excluding the month of initial filling in November 1998, the maximum monthly leachate collection from the primary LCRS up to the end of 2002 (See Attachment A) for the Class II/III area has been 9,886 gallons[4]. This variance between the HELP analysis and the actual leachate collected is not unexpected. The HELP model has been shown to conservatively predict leachate generation (overestimate), particularly in dry climates.

The northeastern LCRS sump (See Drawing 5, "Leachate Collection Sump") was constructed in 1998, and will collect leachate flows from the drainage layer of both the bioreactor unit (18.23 acres) and control unit (11.73 acres). This is the same total 30 acres that the sump was initially designed to handle in the 1998 "dry cell" design. The

[1] Rust Environment and Infrastructure, 8/30/97; Page 1 of 12, Appendix E, Attachment 4; 18.4 and 11.6 acres for northeastern sump.
[2] Approximately 3.15 inches; Section 5.2.4.3 of JTD, Rev. 1, February 1998. The analysis was based on a simulation of 40 feet of waste in place over ¼ of the Class I area.
[3] Based on a simulation case where 80 feet of waste would be in place.
[4] For the month of April 1999.

southern 11.6 acres of Class II/III disposal, planned in 1998 to receive waste and use the southeastern sump, is not proposed to receive waste.

Leachate Flow Conditions in the Bioreactor Unit

In addition to liquid entering the waste mass from storm events, liquids will be added to the bioreactor unit on a regular basis to increase the moisture content of the waste. Leachate will also be collected from the LCRS and reintroduced into the waste, i.e. recirculated. The goal of the operation is to raise and maintain the moisture content of the waste to "field capacity", which is the condition beyond which any excess moisture begins to leach out from the waste due to gravity. Experience at other bioreactor landfills suggests that the moisture content of the waste near field capacity promotes the most rapid decomposition of the waste. Based on testing of the waste in Landfill B-19 and experience with other bioreactor projects and analysis, WM estimates that roughly 60 gallons of liquids per in-place cubic yard of fresh waste in Landfill B-19 should be added to bring the waste to field capacity.

Liquids are proposed to be placed in horizontal injection galleries, vertical injection wells and trenches in the upper portion of the landfill to introduce moisture to the existing waste in lower portions of the Landfill B-19 Class II/III waste as well as waste to be placed in the future. Leachate will percolate from the upper injection zones to lower portions of the existing waste in the landfill, and ultimately to the LCRS once field capacity of the waste is reached. Some liquid introduced into the waste may find preferential pathways through the waste and migrate to the LCRS sooner.

The maximum amount of liquids that can be added to the bioreactor unit will vary over time based on the potential of the waste to absorb liquids. The maximum amount of liquids, which can be delivered from off-site to be injected to the bioreactor unit, is approximately 170,000 gallons per day. This quantity is based on a proposed maximum of 34 trucks delivering liquids in 5,000-gallon loads. The figure of 34 trucks was proposed based on the expected liquid needed to bring 2,000 tons per day (TPD) of solid waste from initial moisture conditions to field capacity, by the addition of 60 gallons per cubic yard of waste (assumed to be at a density of 1,350 lbs/cy). This operating condition is based on the proposed project to increase the disposal tonnage to 2,000 TPD and implement bioreactor operations. Figure 9 within this JTD presents a schematic of the liquids management system proposed for the bioreactor unit.

It is estimated that if bioreactor operations are implemented in early 2006, roughly 80% of the proposed bioreactor unit capacity will already be filled under "dry cell conditions". The liquids additions that follow to this existing waste will percolate down to increase the moisture of the waste and ultimately generate leachate that will be collected in the LCRS.

Analysis of LCRS Capacity

HELP Analysis of LCRS Drainage Layer Flow Conditions Under Proposed Bioreactor Conditions

Base Liner Gravel LCRS

EMCON/OWT performed HELP analysis in order to determine the capability of the existing LCRS to serve the proposed bioreactor operations. This analysis focused on the capability of the LCRS gravel drainage layer to maintain less than 12 inches of head over the base liner per regulatory requirements. Table 1 summarizes the results of the HELP analysis simulations[5].

The following general criteria and simulations were used in the HELP analysis and are summarized in Table 1 (refer to printout for detailed parameters):

1. A test result from the gravel used in the construction of the LCRS for Cell B-19 presented a hydraulic conductivity (k) for this material of 6 cm/sec[6]. A sensitivity analysis was run using fractions of this figure in the HELP Model analysis. In the analysis, the hydraulic conductivity of the gravel drainage layer was reduced to 0.3 cm/sec (5 percent), and 0.6 cm/sec (10 percent) to account for variations in the conductivity and the potential for biological and/or chemical clogging. We believe these fractions used are conservative.
2. The HELP analysis assumed that waste is placed in 20 foot lifts with a one-foot thick cover soil layer placed on top of each lift. Four lifts were assumed for case one (a total of 80 foot waste thickness). Case two was modeled assuming eight lifts, or a 160 foot thickness of waste that resembles later portions of Phase 4, when the landfill nears final grades.
3. A range of "recharge" rates (leachate infiltration flow rates in gpad) was assumed to represent the moisture flow conditions in the landfill. The ability of moisture to flow from injection points through the waste to the LCRS will depend on many factors, including the initial waste moisture content and the permeability of waste. The permeability of the waste will decrease as it decomposes and compresses due to overburden pressures. As the recharge rate increases or becomes too high, perching of the liquids may occur which could lead to lateral movement of liquid, reduction in the actual recharge rate, and leachate seeps appearing on the landfill side slopes. These conditions will be closely monitored to limit their occurrence. Recharge rates of 3,000 and 10,000 gpad were used in the HELP analysis. It is possible that perching of liquids will occur in this range (i.e., above rates of 3,000 to 5,000 gpad[7]), thus limiting the actual flow to the LCRS below this amount. The assumed figure of 10,000 gpad of recharge is judged as a worst case because of the potential for preferential pathways and short-circuiting as liquid migrates though the waste and the maximum amount of liquid deliveries, discussed below.

[5] HELP analysis was performed for a period of 10 years.
[6] Based on test data dated August 20, 1998, provided by CWMI.
[7] Expected rates are 3,000 to 5,000 gpad for waste placed at 1,350 lbs./cy; based on telephone conversation with Gary Hater, WM director of bioreactor research, April 21, 2004

The quantities of leachate generated as shown in Table 1, column 2, are based on applying this range of recharge rate using the entire 18.23-acre footprint proposed for the bioreactor operations[8]. The resulting maximum 182,300 gpd shown in Table 1 is based on a 10,000 gpad assumed maximum recharge rate over the entire bioreactor footprint of 18.23 acres. It is also noted that the maximum liquid addition is limited to 170,000 GPD based on a maximum of 34 trucks. As a substantial portion of the landfill reaches field capacity, leachate recirculation alone would maintain the landfill waste mass near field capacity.

TABLE 1: SUMMARY OF HELP CALCULATIONS

80 Foot Thickness of Waste					
Recharge, (gpad) [1]	gpd over 18.23 acre footprint [2]	Head on liner (inches) [3]		Gravel Drainage Layer Permeability "k" (cm/sec) [4]	LCRS Flow (gpad)
		Avg. Annual	Peak Daily		
3,000	54,690	0.89	2.64	0.3	3,083
3,000	54,690	0.45	1.37	0.6	3,084
10,000	182,300	2.91	6.74	0.3	10,074
10,000	182,300	1.46	3.59	0.6	10,073
160 Foot Thickness of Waste					
Recharge, (gpad)	gpd over 18.23 acre footprint	Head on liner (inches)		Gravel Drainage Layer Permeability "k" (cm/sec)	LCRS Flow (gpad)
		Avg. Annual	Peak Daily		
3,000	54,690	0.89	2.42	0.3	3,082
3,000	54,690	0.45	1.24	0.6	3,082
10,000	182,300	2.91	6.49	0.3	10,079
10,000	182,300	1.46	3.43	0.6	10,079

Notes:

1. Recharge Rate shown includes total recharge from leachate recirculation and liquid injection; stormwater infiltration is additional
2. Recharge in gpd shown is conservatively based on column 1 x 18.63 acres of bioreactor unit footprint.
3. Head on Liner is maximum head calculated from HELP analysis
4. Gravel drainage layer permeability has been tested during installation to be 6 cm/sec. Fractions of this permeability have been used in the analysis to account for clogging and other factors that may reduce the actual permeability.

Initial Case – 80 Foot Waste Depth

This case represents the thinnest waste depth in the bioreactor unit. The results of the HELP calculations indicate that the theoretical maximum depth that liquid could reach in the LCRS would be approximately seven (6.74) inches above the liner, assuming a recharge rate of 10,000 gpad in addition to storm water infiltration; and a gravel drainage layer hydraulic conductivity in the LCRS of 0.3 cm/sec or 5% of the test value. However, it should be noted that this recharge event could not occur because flows in the LCRS will not substantially increase until the existing waste in the bioreactor reaches field capacity from the addition of liquids. It is estimated that if the maximum daily amount of 170,000 gpd of liquids were added consistently to the bioreactor unit six days

[8] The control unit is ignored in analysis because it will generate less than 1% of LCRS flows. The maximum monthly LCRS flow up to 2003 in B191AP of 9,886 gallons occurred in April 1999 over approximately 25 acres. This corresponds to a flow of 13 gpad. (Most other monthly flows are far less.) This is 0.43% and 0.13%, respectively, of the range of LCRS flows of 3,084 and 10, 079 gpad analyzed below in cases of bioreactor infiltration rates of 3,000 and 10,000 gpad.

per week, it would take approximately 2.5 years before the entire mass of waste in the landfill would reach field capacity[9]. Therefore, the actual depth of flow in the LCRS for this case, which will take place at the initial stages of bioreactor operations, is anticipated to be no more than 1.37 inches, assuming that the recharge from liquid additions is 3,000 gpad and the LCRS gravel is functioning at 10% of the actual reported hydraulic conductivity.

Final Case – 160 Foot Waste Depth

This case represents the conditions in the final phase of operations (Phase 4). The results of the HELP modeling for this scenario indicate that the theoretical maximum depth that liquid could reach in the LCRS would be approximately six (6.49) inches above the liner, assuming a recharge rate of 10,000 gpad plus storm water infiltration, and assuming that the permeability of the gravel in the LCRS is 0.3 cm/sec, or 5 percent of the actual sample. This case is also considered to be conservative given that the hydraulic conductivity of the gravel drainage layer has been reduced by 95 percent of the actual reported hydraulic conductivity. Additionally, this case assumes that 10,000 gpad is injected into the landfill waste mass. This 10,000 gpad is believed to be a maximum that can be applied (both recirculated and liquid additions) to the waste mass. It is not anticipated that this flow rate will be sustained over the operating life of the landfill; therefore, the peak daily head on the base liner for this condition is believed to be a conservative estimate. However, it is noted that the analysis above is theoretical based on uniform recharge conditions. The actual conditions of leachate flow and channelization in the bioreactor can vary, which will lead to variation of flow depths over the area of the base LCRS drainage system.

Separation Liner Geocomposite LCRS

A separation liner was placed over the side slope of the existing Class I waste fill to provide a barrier between the Class I waste and the Class II/III waste. The separation liner is comprised of the following components from top to bottom of:

- 24 inch thick operations layer
- Geocomposite drainage layer
- 60 mil HDPE geomembrane
- 24 inch thick foundation layer ($k \leq 1x10\text{-}5$ cm/sec)

To ensure that the operations of the bioreactor over this liner would not create head build up over the regulatory mandated maximum of 12 inches, the geocomposite drainage layer was analyzed to determine its performance under increased leachate flow.

Two recirculation rates, 3,000 gpad and 10,000 gpad, were analyzed to judge the adequacy of the existing geocomposite. For each recirculation rate two hydraulic gradients, 5 and 26 percent, with flow lengths of 150 and 300 feet, respectively, were

[9] Assuming that 60 gallons per CY is required to reach field capacity and that moisture addition to the bioreactor waste include infiltration of ½ of the average rainfall (3.25 inches) plus the addition of 170,000 gallons per day of liquids. This is based on in-place and incoming waste tonnage conditions and addition of liquids from mid-2006 to 2009.

used to simulate the existing separation liner conditions within the bioreactor unit. The 26 percent gradient is located on the upper portion of the separation liner slope within the bioreactor unit, and the 5 percent gradient is located near the bottom of the separation liner[10].

The flow adequacy was determined based on the following references:

1. Koerner, R.M., (1998). *Designing with Geosynthetics,* Fourth Edition.
2. Geosynthetic Research Institute. (2001). *GRI Standard - GC8*
3. Giroud, J.P., Zornberg, J.G., and Zhao, A. (2000). "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", *Geosynthetic International*, Vol. 7, Nos. 4-5.

The calculations use published reduction factors for geocomposite creep, intrusion, and biological and chemical clogging. Based on the geometry of the site; the normal load, slope inclination and the length are input. These values along with the reduction factors are used to calculate two required geocomposite flow rates. For a geocomposite, the flow rate is expressed as a transmissivity value. First, the required transmissivity is calculated based on the geometric conditions at the site. A second transmissivity is calculated based on a reduction of the design transmissivity by the reduction factors. A total reduction factor of 7.1 (TSF or total serviceability factor) is used for the analysis, to yield a required "index transmissivity". This index transmissivity is then compared against the reported manufacturer transmissivity and/or conformance transmissivity testing data performed on the geocomposite at the time of installation to determine the flow adequacy. The index transmissivity was used in calculations to check the capability of the in-place geocomposite drainage layer at the recharge rates of 3,000 and 10,000 gpad, modeled above. A manufacturer reported transmissivity of $5x10^{-4}$ m^2/sec is used as a standard for analysis based on the product data sheet (Attachment B; 8 oz/yd^2 geocomposite[11]) for the geocomposite installed for the separation liner. This transmissivity was also tested and verified during construction quality assurance with a result of $8.7x10^{-4}$ m2/sec[12], which is greater than the manufacturer's reported transmissivity. The geocomposite Fabrinet HF produced by GSE is 250 mils thick, as shown on the product data sheet.

Tables 2 and 3, at the end of this report, show calculations using a recharge rate of 3,000 gpad and hydraulic gradients of 5 and 26 percent. These results indicate that the existing geocomposite on the separation liner should transmit this flow to the base liner gravel drainage layer without head build-up above of the thickness of the geocomposite. The calculated index transmissivity required to convey recharge rates assumed are presented below.

[10] See Drawing 5 and Section A-A of JTD.
[11] Data sheet provided by email from Fred Paap, CWMI, February 17, 2006.
[12] Based on test data provided by Scott Sumner, Golder Associates, Inc., via email.

Recharge Rate (gpad)	Gradient (percent)	Required Index Transmissivity (m^2/sec)	Manufacturer's Transmissivity[1] (m^2/sec)	Tested Transmissivity[2] (m^2/sec)
3,000	5	2.2E-04	5E-04	8.72E-04
3,000	26	8.7E-05	5E-04	8.72E-04
10,000	5	7.1E-04	5E-04	8.72E-04
10,000	26	2.8E-04	5E-04	8.72E-04

1. Transmissivity based on 10 percent gradient and 10,000 psf normal load.
2. Transmissivity based on 10 percent gradient and 10,000 psf normal load.

Based on the results presented above, the index transmissivity required for a recharge rate of 3,000 gpad is less than the transmissivity reported by the geocomposite manufacturer and the actual tested transmissivity of the material installed at the site, therefore, the calculations indicate that the flows for this condition would be contained within the thickness of the geocomposite drainage layer.

The calculation using a recharge rate of 10,000 gpad (Tables 4 and 5, at the end of this report) show that the existing geocomposite can transmit this flow to the base liner gravel drainage layer without head build up above the liner of greater than the thickness of the geocomposite drainage layer. This finding for a gradient of 5 percent is based on the tested transmissivity[13] of the geocomposite installed and not the minimum manufacturers reported value.

Analysis of Flow Capacity of Leachate Sump Gravel to Support Proposed Bioreactor Operations

In addition to checking the drainage layer of the LCRS, calculations regarding the capacity of flow through the drainage gravel in the sump were performed. Using similar analysis provided by Rust[14] for the design of the sump in the Class II/III disposal area, and updating the permeability "k" value (6 cm/sec) as provided by CMWI test data; the flow capacity of the gravel in the LCRS and flow to the pipe in the LCRS sump through the gravel was checked. The calculations are in Attachment C. The calculations assumed flow conditions at 50% of the test "k" value for permeability. The result indicates a flow capacity of approximately 220,000 gallons per day. Therefore, the sump extraction rate (220,000 gpd) exceeds the expected maximum leachate flow rate from the HELP modeling (182,300 gpd) as described, above.

[13] It should also be noted that the actual transmissivity of the geocomposite at 5 percent would be greater than the tested transmissivity, which was measured at 10 percent, because turbulent flow is reduced at the lesser slope, providing a greater transmissivity.
[14] JTD, Rev. 1, February 1998; Appendix E, Attachment 4; pages 6 and 7, with updated "k" value.

CONCLUSIONS

Based on the HELP modeling, calculations for the base liner drainage gravel and capacity calculations for the sump, the levels in the LCRS should not exceed the 12-inch head limitation required by Title 27 CCR. (A copy of the HELP model output files is in Attachment D). The HELP modeling predicts that the maximum peak daily head on the base liner would not exceed 6.74 inches. This analysis has been performed by assuming conservative LCRS hydraulic conductivity values and a recharge rate of 10,000 gpad consistent with the maximum liquid injection rates proposed.

The adequacy of the 250 mil geocomposite drainage layer over the separation liner was evaluated using manufacturer and CQA transmissivity data and industry accepted flow reduction factors. This analysis included calculations for recharge rates of 3,000 gpad and 10,000 gpad and hydraulic gradients of 5 and 26 percent. The 10,000 gpad figure represents the worst case bioreactor infiltration rate.

These analyses were performed using assumptions and the factors of safety noted to demonstrate that the LCRS for the bioreactor will perform in accordance with Title 27 CCR. The actual conditions in the landfill and LCRS will be more complex as channelization of liquid may occur. The actual achievable recharge rate will vary considerably over the landfill and over time. We recommend the quantities of liquid pumped from the sump be monitored daily. Should the quantity of leachate pumped from the sump exceed 220,000 gpd or the depth in the sump indicates that greater than 12 inches of leachate head has built up on the liner, addition of liquid to the landfill should cease until liquid can be evacuated and the head reduced. Analysis and regular monitoring should also be performed to determine if the landfill has reached field capacity and to develop a relationship between liquid injections and LCRS sump performance so that injections can be controlled to maintain proper operating conditions. As the landfill reaches field capacity and recirculation of leachate increases, the amount of outside liquids introduced will need to be monitored and adjusted such that the head on the liner is maintained below 12 inches and leachate does not build up causing seeps or unstable conditions.

Table 2
Geocomposite Transmissivity Calculations
Based on Infiltration (3,000 gpad, 5% Gradient)

Prepared By: R. Wall
Date: 2/26/2006

Checked By: MJU/NK
Date: 2/28/2006

REQUIRED: Transmissivity of geocomposite drain based on infiltration rate

REFERENCES:

1. Koerner, R.M., (1998). *Designing with Geosynthetics,* Fourth Edition.
2. Geosynthetic Research Institute. (2001). *GRI Standard - GC8*
3. Giroud, J.P., Zornberg, J.G., and Zhao, A. (2000). "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", *Geosynthetic International* , Vol. 7, Nos. 4-5.

DESIGN DATA:

Infiltration rate in to the geocomposite drain	q =	3084	gpad
or	e =	0.11	inch/day
	=	3.34E-08	m/sec
Slope length measured horizontally (from crest of slope to toe of slope)	L =	150	ft
	=	45.7	m/sec
Maximum waste height	H =	160	ft
Waste unit weight	g_t =	85	pcf
Baseliner/geocomposite slope:	i =	5	%
	b =	0.05	radians
Geocomposite thickness	t_g =	250.00	mil
Thickness of the liquid collection layer for geocomposite	t_{CLC} =	0.0064	m

REDUCTION FACTORS:

Global factor of safety	FS =	1.5

Note:
(1) The values of RF_{in}, RF_{cr}, RF_{cc}, and RF_{bc} below may be selected based Koerner (1998)
(2) The value of RF_{cr} can also be determined using GRI Standard GC8

Reduction factor for intrusion due to elastic deformation	RF_{in} =	1.8
Reduction factor for creep deformation	RF_{cr} =	1.6
Reduction factor for chemical clogging/precipitation	RF_{cc} =	1.5
Reduction factor for biological clogging	RF_{bc} =	1.1

Total serviceability factor (TSF)

$TSF = FS \times RF_{in} \times RF_{cr} \times RF_{cc} \times RF_{bc}$ TSF = 7.1

CALCULATIONS:

Total flow at the toe of geocomposite,

$q = e \times L$ q = 1.53E-06 m^2/sec

Required transmissivity,

$q = q/\sin b$ q = 3.06E-05 m^2/sec

Required **index transmissivity**, based on test using 15-minute seating time using rigid boundary conditions,

$q_{15} = q \times TSF$ q_{15} = 2.2E-04 m^2/sec

Table 2 (cont'd)
Geocomposite Transmissivity
Calculations (3,000 gpad, 5% Gradient)

Prepared By: R. Wall — Checked By: _____

Date: 2/26/2006 — Date: _____

Check using Giroud et al.(2000) equation:

$$\theta_{15} = TSF \left[\frac{e\ L}{\sin\beta + \frac{t_{LCL}/L}{TSF} Cos^2\beta} \right] = \quad 2.2\text{E-}04\ m^2/sec$$

Required **design transmissivity** based on test using
100-hour seating with site-specific boundary conditions,

$q_{100} = q_{15}/RF_{in}$ $q_{100} =$ 1.2E-04 m^2/sec

CONCLUSIONS:

The proposed geocomposite should satisfy a **index transmissivity (q_{15})** of when tested under rigid boundary conditions with seating time of 15 minutes	**2.2E-04 m^2/sec**
and/or	
The proposed geocomposite should satisfy a **design transmissivity (q_{100})** of when tested under site-specific boundary conditions with seating time of 100 hours	**1.2E-04 m^2/sec**

MATERIAL PROPERTIES:

GSE Fabrinet HF has an adversized index transmissivity of 5E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

GSE Fabrinet HF installed in Landfill B-19 had a tested transmissivity of 8.7E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

Actual transmissivity conformance test results performed on material installed = 8.72E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

Table 3
Geocomposite Transmissivity Calculations
Based on Infiltration (3,000 gpad, 26% Gradient)

Prepared By: R. Wall
Date: 2/26/2006

Checked By: MJU/NK
Date: 2/28/2006

REQUIRED: Transmissivity of geocomposite drain based on infiltration rate

REFERENCES:

1. Koerner, R.M., (1998). *Designing with Geosynthetics,* Fourth Edition.
2. Geosynthetic Research Institute. (2001). *GRI Standard - GC8*
3. Giroud, J.P., Zornberg, J.G., and Zhao, A. (2000). "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", *Geosynthetic International* , Vol. 7, Nos. 4-5.

DESIGN DATA:

Infiltration rate in to the geocomposite drain	q =	3084	gpad
or	e =	0.11	inch/day
	=	3.34E-08	m/sec
Slope length measured horizontally (from pipe to the crest of slope)	L =	300	ft
	=	91.5	m/sec
Maximum waste height	H =	160	ft
Waste unit weight	g_t =	85	pcf
Baseliner/geocomposite slope:	i =	26	%
	b =	0.25	radians
Geocomposite thickness	t_g =	250.00	mil
Thickness of the liquid collection layer for geocomposite	t_{CLC} =	0.0064	m

REDUCTION FACTORS:

Global factor of safety	FS =	1.5

Note:
(1) The values of RF_{in}, RF_{cr}, RF_{cc}, and RF_{bc} below may be selected based Koerner (1998)
(2) The value of RF_{cr} can also be determined using GRI Standard GC8

Reduction factor for intrusion due to elastic deformation	RF_{in} =	1.8
Reduction factor for creep deformation	RF_{cr} =	1.6
Reduction factor for chemical clogging/precipitation	RF_{cc} =	1.5
Reduction factor for biological clogging	RF_{bc} =	1.1

Total serviceability factor (TSF)

$TSF = FS \times RF_{in} \times RF_{cr} \times RF_{cc} \times RF_{bc}$ TSF = 7.1

CALCULATIONS:

Total flow at the toe of geocomposite,

$q = e \times L$ q = 3.05E-06 m^2/sec

Required transmissivity,

$q = q/\sin b$ q = 1.21E-05 m^2/sec

Required **index transmissivity**, based on test using 15-minute seating time using rigid boundary conditions,

$q_{15} = q \times TSF$ q_{15} = 8.7E-05 m^2/sec

Table 3 (cont'd)
Geocomposite Transmissivity
Calculations (3,000 gpad, 26% Gradient)

Prepared By: R. Wall Checked By: _____

Date: 2/26/2006 Date: _____

Check using Giroud et al.(2000) equation:

$$\theta_{15} = TSF \left[\frac{e\ L}{\sin\beta + \frac{t_{LCL}/L}{TSF} Cos^2\beta} \right] = \quad 8.7\text{E-}05\ m^2/sec$$

Required design transmissivity based on test using
100-hour seating with site-specific boundary conditions,

$q_{100} = q_{15}/RF_{in}$ $q_{100} =$ 4.8E-05 m^2/sec

CONCLUSIONS:

The proposed geocomposite should satisfy a **index transmissivity (q_{15})** of when tested under rigid boundary conditions with seating time of 15 minutes	**8.7E-05 m^2/sec**
and/or	
The proposed geocomposite should satisfy a **design transmissivity (q_{100})** of when tested under site-specific boundary conditions with seating time of 100 hours	**4.8E-05 m^2/sec**

MATERIAL PROPERTIES:

GSE Fabrinet HF has an adversized index transmissivity of 5E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

GSE Fabrinet HF installed in Landfill B-19 had a tested transmissivity of 8.7E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

Actual transmissivity conformance test results performed on material installed = 8.72E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

Table 4
Geocomposite Transmissivity Calculations
Based on Infiltration (10,000 gpad, 5% Gradient)

Prepared By: R. Wall
Date: 2/26/2006

Checked By: MJU/NK
Date: 2/28/2006

REQUIRED: Transmissivity of geocomposite drain based on infiltration rate

REFERENCES:

1. Koerner, R.M., (1998). *Designing with Geosynthetics,* Fourth Edition.
2. Geosynthetic Research Institute. (2001). *GRI Standard - GC8*
3. Giroud, J.P., Zornberg, J.G., and Zhao, A. (2000). "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", *Geosynthetic International* , Vol. 7, Nos. 4-5.

DESIGN DATA:

Infiltration rate in to the geocomposite drain	q =	10079	gpad
or	e =	0.37	inch/day
	=	1.09E-07	m/sec
Slope length measured horizontally (from crest of slope to toe of slope)	L =	150	ft
	=	45.7	m/sec
Maximum waste height	H =	160	ft
Waste unit weight	g_t =	85	pcf
Baseliner/geocomposite slope:	i =	5	%
	b =	0.05	radians
Geocomposite thickness	t_g =	250.00	mil
Thickness of the liquid collection layer for geocomposite	t_{CLC} =	0.0064	m

REDUCTION FACTORS:

Global factor of safety	FS =	1.5

Note:
(1) The values of RF_{in}, RF_{cr}, RF_{cc}, and RF_{bc} below may be selected based Koerner (1998)
(2) The value of RF_{cr} can also be determined using GRI Standard GC8

Reduction factor for intrusion due to elastic deformation	RF_{in} =	1.8
Reduction factor for creep deformation	RF_{cr} =	1.6
Reduction factor for chemical clogging/precipitation	RF_{cc} =	1.5
Reduction factor for biological clogging	RF_{bc} =	1.1

Total serviceability factor (TSF)

$TSF = FS \times RF_{in} \times RF_{cr} \times RF_{cc} \times RF_{bc}$ TSF = 7.1

CALCULATIONS:

Total flow at the toe of geocomposite,

$q = e \times L$ q = 4.99E-06 m^2/sec

Required transmissivity,

$q = q/\sin b$ q = 9.99E-05 m^2/sec

Required **index transmissivity**, based on test using 15-minute seating time using rigid boundary conditions,

$q_{15} = q \times TSF$ q_{15} = 7.1E-04 m^2/sec

Table 4 (cont'd)
Geocomposite Transmissivity
Calculations (10,000 gpad, 5% Gradient)

Prepared By: R. Wall Checked By: _____

Date: 2/26/2006 Date: _____

Check using Giroud et al.(2000) equation:

$$\theta_{15} = TSF \left[\frac{e\ L}{\sin\beta + \frac{t_{LCL}/L}{TSF} Cos^2\beta} \right] = \quad 7.1E\text{-}04\ m^2/sec$$

Required **design transmissivity** based on test using
100-hour seating with site-specific boundary conditions,

$q_{100} = q_{15}/RF_{in}$ $q_{100} =$ 4.0E-04 m^2/sec

CONCLUSIONS:

The proposed geocomposite should satisfy a **index transmissivity (q_{15})** of when tested under rigid boundary conditions with seating time of 15 minutes	**7.1E-04 m^2/sec**
and/or	
The proposed geocomposite should satisfy a **design transmissivity (q_{100})** of when tested under site-specific boundary conditions with seating time of 100 hours	**4.0E-04 m^2/sec**

TEST CONDITIONS:

GSE Fabrinet HF has an adversized index transmissivity of 5E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

GSE Fabrinet HF installed in Landfill B-19 had a tested transmissivity of 8.7E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

Actual transmissivity conformance test results performed on material installed = 8.72E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

Table 5
Geocomposite Transmissivity Calculations
Based on Infiltration (10,000 gpad, 26% Gradient)

Prepared By: R. Wall
Date: 2/26/2006

Checked By: MJU/NK
Date: 2/28/2006

REQUIRED: Transmissivity of geocomposite drain based on infiltration rate

REFERENCES:

1. Koerner, R.M., (1998). *Designing with Geosynthetics,* Fourth Edition.
2. Geosynthetic Research Institute. (2001). *GRI Standard - GC8*
3. Giroud, J.P., Zornberg, J.G., and Zhao, A. (2000). "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers", *Geosynthetic International* , Vol. 7, Nos. 4-5.

DESIGN DATA:

Infiltration rate in to the geocomposite drain	q =	10079	gpad
or	e =	0.37	inch/day
	=	1.09E-07	m/sec
Slope length measured horizontally (from pipe to the crest of slope)	L =	300	ft
	=	91.5	m/sec
Maximum waste height	H =	160	ft
Waste unit weight	g_t =	85	pcf
Baseliner/geocomposite slope:	i =	26	%
	b =	0.25	radians
Geocomposite thickness	t_g =	250.00	mil
Thickness of the liquid collection layer for geocomposite	t_{CLC} =	0.0064	m

REDUCTION FACTORS:

Global factor of safety	FS =	1.5

Note:
(1) The values of RF_{in}, RF_{cr}, RF_{cc}, and RF_{bc} below may be selected based Koerner (1998)
(2) The value of RF_{cr} can also be determined using GRI Standard GC8

Reduction factor for intrusion due to elastic deformation	RF_{in} =	1.8
Reduction factor for creep deformation	RF_{cr} =	1.6
Reduction factor for chemical clogging/precipitation	RF_{cc} =	1.5
Reduction factor for biological clogging	RF_{bc} =	1.1

Total serviceability factor (TSF)

$TSF = FS \times RF_{in} \times RF_{cr} \times RF_{cc} \times RF_{bc}$ TSF = 7.1

CALCULATIONS:

Total flow at the toe of geocomposite,

$q = e \times L$ q = 9.98E-06 m^2/sec

Required transmissivity,

$q = q/\sin b$ q = 3.97E-05 m^2/sec

Required **index transmissivity**, based on test using 15-minute seating time using rigid boundary conditions,

$q_{15} = q \times TSF$ q_{15} = 2.8E-04 m^2/sec

Table 5 (cont'd)
Geocomposite Transmissivity
Calculations (10,000 gpad, 26% Gradient)

Prepared By: R. Wall Checked By: _____

Date: 2/26/2006 Date: _____

Check using Giroud et al.(2000) equation:

$$\theta_{15} = TSF \left[\frac{e\ L}{\sin\beta + \frac{t_{LCL}/L}{TSF} Cos^2\beta} \right] = \quad 2.8\text{E-}04\ m^2/sec$$

Required **design transmissivity** based on test using 100-hour seating with site-specific boundary conditions,

$q_{100} = q_{15}/RF_{in}$ $q_{100} =$ 1.6E-04 m^2/sec

CONCLUSIONS:

The proposed geocomposite should satisfy a **index transmissivity (q_{15})** of when tested under rigid boundary conditions with seating time of 15 minutes	**2.8E-04 m^2/sec**
and/or	
The proposed geocomposite should satisfy a **design transmissivity (q_{100})** of when tested under site-specific boundary conditions with seating time of 100 hours	**1.6E-04 m^2/sec**

MATERIAL PROPERTIES:

GSE Fabrinet HF has an adversized index transmissivity of 5E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

GSE Fabrinet HF installed in Landfill B-19 had a tested transmissivity of 8.7E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

Actual transmissivity conformance test results performed on material installed = 8.72E-04 m^2/sec (gradient of 0.1 with a 10,000 psf load)

ATTACHMENT A

HISTORICAL LCRS REMOVAL VOLUMES – CLASS II/III WASTE [B191A]

KHF Landfill B-19 Phase 1A (Class II & Class III Wastes)
Monthly Leachate Pumped (Gallons) and Rainfall (Inches)

	Nov-98	Dec-98
B191AP	34,740	3,212
B191AS	0	0
B191AV	0	0
Rainfall	0.70	0.45

	Jan-99	Feb-99	Mar-99	Apr-99	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99
B191AP	0	2,622	7,888	9,886	2,490	0	0	1,878	0	0	0	0
B191AS	0	0	0	0	0	0	0	0	0	0	0	0
B191AV	0	0	0	0	0	0	0	0	0	0	0	0
Rainfall	1.60	0.18	0.96	0.74	0.00	0.00	0.00	0.00	0.30	0.00	0.07	0.02

	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00
B191AP	1,924	6,723	9,285	0	890	0	0	0	2,237	0	0	0
B191AS	0	0	0	0	0	0	0	0	0	0	0	0
B191AV	0	0	0	0	0	0	0	0	0	0	0	0
Rainfall	1.38	1.96	0.60	0.88	0.00	0.22	0.00	0.00	0.00	0.41	0.02	0.13

	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01
B191AP	0	0	4,090	0	0	2,140	0	0	0	685	0	0
B191AS	0	0	0	0	0	0	0	0	0	0	0	0
B191AV	0	0	0	0	0	0	0	0	0	0	0	0
Rainfall	1.60	2.41	1.55	0.66	0.00	0.00	0.00	0.00	0.00	0.18	1.56	1.21

	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02
B191AP	0	0	0	1,756	0	0	0	818	0	0	0	0
B191AS	216	0	0	97	0	0	73	0	0	0	0	0
B191AV	0	0	0	0	0	0	0	0	0	0	0	0
Rainfall	0.67	0.15	0.94	0.02	0.72	0.02	0.00	0.00	0.00	0.00	0.64	1.13

P = Primary LCRS
S = Secondary LCRS
V = Vadose LCRS

ATTACHMENT B

LCRS SUMP CAPACITY CALCULATIONS

CAPACITY OF SUMP GRAVEL- PERIMETER NEAR BASE OF SUMP

Slope of liner, I	5.0%		
head on liner, h	1.0	ft maximum	
Neglect sideslope to sump			
Q=k*I*A			
Test k, Hyd Conductivity =	6	cm/sec	
Assumed k, Hyd Conductivity =	3	cm/sec	**50% of test**
A= L * h	70	sf	
L = sum perimeter	70	ft	
Conversions	0.0328083	cm = 1 ft	
	86400	day= sec	
	7.48052	cf=gal	
Q=	29,764	cf/day	
	222,648	**Gallons per day**	

CAPACITY OF FLOW TO PIPE THROUGH SUMP GRAVEL

(Assumed Pipe and pump capacity greater than flow reaching pipe through gravel)

Assumes Darcy's Law is valid to estimate quantity through flow net.
Use flow diagram for Nf, Nd; and L and H (page /12, Rust).

head on liner, h	1.0	ft maximum	
Nf	5.0		
Nd	3.0		
Q=k*H*(Nf/Nd)*L			
Test k, Hyd Conductivity =	6	cm/sec	
Assumed k, Hyd Conductivity =	3	cm/sec	**50% of test**
H= depth of sump gravel plus h	5.0	ft	
L = Length of Perforated pipe	8	ft	
Conversions	0.0328083	cm = 1 ft	
	86400	day= sec	
	7.48052	cf=gal	
Q=	566,927	cf/day	
	4,240,912	**Gallons per day**	

ATTACHMENT C

SEPARATION LINER GEOTEXTILE DRAINAGE LAYER TRANSMISSIVITY TEST INFORMATION

GSE

GSE STANDARD PRODUCTS

Product Data Sheet

GSE FabriNet HF Geocomposites

GSE FabriNet HF geocomposite consists of GSE HyperNet HF geonet heat-laminated on one or both sides with a GSE nonwoven needlepunched geotextile. GSE HyperNet HF is a 250 mil thick geonet manufactured from a premium grade high density polyethylene resin. For the purpose of lamination to geonets, GSE nonwoven needlepunched geotextiles are available in mass per unit area range of 6 oz/yd² (200 g/m²) to 16 oz/yd² (540 g/m²). GSE FabriNet HF geocomposites are designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions. Index properties for the product are provided in the table below. Please contact GSE for further information regarding performance under site-specific conditions.

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE ROLL VALUE[4,5]		
Geocomposite			**6 oz/yd²**	**8 oz/yd²**	**10 oz/yd²**
Product Code:			FS20600605	FS20800805	FS21001005
Transmissivity[4], gal/min/ft (m²/sec)	ASTM D 4716-00	1/540,000 ft²	2.41 (5x10⁻⁴)	2.41 (5x10⁻⁴)	2.41 (5x10⁻⁴)
Ply Adhesion, lb/in (g/cm)	GRI GC-7	1/50,000 ft²	1.0 (178)	1.0 (178)	1.0 (178)
Roll Width, ft (m)			14.5 (4.4)	14.5 (4.4)	14.5 (4.4)
Roll Length, ft (m)			200 (60)	190 (57.9)	180 (54.9)
Roll Area, ft² (m²)			2,900 (269)	2,755 (256)	2,610 (242)
Geonet core[4,5]					
Transmissivity[4], gal/min/ft (m²/sec)	ASTM D 4716-00		14.49 (3x10⁻³)	14.49 (3x10⁻³)	14.49 (3x10⁻³)
Thickness, mil (mm)	ASTM D 5199	1/50,000 ft²	250 (6.3)	250 (6.3)	250 (6.3)
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	1/50,000 ft²	55 (9.6)	55 (9.6)	55 (9.6)
Carbon Black Content, %	ASTM D 1603	1/50,000 ft²	2.0	2.0	2.0
Geotextile (prior to lamination)[4,6]					
Mass per Unit Area, oz/yd² (g/m²)	ASTM D 5261	1/90,000 ft²	6 (200)	8 (270)	10 (335)
Grab Tensile, lb (N)	ASTM D 4632	1/90,000 ft²	170 (755)	220 (975)	260 (1,155)
Puncture Strength, lb (N)	ASTM D 4833	1/90,000 ft²	90 (395)	120 (525)	165 (725)
AOS, US Sieve (mm)	ASTM D 4751	1/540,000 ft²	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, (sec⁻¹)	ASTM D 4491	1/540,000 ft²	1.5	1.5	1.2
Flow Rate, gpm/ft² (l/min/m²)	ASTM D 4491	1/540,000 ft²	110 (4,480)	110 (4,480)	85 (3,460)
UV Resistance, % Retained	ASTM D 4355 (after 500 hours)	once per formulation	70	70	70

NOTES:

- [4]Gradient of 0.1, normal load of 10,000 psf, water at 70° F between stainless steel plates for 15 minutes.
- [5]Component properties prior to lamination.
- [6]Several geotextiles are available and may be supplied as determined by GSE.
- [4,5]These are MARV values and are based on the cumulative results of specimens tested and as determined by GSE. AOS in mm is a maximum average roll value.

D3043 R07/07/03

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Europe/Middle East/Africa	GSE Lining Technology GmbH	Hamburg, Germany		49-40-7674290	Fax: 49-40-7674233
Asia/Pacific	GSE Lining Technology Company Ltd.	Bangkok, Thailand		66-2-937-0091	Fax: 66-2-937-0097

This product data sheet is also available on our website at:

www.gseworld.com

GSE Lining Technology, Inc.

Transmissivity Report
ASTM D4716

Roll No. 131136955

ROLL IDENTIFICATION		CUSTOMER INFORMATION	
Roll Number	131136955	Order Number	32846
Product Name	F520800805	Customer Name	WMI
Production Date	11/19/2003	Project Name	WMI CWM Kettleman Hills Cell B19
Resin Lot #	D30821440	Location	Kettleman City, CA

Pressure (psf)	Gradient	Net/Composite	Transmissivity Results (m^2/sec)	(gal/min/ft)	Seat Time (min)	Boundary
10000	0.10	Composite	8.72E-04	4.02	15	SS Plates