

Exhibit C

Technical Specifications Phase II MSW Area Closure & Photovoltaic System Project Hartford Landfill

Connecticut Resources
Recovery Authority
Hartford, Connecticut

March 5, 2013



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SECTION 02 66 21 – LANDFILL EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Preparing landfill subgrade including general fill where required.
 - 2. Cap base material.
 - 3. Sand Drainage layer which includes the following:
 - a. Geocomposite (Geonet and non-woven geotextile cover)
 - b. Drainage Sand.
 - 4. Disposal of unsuitable material.
 - 5. Disposal of surplus suitable material, if required.
- B. Related Sections include the following:
 - 1. Division 02 Section "Landfill Vegetative Support Material" for landfill topsoil.
 - 2. Division 02 Section "Underdrains" for piped subdrainage systems.
 - 3. Division 31 Section "Site Earth Moving" for miscellaneous earthwork materials and procedures for utility systems and locations beyond landfill limits.
 - 4. Division 31 Section "Temporary Erosion and Sedimentation Control" for temporary site measures.
 - 5. Division 31 Section "Permanent Erosion and Sedimentation Control" for riprap at cap anchors.

1.3 DEFINITIONS

- A. ASTM: American Society for Testing and Materials.
- B. ETPH: Extractable Total Petroleum Hydrocarbons.
- C. HDPE: High Density Polyethylene
- D. LLDPE: Linear Low Density Polyethylene
- E. RCRA: Resource Conservation Recovery Act.

1.4 SUBMITTALS

- A. Product Data and Material Certifications: For the following:
1. General fill
 2. Cap Base material
 3. Drainage Sand material. Each type.
 4. Non-woven geotextile
 5. Geocomposite
- B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance with requirements indicated. Prepare separate reports for each type and application of soil material.
1. Gradation according to ASTM D 422 and classification according to ASTM D 2487, prior to delivery and at a rate of one per 5,000 cu. yd.
 2. Modified Proctor Testing according to ASTM D 1557.
 - a. General Fill, Cap Base and Sand Drainage Layer: prior to delivery and at a rate of one per 5,000 cu. yd.
 3. Origin of material, prior to delivery.
 4. Permeability Testing according to ASTM D 5084:
 - a. Cap Base and Sand Drainage Layer: One prior to delivery and one per 5,000 cu. yd. delivered.
 5. Interface Friction Angle Testing according to ASTM D5321:
 - a. Cap Base: One prior to delivery and one per 5,000 cu. yd. delivered.
 - b. Drainage Sand: One prior to delivery and one per 5,000 cu. yd. delivered.
 6. Internal Friction Angle Testing according to ASTM D 3080:
 - a. General Fill, Cap Base and Sand Drainage Layer: One prior to delivery and one per 5,000 cu. yd. delivered.
 - b. Geocomposite: One per proposed geomembrane liner type prior to delivery
 7. Soil Chemical Analysis Reports:
 - a. RCRA 8 Metals (EPA Method 6010 / 7421 / 7470), Polychlorinated Biphenyls (EPA Method 8082), Total Volatile Organic Compounds (EPA Method 8260), Semi-Volatile Organic Compounds/Polyaromatic Hydrocarbons (EPA Method 8270), Pesticides (EPA Method 8081), and Total Petroleum Hydrocarbons (CTETPH method): prior to delivery and one report for each 10,000 cu. yd., or portion thereof, delivered. Owner reserves the right to disqualify the source based on the results of the chemical testing.
 - 1) Soil/material shall not exceed any GB pollutant mobility criteria (GB PMC) or residential direct exposure criteria (RES DEC) established in

Sections 22a-133k-1 through 22a-133k-3 of the regulations of Connecticut state agencies.

C. Field Test Reports

1. Depth Test Hole Drawing: Identify installed layer, locate field test holes on plan, and record depth of tested layer. Submit before proceeding with subsequent layer installation.
2. Compaction Testing: Submit reports generated from field compaction testing.
 - a. Refer to "Field Quality Control" for frequencies and locations of tests.

1.5 QUALITY ASSURANCE

- A. Where "Form 816" is referenced, it shall mean "State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 816," and issued supplements.
- B. Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials testing, as documented according to ASTM D 3740 and ASTM E 548.
 1. Testing Agency performing tests involving geosynthetic materials shall also be accredited by the Geosynthetics Research Institute.

1.6 PROJECT CONDITIONS

- A. Stage earthwork operations to minimize travel of vehicular traffic over the cap area.
 1. Damage to the LLDPE geomembrane liner resulting from construction activities shall be repaired at the Contractor's expense.
 2. No vehicular traffic shall be allowed to operate directly on the geomembrane liner.
 - a. Construction vehicles will not be allowed to travel over installed geomembrane liner without use of a sacrificial geosynthetic (e.g. strip of membrane or geotextile).
 - b. Limit construction vehicle loads to a maximum ground pressure approved by the manufacturer.
 - c. Sacrificial geosynthetic material shall not be incorporated into The Work.

PART 2 - PRODUCTS

2.1 GENERAL FILL

- A. General Fill: Free from ice, snow, roots, sod, rubbish, and other deleterious or organic matter.
 1. Use for general raises in landfill grade and waste cover.

2. Meet the following gradation:

<u>U.S. Standard Sieve</u> <u>Size</u>	<u>Percent Finer By</u> <u>Weight</u>
3-inch	100
No. 10	30-90
No. 40	10-70
No. 200	0-20

3. Minimum Internal Friction Angle: When tested in accordance with ASTM D 3080 shall be 29 degrees peak. Test shall be performed with general fill compacted to a dry density equal to a range between 85 and 90 percent of the maximum density, at a moisture content 3 percent wet of optimum moisture, obtained in accordance with ASTM D 1557 after soaking the prepared samples for a period of at least 24 hours to obtain uniform moisture content in the materials being tested. The specimens shall be sheared via the large scale direct shear method with 1 and 5 psi normal stresses.
4. Minimum Compacted Wet Unit Weight: When compacted to 90 percent of maximum dry density at a moisture content of 3 percent wet of optimum, obtained in accordance with ASTM D 1557, shall be 120 pounds per cubic foot.

2.2 CAP BASE

- A. Cap Base Material. Naturally or artificially graded mixture of natural or crushed gravel free of sharp edges, and natural or crushed sand.
 1. Use directly beneath landfill geomembrane liner.
 2. Minimum Permeability: ASTM D 5084, 1.0×10^{-3} cm/sec when compacted at optimum to 3 percent of optimum moisture content, and 90 percent of maximum density in accordance with ASTM D 1557.
 - a. Test samples at effective confining pressure of 3 psi, under hydraulic gradients ranging from 5 to 20.
 3. Minimum Interface Friction Angle: Between the cap base material and geomembrane liner. Test shall be performed with cap base material compacted to a dry density equal to a range between 85 and 90 percent of the maximum density, at a moisture content 3 percent wet of optimum moisture, obtained in accordance with ASTM D 1557 and tested in accordance with ASTM D 5321 after soaking the prepared samples for a period of at least 24 hours to obtain uniform moisture content in the materials being tested. The specimens shall be sheared via the large scale direct shear method at a rate of 0.005 in/minute at 1, 3 and 5 psi normal stresses.
 - a. Closure Turf™ Liner: Minimum interface friction angle of 35 degrees peak.
 - b. TPO Liner: Minimum interface friction angle of 8 degrees peak.
 4. Minimum Internal Friction Angle: Shall be 35 degrees when tested in accordance with ASTM D 3080. Test shall be performed with cap base material compacted to a dry density equal to a range between 85 and 90 percent of the maximum density, at a

moisture content 3 percent wet of optimum moisture, obtained in accordance with ASTM D 1557 after soaking the prepared samples for a period of at least 24 hours to obtain uniform moisture content in the materials being tested. The specimens shall be sheared via the large scale direct shear method with 1, 3 and 5 psi normal stresses.

5. Minimum Compacted Wet Unit Weight: Shall be 110 pounds per cubic foot when compacted to 90 percent of maximum dry density at a moisture content of 3 percent wet of optimum, obtained in accordance with ASTM D 1557.
6. Meet the following gradation:

<u>U.S. Standard Sieve Size</u>	<u>Percent Finer By Weight</u>
1-inch	100
No. 10	30-90
No. 40	10-70
No. 200	0-10

2.3 DRAINAGE LAYER

- A. Geocomposite (Bi-Planar or Tri-Planar): Drainage net with non-woven geotextile fabric bonded to each side. For use only where indicated on the plans.

1. Geonet: HDPE material.

<u>Properties</u>	<u>Unit</u>	<u>Value</u>	<u>Test</u>
Carbon Black Content	Percentage	2 to 3	ASTM D1603
Transmissivity	m ² /sec	≥1.4 x 10 ⁻³	GRI GC8
Polymer Specific Gravity		0.93	ASTM D1505
Polymer melt flow index	g/10 min	≤1.0	ASTM D1238
Thickness	millimeters	5.3	ASTM D5199

- a. Perform transmissivity test with rigid platter or substratum and Ottawa Sand on super stratum. Test at gradient of 0.04 at a temperature of 68 degrees F and normal stress of 1,000 psf.

2. Non-Woven Geotextile:

<u>Properties</u>	<u>Unit</u>	<u>Value</u>	<u>Test</u>
Unit Weight per Area	oz./yd ²	6.0	N/A
Flow	gpm/sf	150	ASTM D4491
Grab Tensile	lbs.	120	ASTM D4632

3. Ties: Strings, plastic fasteners, or polymer braid used to secure adjacent sheets of drainage composite
 - a. Metallic ties will not be allowed.
 - b. Color: Yellow or white to facilitate inspection.
 4. Minimum Interface Friction Angle: Between each type of proposed geomembrane liner and geocomposite geonet (with non-woven geotextile heat-bonded to each side). The specimens shall be sheared via the large scale direct shear method at a rate of 0.005 in/minute at 1, 5 and 12 psi normal stresses. .
 - a. Material proposed for slopes >10%: Minimum interface friction angle of 29 degrees peak and 29 degrees residual.
 - b. Material proposed for slopes ≤10%: Minimum interface friction angle of 8 degrees peak and 8 degrees residual.
- B. Drainage Sand for Slopes Greater Than or Equal to 10 Percent.
1. Minimum Permeability: ASTM D 5084, 1.0×10^{-2} cm/sec when compacted at optimum to 3 percent of optimum moisture content, and 90 percent of maximum density in accordance with ASTM D 1557.
 - a. Test samples at effective confining pressure of 3 psi, under hydraulic gradients ranging from 5 to 20.
 2. Minimum Interface Friction Angle: Between the geomembrane liner and drainage sand. Test shall be performed with drainage sand compacted to a dry density equal to a range between 85 and 90 percent of the maximum density, at a moisture content 3 percent wet of optimum moisture, obtained in accordance with ASTM D 1557 and tested in accordance with ASTM D 5321 after soaking the prepared samples for a period of at least 24 hours to obtain uniform moisture content in the materials being tested. The specimens shall be sheared via the large scale direct shear method at a rate of 0.005 in/minute at 1, 3 and 5 psi normal stresses.
 - a. Minimum interface friction angle of 32 degrees peak.
 3. Minimum Internal Friction Angle: Between the geocomposite geonet and drainage sand. When tested in accordance with ASTM D 3080. Test shall be performed with drainage sand compacted to a dry density equal to a range between 85 and 90 percent of the maximum density, at a moisture content 3 percent wet of optimum moisture, obtained in accordance with ASTM D 1557 after soaking the prepared samples for a period of at least 24 hours to obtain uniform moisture content in the materials being tested. The specimens shall be sheared via the large scale direct shear method with 1, 3 and 5 psi normal stresses.
 - a. Minimum internal friction angle of 32 degrees.
 4. Minimum Compacted Wet Unit Weight: When compacted to 90 percent of maximum dry density at a moisture content of 3 percent wet of optimum, obtained in accordance with ASTM D 1557.
 - a. Minimum of 110 pounds per cubic foot

5. In addition to the permeability requirements, all drainage sand shall be free of sharp edges and meet the following gradation requirement.

<u>U.S. Standard</u>	<u>Percent Finer</u>
<u>Sieve Size</u>	<u>By Weight</u>
1-inch	100
No. 10	30-90
No. 40	10-70
No. 200	0-10

- C. Non-Woven Geotextile Cover: Placed between drainage sand and vegetative support material and between road embankment material and drainage sand.
1. Needle-punched fabric of polypropylene fibers, conforming with Form 816, Article M.08.01-26.
 2. Geotextile shall have the following properties:
 - a. Minimum Mass per Unit Area of 8.0 oz/yd²
 - b. Minimum Tensile strength of 90 lbs.
 - c. Minimum elongati on of 50 percent
 - d. Minimum flow rate of 150 gpm/sq.ft.
 - e. Minimum U.V. resistance of 70 percent at 150 hrs.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Protect subgrades and foundation soils against freezing temperatures or frost.

3.2 LANDFILL SITE CLEARING

- A. Strip existing vegetation to root depth to enable placement of cap base material directly on daily cover material. Collect and dispose of all vegetated material.

3.3 APPROVAL OF SUBGRADES

- A. Notify Engineer when site has reached proposed landfill subgrade and each material level subgrade.
- B. If Engineer determines that unsatisfactory conditions are present, remove and replace material to the satisfaction of the Engineer at no additional cost to the Owner.

1. Reconstruct subgrade damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Engineer.

3.4 STORAGE OF SOIL MATERIALS

- A. Stockpile materials and excavated soil materials meeting project specifications. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Prevent windblown dust.

3.5 FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 10 percent so fill material will bond with existing material.
 1. Refuse Area Grades:
 - a. Maximum Slope: 3H:1V (33 percent) (except as indicated).
 - b. Minimum Slope: 25H:1V (4 percent).

3.6 CAP BASE MATERIAL

- A. Place and compact cap base material in one layer or 6 inch maximum lifts, to the lines and grades indicated.
- B. Perform depth test hole testing.

3.1 GEOCOMPOSITE

- A. Installation:
 1. Install geocomposite on top of geomembrane liner in accordance with manufacturer's requirements.
 - a. A manufacturer's Technical Service Representative shall be present during all geonet installation activities.
 - b. The Contractor shall bear the expense of this Technical Service Representative.
 2. Placement of the geocomposite shall be done without damaging any underlining geosynthetic. The geocomposite shall be placed on the prepared surface in such a manner as to assure minimum handling. Any necessary surface preparation should be completed before installation begins.
 3. Geocomposite shall be anchored in anchor trenches with the geomembrane cap as detailed on the approved shop drawings.
 - a. Only those rolls of geocomposite material which can be anchored and tied together that same day shall be unpackaged and placed in position.
 4. Adjacent rolls shall be overlapped and plastic ties pushed through the geocomposite in the overlap area. Plastic ties shall be white or other bright color to allow easy

inspection and metallic ties shall not be allowed. Plastic ties shall be installed at 5 foot intervals. There shall be no slack in the geocomposite, but the material shall be installed in a relaxed condition.

5. In the corners of the side slopes where there is a gap between overlapping rolls of the geocomposite, an extra layer of material shall be installed from the top to the bottom of the slope.

B. Protection:

1. Materials, equipment, or other items shall not be dragged across the surface of the geocomposite and no materials shall be allowed to slide down the slopes on the geocomposite.
2. The Contractor shall place all cover materials in such a manner as to ensure the geocomposite is not damaged.

3.2 DRAINAGE SAND LAYER

- A. Place sand drainage material in one continuous lift and spread using tracked equipment having a ground pressure less than or equal to 10 psi.
- B. Immediately track sand after fine grading has been completed. Utilize tracked bulldozers with grousers of sufficient height to leave visible depressions in the subgrade. Operate equipment parallel to the direction of water flow, leaving track depressions that are perpendicular to the direction of water flow, which will reduce erosion potential until placement of Vegetative Support Material.
- C. Perform depth test hole testing.

3.3 NON-WOVEN GEOTEXTILE

A. Installation:

1. Install non-woven geotextile where shown on the drawings in accordance with manufacturer's requirements.
 - a. The surface on which the geotextile is placed shall be maintained in a firm, clean, dry and smooth condition during installation.
 - b. The geotextile shall be placed over the prepared surface in a manner as to assure minimum handling.
 - c. The sheets shall be of such lengths and widths and shall be placed in such a manner as to minimize field seaming.
 - d. Horizontal field seams on the slopes shall be kept to a minimum.
2. Geotextile material shall be anchored as shown on the approved shop drawings, as shown on the plans or as directed by the Engineer.
 - a. Geotextile shall not be welded to the liner.

- b. Only those sheets of material which can be anchored and sealed together that same day shall be unpackaged and placed in position.
- c. The leading edge of the material shall be secured at all times with sandbags or other means sufficient to hold it down during high winds.
- 3. Adjacent rolls shall be overlapped a minimum of 12 inches to assure continuity or as specified by the manufacturer with approval of the Engineer.
 - a. The overlap shall be in the direction, such that the aggregate being spread does not push the fabric apart.
- 4. Installation of the geotextile shall be approved by the Engineer prior to placing cover material over the geotextile.

B. Patching:

- 1. If the geotextile is damaged during installation, it shall be immediately repaired.
 - a. A patch of fabric large enough to cover the damage, plus an 18 inch overlap shall be placed on top of the damaged section or as specified by the manufacturer.

3.4 MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill layer before compaction to no more than 1 percent dryer and 3 percent wetter than optimum.
- B. Do not place fill material on surfaces that are muddy, frozen, or contain frost or ice.
- C. Remove and replace, or scarify and air-dry, otherwise satisfactory soil material that exceeds optimum moisture and is too wet to compact to specified dry unit weight.

3.5 COMPACTION OF FILL

- A. Place and compact fill materials in the presence of the Engineer.
- B. Compact soil to not less than the following percentages of maximum dry density according to ASTM D1557:
 - 1. General Fill: 90 percent minimum.
 - 2. Cap Base Material: 90 percent minimum.
 - 3. Drainage Soil: Two passes of a Caterpillar D-6 bulldozer, or equal.
 - 4. Landfill Slopes: Scarify and recompact top 6 inches below subgrade.

3.6 GRADING

- A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Grading: Slope grades to prevent ponding. Finish subgrade to required elevations within the following tolerances:
1. Lawn or Unpaved Areas: Plus or minus 1 inch, however, not consistently in one direction.

3.7 FIELD QUALITY CONTROL

- A. Allow testing agency to inspect and test subgrade and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
- B. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
1. Perform six tests per acre, minimum.
- C. When testing agency reports that subgrade or fill has not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.
- D. Depth Test Hole. Confirm depth of cap base material and sand drainage layer before placement of subsequent membrane or cover material.
1. Hand excavate test holes at 100 feet on-center, maximum.
 2. Record depth of layer at each test hole on site plan.
 3. Refill test hole and compact material as required.
 4. Engineer shall review depth readings and determine extent of areas that contain an insufficient depth of material. Provide additional material as required to meet minimum layer thickness at no additional cost. Repeat test hole process until satisfactory results are obtained.

3.8 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.9 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Transport waste material, including unsatisfactory soil, trash, and debris, to designated locations on Owner's property.
 - 1. To minimize voids within on-site disposal areas, crush rocks and pieces of concrete-site improvements 6 inches and larger in size to a maximum size of 3 inches. At the Contractor's option, items of this nature may be:
 - a. Crushed for recycled fill.
 - b. Disposed of off-site.
- B. Disposal: Transport surplus satisfactory soil to designated locations on Owner's property. Stockpile or spread satisfactory soil as directed by Engineer.

END OF SECTION

SECTION 02 66 52 –CLOSURE TURF™ ALTERNATIVE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes a composite system of Linear Low-Density Polyethylene geomembrane and a synthetic turf protection layer.
- B. Related Sections include the following:
 - 1. Division 02 Section "Landfill Earth Moving" for general site earthwork requirements.
 - 2. Division 48 Section "Solar Energy Electrical Generation System" for photovoltaic requirements.

1.3 REFERENCES

- A. Geosynthetic Research Institute: GRI GM11, GRI GM12
- B. ClosureTurf™ Quality Control Manual

1.4 DEFINITIONS

- A. ClosureTurf™: Manufacturer's brand name for a proprietary system comprised of 50-mil LLDPE "Super Gripnet" liner, synthetic turf, and sand ballast.
- B. Installer: Authorized installer of geomembrane manufacturer.
- C. LLDPE: Linear Low Density Polyethylene
- D. Manufacturer's Field Representative: Authorized and trained manufacturer representative.
- E. Quality Assurance Consultant (QAC): Owner's representative that will review material, procedure, and testing submittals; and will observe on-site installation including seaming operations and repair work.

1.5 PROPOSAL SUBMITTALS

- A. Installer name and qualifications, including Project experience descriptions.
- B. Superintendent qualifications.

1.6 ACTION SUBMITTALS

A. As prepared by the Installer.

1. Product Data:
 - a. For each type of product indicated.
 - b. Include manufacturer's requirements for surface preparation, technical data, and tested physical and performance properties of geomembrane.
2. Qualification Data: For Installer and geomembrane manufacturer's Field Representative.
3. Shop Drawings: Indicate extent, panel sizes, panel identification number, panel orientation, and details of penetrations and seams for geomembrane and turf panels.
 - a. Assign each panel and seam a simple and logical identification number or letters. Correlate seam identification system with panel identification system.
 - b. Panel layout. Indicate seam orientation and roll sizes.
 - 1) Design layout to utilize largest panel sizes possible, minimize seams, and to minimize horizontal field seams on slopes.
 - 2) For turf panels, identify proposed direction of flipping panel after sewing of seams
 - c. Details
 - 1) Termination of material at perimeter of panel areas.
 - 2) Penetration sealing procedures.
 - 3) Anchoring procedures.
 - 4) Temporary Construction Access Roads.
 - d. Installer's preferred sequence of panel placement.
4. Installation Procedures: Include manufacturer's requirements and detailed quality control procedures.

B. Sand Ballast Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance with requirements indicated. Prepare separate reports for each type and application of soil material.

1. Gradation according to ASTM D 422 and classification according to ASTM D 2487, prior to delivery and at a rate of one per 5,000 cu. yd.
2. Origin of material, prior to delivery.
3. Permeability Testing according to ASTM D 5084; One prior to delivery and one per 5,000 cu. yd. delivered.
4. Soil Chemical Analysis Reports:
 - a. RCRA 8 Metals (EPA Method 6010 / 7421 / 7470), Polychlorinated Biphenyls (EPA Method 8082), Total Volatile Organic Compounds (EPA Method 8260),

Semi-Volatile Organic Compounds/Polyaromatic Hydrocarbons (EPA Method 8270), Pesticides (EPA Method 8081), and Total Petroleum Hydrocarbons (CTETPH method): prior to delivery and one report for each 10,000 cu. yd., or portion thereof, delivered. Owner reserves the right to disqualify the source based on the results of the chemical testing.

- 1) Soil/material shall not exceed any GB pollutant mobility criteria (GB PMC) or residential direct exposure criteria (RES DEC) established in Sections 22a-133k-1 through 22a-133k-3 of the regulations of Connecticut state agencies.

1.7 INFORMATIONAL SUBMITTALS

- A. Material Quality Control Certificate: Provide for each geomembrane roll delivered to the site. List specified material properties. Clearly label with distinctive code number.
- B. Manufacturer's Quality Control Test Data: Provide test data collected in accordance with the requirements of GRI Test Method GM17, dated June 2003, including test frequencies and physical/chemical properties listed in Tables 1(a) and 2(a) thereof.
- C. Samples: As requested by the Quality Assurance Consultant.
- D. Daily Examination Report: Before proceeding with membrane installation, complete and submit to Owner "Letter of Surface Confirmation," which states observation and acceptance of surface area to receive membrane, signed by Installer and QAC.
- E. Trial Seam Test Report: Submit on a weekly basis. Installer shall record date, time, weather conditions, test results, operator, and equipment number for each trial seam tested.
 1. Trial Seam Sample: Submit properly identified unused section of trial weld seam to Owner.
- F. Sand Ballast Depth Test Locations: Locate field test holes on plan, and record depth of Sand Ballast.
- G. Record Drawings: Include panel layout and identification, seam type and identification, repair locations and identifications, and destructive test sample locations and identification.
 1. Record the roll number, location, and date of installation of each panel placed.
 2. Submit working copies when requested by the Quality Assurance Consultant.
 3. Submit final Record Drawings prior to demobilizing from the site.
- H. Installation Certificate: Installer's Final "Certificate of Acceptance" stating that installation procedures and required testing have been completed in accordance with the specifications.
- I. Warranties regarding quality of materials, workmanship, and long-term performance of the completed geomembrane system.

1.8 QUALITY ASSURANCE

- A. Where "Form 816" is referenced, it shall mean "State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 816," and issued supplements.
- B. Geomembrane Manufacturer's Field Representative Qualifications: Competent, field technical representative that has personally supervised and directed the installation of a minimum of 2,000,000 s.f. of the specified geomembrane product.
- C. Installer: An experienced Installer that has successfully completed projects similar in size and scope but no less than 20 geomembrane landfill closures totaling a minimum of 2,000,000 s.f.
 - 1. Installers must be certified by the liner system manufacturer for the installation of the ClosureTurf™ System.
 - 2. Installers not currently certified will be expected to meet the certification criteria included as *Appendix D* of the Technical Specifications.
 - 3. Seaming Personnel: Experienced in projects of similar nature, material, and installation method, with at least one seamer having a minimum of 1,000,000 s.f. installation experience.
- D. Source Limitations:
 - 1. Provide all components of the proprietary closure system from a single manufacturer.
 - 2. The Installer shall promptly inform the Quality Assurance Consultant upon placing an order for materials so that arrangements may be made, if desired, for inspection before shipment from the place of manufacture.
- E. Pre-Installation Conference: Conduct conference at Project site.
 - 1. Review manufacturer requirements including surface condition, forecasted weather conditions, seam details, installation and repair procedures, testing and inspection procedures, and protection of installed geomembrane.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Upon delivery of geomembrane rolls to the site, assist QAC with inspection and provide labor, equipment, and incidentals as needed for inspection.
 - 1. Folded geomembrane is not acceptable. Any evidence of folding or other shipping damage is cause for rejection of the material.
 - 2. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until documentation has been received, approved and accepted.
 - 3. Immediately remove from the site damaged or defective material as directed by the QAC, and at no additional cost to the Owner.

- a. Temporarily store rejected material at a location separate from accepted geomembrane.
- B. Store membrane rolls on a prepared surface approved by the QAC, no more than 3 rolls high. Protect rolls from dirt, grease, water, abrasions, excessive heat or cold, or other damage.
- C. Handle geomembrane rolls with appropriate equipment, designed to handle sheet materials. Use spreader bars and cloth chokers when loading and transporting to prevent damage or stressing of the geomembrane material.

1.10 PROJECT CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit system to be installed according to manufacturer's written instructions and warranty requirements.
 1. Install material when ambient air temperature is within the temperature range as specified and as required by the manufacturer.
- B. Do not allow vehicular traffic directly on geomembrane panels without the prior approval of the Engineer. Only rubber tire/track ATV and trucks with ground pressure less than manufacture's recommendations will be allowed.
 1. Small equipment such as generators must be placed on scrap geomembrane material (rub sheets) above geomembrane.
 2. Prior to driving on geomembrane, check for sharp edges embedded rocks or other foreign materials stuck into or protruding from tires/tracks.
 3. Path driven on geomembrane must be as straight as possible with no sharp turns, sudden stops or quick starts.
 4. No equipment will be left running or unattended over the constructed geomembrane.
- C. Do not allow personnel working with geomembrane panels to wear shoes that will damage the panels.
- D. During installation of the Closure Turf™ system, the Installer shall provide facilities, access, time, labor, tools, equipment and other incidentals as necessary for the QAC and their representatives to perform installation inspection and testing of materials and equipment, all at no additional cost to the Owner.

1.11 WARRANTY

- A. Manufacturer's Warranty: Provide written warranty as it relates to the quality of the material, for a period of not less than 20 years.
- B. Installer: Provide written, standard general contractor's warranty as it relates to performance for a period of not less than 5 years.

PART 2 - PRODUCTS

2.1 LLDPE GEOMEMBRANE

- A. Material: First quality LLDPE resin containing less than 2-percent clean recycled polymer.

<u>Properties</u>	<u>Test Method</u>	<u>Minimum Value</u>
Melt Index	(ASTM D1238, 190°C/2.16kg)	≤ 1 gram/10 min.
Oxidative Inductive Time	(ASTM D3895 1atm/200°C)	≥ 100

- B. Membrane Properties: Unreinforced LLDPE containing 3 percent by weight maximum additives, fillers or extenders including carbon black; free of striations, pinholes, blisters, bubbles, undispersed raw materials, or signs of contamination by foreign matter on the material surface.

1. Super Gripnet® Structured LLDPE: Physical and Chemical properties meeting the requirements of the Geosynthetic Research Institute's "Test Method GM17", Table 2(a)

<u>Properties</u>	<u>Test Method</u>	<u>Minimum Value</u>
Sheet Thickness	(ASTM D 5594)	50 mils (+ 5 mil / - 0 mil)
Density	(ASTM D 792)	> 0.92 g/cm ³
Tensile Strength at Break	(ASTM D 6693)	> 100 lb/in of width
Elongation at Break	(ASTM D 6693)	≥ 300 percent
Tear Strength	(ASTM D 1004)	≥ 30 lbs.
Puncture Resistance	(ASTM D 4833)	≥ 55 lbs.
Carbon Black Content	(ASTM D4218)	2 % (minimum)
Carbon Black Dispersion	(ASTM D5596)	Category 1 or 2 for 9 of 10 views Category 3 for 1 of 10 views (max)

- C. Membrane Seams: Physical properties meeting the requirements of the Geosynthetic Research Institute's "Test Method GM19", Table 2(a)

<u>Properties</u>	<u>Test Method</u>	<u>Minimum Value</u>
Shear Strength	(ASTM D 6392)	90 lb/in

<u>Properties</u>	<u>Test Method</u>	<u>Minimum Value</u>
Shear Elongation at Break	(ASTM D 6392)	50 percent
Peel Strength	(ASTM D 6392)	75 lb/in 66 lb/in (extrusion weld)
Peel Separation	(ASTM D 6392)	25 percent

2.2 PENETRATIONS

- A. Penetrations shall be made as depicted on the Drawings and in accordance with liner manufacturer's instructions.
1. Geomembrane liner boots shall be specifically manufactured by the liner manufacturer for such use or field fabricated of smooth LLDPE Geomembrane Liner material in accordance with manufacturer's instructions.
 2. Banding: Stainless steel, Type 304, 3/4-inch wide, adjustable screw-type clasp, or approved equal.
 3. Gasket: Neoprene, closed cell medium, 1/4-inch thick, 2-inches wide with adhesive on one side as supplied by geomembrane liner manufacturer, or approved equal.
 4. Sealant: 100% Silicone Sealant

2.3 SYNTHETIC TURF SYSTEM

- A. ClosureTurf™: Synthetic grass

<u>Properties</u>	<u>Test Method</u>	<u>Minimum Value</u>
Yarn Count	(ASTM D 1907)	8000 (min 7300) Denier
Tensile Grass at Break	(ASTM D 2256)	20 lbs plus/minus 5 lbs
Elongation at Break	(ASTM D 2256)	30 – 80 Percent
Yarn Weight Minimum	(ASTM D 5261)	19 oz/sy
Double 13/18 Pic Polybag	(ASTM D 5261)	6 oz/sy
Product Weight w/out ballast	(ASTM D 5261)	26 oz/sy ±1%
Pile Height, Minimum		1.25 in
Tufting Gage		3/4 inch plus/minus 1 percent
Transmissivity with underlying structured geomembrane, Minimum	(ASTM D 4716)	2.5E-03 m ² /sec
Internal Friction of combined components, Minimum	(ASTM D 5321)	35 degrees

<u>Properties</u>	<u>Test Method</u>	<u>Minimum Value</u>
UV Resistance and Stability. Tensile testing after weathering, Minimum	(ASTM G 147-02) 200W/m ² 30 years exposure	55% Retained Strength

B. Ballast and Infill:

1. Medium Sand Ballast: ASTM D2487, SW or SP, with 10 percent coarse and 10 percent fine sand.
2. Cemented Ballast
 - a. Sand: See "Medium Sand" above.
 - b. Lime: ASTM C207.
 - c. Portland Cement: ASTM C 150, Types I or II or Type I/II.
 - d. Water: Potable and complying with ASTM C 94.
 - e. Pre-blended and packaged by the ClosureTurf™ system manufacturer.

PART 3 - EXECUTION

3.1 GENERAL

- A. Owner's QAC will observe the complete installation of the Closure Turf™ system including delivery to site, handling, deploying, seaming, testing, and repair work.
 1. Do not install geomembrane without QAC being present.
 2. No additional compensation will be provided for possible delays that may be caused due to inspection and testing of materials and workmanship.
- B. Inform QAC on a daily basis of proposed work schedule, including changes.
- C. Mark geomembrane panels by their identification number or letters.
- D. The Installer shall be responsible for field handling, storing, placing, seaming, plus any other processes required to assemble a continuous secure geomembrane system.

3.2 PREPARATION

- A. See Division 02 Section "Landfill Earthwork" for subgrade preparation and bedding placement.
 1. Surfaces shall be smooth and free of rocks, stones, sticks, roots, sharp objects, and debris, and provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes or break in grade.

3.3 EXAMINATION

- A. Installer and QAC: On a daily basis, simultaneously inspect the prepared subgrade. Immediately inform the Contractor of unsatisfactory conditions and remedial work required for the subgrade to meet the specified criteria before placement of geomembrane.
 - 1. Upon satisfactory subgrade condition, the Installer and QAC will issue a joint "Letter of Surface Confirmation."

3.4 GEOMEMBRANE INSTALLATION

- A. Install and seam membrane panels when the ambient air temperature is between 40 degrees F and 104 degrees F, as measured 6 inches above subgrade surface elevation.
 - 1. Do not install, seam, or repair membrane panels during precipitation, excessively high winds, or in areas of ponded water or excessive moisture.
 - 2. Do not install and seam geomembrane panels in ambient temperatures below 40 degrees F unless approved by the Quality Assurance Consultant, and only if trial seams demonstrate the ability to meet seaming specifications.
- B. Before deploying geomembrane panels, Installer shall repair subgrade or other underlying surface disturbed or damaged after issuance of "Letter of Surface Confirmation."
- C. Place material over prepared subgrade with minimum handling. Place rolls in accordance with approved panel layout.
 - 1. Install only rolls of material that can be anchored and sealed by end of each day's operation.
- D. Properly secure geomembrane during installation with sandbags, rubber tires or other means approved by the QAC. Do not use large or sharp rocks, or other sharp objects.
- E. Install geomembrane material in relaxed condition. Provide excess material for each panel as per requirements. Do not stretch material to fit area; keep material free from stress and tension during installation.
 - 1. Unroll geomembrane panels in a manner that will not stretch, crimp, abrade, or otherwise damage panels. Place panels in a manner that minimizes wrinkles and differential wrinkles between adjacent panels.
- F. Overlap geomembrane panels to facilitate drainage of water. All panels deployed during a single day shall be seamed or tack welded together that same day to the extent practicable.
- G. Anchor perimeter of geomembrane panels in trench as indicated on the Drawings.

3.5 GEOMEMBRANE FIELD SEAMING

- A. Lay out the geomembrane seams parallel to the line of maximum slope.

1. Minimize the use of cross or butt seams on slopes, seams located in corners, and unusual geometric panel shapes.
- B. The seam identification system shall be related to and compatible with the panel identification system.
- C. Equipment: Include temperature gages and readout devices that allow continuous monitoring of apparatus temperatures during seaming. Electric generators shall be capable of providing constant voltage under load and shall be underlain with a splash pad to collect spilled fuel or oil when located on the membrane.
- D. Overlap geomembrane surfaces a minimum of 4 inches and clean surfaces of moisture, grease, dust, dirt, debris and foreign material.
 1. Do not use solvent or adhesive for seaming without approval from the manufacturer and the QAC.
 2. Install a protective sheet of plastic below the geomembrane material being seamed when needed and where moisture or dirt causes seaming difficulty. As seaming progresses, pull the protective sheet along beneath the seaming apparatus.
 - a. Do not permanently leave the protective plastic sheet beneath the geomembrane.
 3. For extrusion welding, clean surfaces to be seamed of oxidation by disc grinder not more than one hour before extruding the seam. Abrasion of the seam area with the disc grinder shall not extend more than one-half inch beyond the extrusion bead area. Tack welding of the panels to be seamed shall not damage the membrane or adversely affect the seaming operation. The top membrane of the seam overlap shall be beveled and the extrusion apparatus shall be purged of heat-degraded extrudant before seaming.
 4. Fish mouths shall be cut along the ridge of the wrinkle and laid flat to overlap the edges of the cut. The overlap shall be extrusion-seamed and any portion of the seam with less than 3 inches of overlap shall be patched with a circular or oval patch extending a minimum of 6 inches beyond the cut in all directions.
- E. The Installer shall log the ambient air temperature 6 inches above the membrane elevation, extruded temperatures in extruder barrels and nozzles, and operating temperatures of hot wedge seamers at intervals of 2 hours or less.

3.6 GEOMEMBANE CAP PENETRATIONS

- A. Any penetrations in the liner required by a pipe, vent, utility pole, fence post, concrete structure or other constructed feature shall be connected to the liner as depicted on the drawings and in accordance with the geomembrane Manufacturer's recommendations as approved by the Engineer.
 1. The connection to the geomembrane shall be made to assure the permeability of the liner at the connection has not been increased.

2. Test all penetrations for air tightness using procedures recommended by the Manufacturer.
3. Each penetration shall be inspected and approved by the Engineer prior to being covered.
4. Any damage to the liner materials shall be repaired in accordance with the specifications.

3.7 GEOMEMBRANE INSPECTION

- A. Visually inspect seams and panels for holes, crimps, abrasions, or defects, and mark suspect locations. Clearly mark repair locations on the membrane panel and assign an appropriate identifying label
 1. Clearly mark and record repair locations and non-destructive test data on the Record Drawings with swing ties to fixed improvements (wells, poles, buildings, etc.).
 2. Do not cover repairs until passing results of non-destructive tests are achieved and accepted by the QAC.
- B. Remove wrinkles in geomembrane panels larger than 3 inches. Cut wrinkle, reseam and test until an acceptable seam is obtained.

3.8 GEOMEMBRANE REPAIRS

- A. Remove or repair damaged geomembrane panels damaged during installation at no additional cost to Owner.
- B. Repair geomembrane panels as follows:
 1. Preparation. Abrade surface of geomembrane in the seam/repair area no more than one hour before the repair is made. Keep repair/seam areas clean and dry at the time of the repair.
 2. Spot weld small tears, pinholes or over-abraded areas where thickness of the geomembrane has been reduced by more than 4 mils (0.004 inches).
 3. Abrade and reweld small sections of defective extrusion welds.
 4. Remove defective seam and replace with a new strip of material. Defective hot wedge seams may be abraded and extrusion welded providing the top membrane overlap is carefully cut off.
 5. Patch larger holes and defects. Extend patch material a minimum of 6 inches beyond the edges of the defect. Round corners of patches with a radius of at least 3 inches.

3.9 CLOSURE TURF™ SYSTEM INSTALLATION

- A. Closure Turf™

1. Prior to turf installation, inspect geomembrane layer and determine that the geomembrane has been properly installed and completed, and the supporting surface does not contain stones or debris that could damage the Turf.
 2. Deploy panels from the top of slope in a way that the leading edge of the roll stays at the top of the slope and with the grass filaments are downward.
 - a. Anchor panel with sand bags at top of slope during installation to prevent movement by wind.
 - b. Control the decent of the roll during deployment.
 3. Seaming Operation.
 - a. Provide 4-inch overlap and fasten with heavy-duty textile stitching machine (Nulong sewing machine or approved equal).
 - 1) Thread Material: Polyester
 - 2) Stitch Density: 4 stitches/inch
 - 3) Stitch Type: Type 401 Lock Stitch
 - 4) Seam Type: Single row prayer stitch.
 - b. After sewing, cut excess flap before flipping the panel, to reduce likelihood of a ridge.
 - c. Perform stitching operations so that woven geotextile base fabric is not exposed in the finished installation
- B. Sand Ballast:
1. Spread sand using manufacturer's approved method for installation and broom as infill between synthetic yarn blades of Turf.
 - a. Use low ground pressure equipment and pull-behind spreader bar or other approved manufacturer's methods for sand installation.
 - b. For slopes 3H:1V or steeper, install sand infill using long reach conveyor belts or water or air express blower methods.
 2. Lay sand with minimal compaction.
 3. Place sand in front of deployment equipment to improve bearing capacity of cover system.
 4. Install minimum thickness of 1/2-inches of sand before allowing lightweight vehicles on the Turf.
- C. Cemented Ballast
1. Do not spread dry mix on wet or moist conditions, and if rain is anticipated within 24 hours of spreading process.
 2. Spread dry blend of cement mix in accordance with "Sand Ballast" requirements specified herein.

3. After installation of dry mix, apply water at a rate prescribed by Turf manufacturer to hydrate cement mix.
4. Employ curing methods in accordance with Turf manufacturer's requirements.

3.10 CLOSURE TURF™ SYSTEM REPAIRS

- A. Use hot glue gun to patch holes or tears in Turf by placing a patch 2 feet beyond edges of hole or tear.
 1. If hole or tear width is more than 50 percent of the roll width, cut out damaged area across the entire roll and join two segments by stitching.

3.11 FIELD QUALITY CONTROL TESTING

- A. Geomembrane Seam Testing. Record locations and results of seam tests on the Record Drawing. Keep records on site for inspection by the Owner and QAC.
- B. Geomembrane Trial Seams
 1. Sample Quantity: For each seaming apparatus, for the following instances.
 - a. At the beginning of each shift.
 - b. After apparatus has been turned off or disconnected from its power source.
 - c. When apparatus has been idle for 30 minutes (extrusion welder) or 60 minutes (hot wedge welder).
 - d. Change in operator personnel.
 - e. When deemed necessary by the QAC.
 2. Sample Size: 3 feet long and 12 inches wide (perpendicular to the seam), minimum.
 - a. Cut 1-inch-wide samples perpendicular to the seam for testing. Provide at a minimum, six for peel test and three for shear test.
 3. Shear (Bonded Seam Strength) and Peel (Adhesion) Tests: In accordance with ASTM D6392. Installer shall provide tensiometer, calibrated within one year from start of geomembrane installation.
 4. Conduct trial seams under the same physical conditions as permanent seaming.
 - a. For double-fusion hot wedge seams, both seams in each sample shall be tested for peel adhesion.
 - b. All six peel tests and all three shear tests are required to pass for the trial seam to be acceptable.
 - c. Each sample failure must consist of a ductile break that is film tearing bond.
 5. If either test sample fails (shear or peel), repeat trial seam test procedure. If any test seams fail on the second trial seam, the seaming apparatus shall not be used until it is repaired or faulty conditions are corrected, and two trial seams pass the destructive tests.

C. Geomembrane Non-destructive Seam Testing

1. Acceptable Methods. Vacuum box testing, air-pressure testing of double-fusion seams, or other methods approved by the manufacturer and QAC.
2. Perform non-destructive testing over the full length of each seam. Perform testing as work progresses. Do not wait to perform testing until the completion of large segments of field seaming.
3. Vacuum Box Testing: In accordance with ASTM D5641. Utilize vacuum box approved by the Quality Assurance Consultant. Vacuum box shall include rigid housing, transparent viewing window, a soft rubber gasket on the bottom edge, and a valve assembly with a vacuum gage.
 - a. Mark geomembrane seamed areas when soap bubbles are visible in the viewing window.
 - b. Repair marked locations and retest.
4. Air Pressure Testing: In accordance with ASTM D5820. Perform air –pressure test on double-fusion seams having an air channel between the seams. Mark results on the geomembrane adjacent to the test location.
5. If a seam is located where non-destructive testing cannot be performed, the seam shall, at the discretion of the QAC, be cap-stripped. Installer shall perform cap-stripping operation only in presence of QAC.

D. Geomembrane Destructive Seam Testing

1. Samples: The Installer shall cut and remove destructive test samples from the installed geomembrane material, assign the sample an identification number, and record the sample location on the Record Drawings.
 - a. Perform one series of destructive seam tests per 1,000 l.f. of seam, minimum. One test must be performed per welding machine per day.
 - b. Locations: As determined by the QAC.
 - c. Sample Size: 12 inches wide and 40 inches long with the seam centered lengthwise.
 - d. Perform destructive seam strength testing as work progresses in order to obtain test results before seams are covered.
 - e. The Installer shall immediately repair the geomembrane at the destructive test sample location, and perform non-destructive test.
2. Destructive Seam Series Test: In accordance with ASTM D6392.
 - a. Field Testing. Installer shall provide field tensiometer, calibrated within one year from start of geomembrane installation.
 - 1) Shear (Bonded Seam Strength)
 - a) One 1-inch strip cut from sample.
 - 2) Peel (Adhesion) Tests:

- a) Laboratory Test: Five 1-inch strips cut from samples.
 - b. Laboratory Testing. Coordinated by the Quality Assurance Consultant and performed by an independent geosynthetic testing laboratory paid for by the Owner.
 - 1) Shear (Bonded Seam Strength)
 - a) Laboratory Test: Five 1-inch strips cut from samples.
 - 2) Peel (Adhesion) Tests:
 - a) Laboratory Test: Five 1-inch strips cut from samples.
 - 3) Double-fusion Hot Wedge Seams. Test both seams in each sample for peel. Testing shall include, but not necessarily be limited to, thickness (ASTM D 5199/D 5594)
- E. Failure of Geomembrane Seam Tests.
1. If either field destructive test seams or laboratory test seams do not pass, reconstruct the seam between two passing test seam locations. Intermediate tests may be performed on each side of the failed test sample location to further isolate the defective seam area.
 2. If intermediate field test seams pass, laboratory test seams shall be performed on samples from the same locations.
 3. If laboratory test seams also pass, then the seam shall be reconstructed between the intermediate sample locations.
 4. If the intermediate or laboratory test seams fail, repeat the process with intermediate samples located further away from the original failing seam area to determine the defective seam area.
- F. Acceptable Geomembrane Seams.
1. Each seam shall be bounded by two locations where samples passed the laboratory destructive tests.
 2. Whenever a reconstructed seam exceeds 200 feet, an additional sample shall be obtained for destructive testing along the reconstructed seam.
 3. At the QAC's discretion, the Installer may be directed to take additional samples from seams welded on the same day by a seaming apparatus that welded a failed seam, at no additional cost to the Owner.
- G. Sand Infill Testing:
1. Field measure and verify minimum thickness of sand.
 - a. Frequency: 20 measurements per acre, randomly determined by Engineer.

3.12 TEMPORARY CONSTRUCTION ACCESS ROADS

- A. Install Temporary Construction Access Roads whenever vehicular traffic must traverse any portion of the installed liner system.
- B. Temporary Construction Access Road shall be installed in accordance with liner manufacturer's instructions and shall be capable of supporting vehicular and equipment loads of 60 psi.
- C. Clearly delineate limits of roadways to prevent vehicles or equipment from travelling off roadway.
- D. Remove all components of Temporary Construction Access Road and repair any damage caused by installation, use, and/or removal of roadway.

3.13 CLEANING

- A. Clean the work area at the end of each work day of unnecessary scrap material, sand bags, tools and other materials used during geomembrane installation.

3.14 INSTALLER DEMOBILIZATION

- A. Identified problem areas must be repaired by Installer and accepted by QAC before final inspection is performed by Installer, QAC, and Owner.
- B. Installer will not demobilize capping crew or equipment from site until final "Certificate of Acceptance" has been completed.

END OF SECTION

SECTION 02 66 54 –EXPOSED TPO ALTERNATIVE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes an exposed geomembrane cap (EGC) with the option of photovoltaic panel assemblies.
- B. Related Sections include the following:
 - 1. Division 02 Section "Landfill Earth Moving" for landfill cap materials.
 - 2. Division 31 Section "Earth Moving" for general site earthwork requirements.
 - 3. Division 48 Section "Solar Energy Electrical Generation System" for AC Distribution system and grid connection.

1.3 REFERENCES

- A. Geosynthetic Research Institute: GRI GM11, GRI GM12

1.4 DEFINITIONS

- A. Installer: Authorized installer of geomembrane manufacturer.
- B. TPO: Thermoplastic Polyolefin
- C. Manufacturer's Field Representative: Authorized and trained manufacturer representative.
- D. Quality Assurance Consultant (QAC): Owner's representative that will review material, procedure, and testing submittals; and will observe on-site installation including seaming operations and repair work.

1.5 PROPOSAL SUBMITTALS

- A. Installer name and qualifications, including Project experience descriptions.
- B. Superintendent qualifications.
- C. Geomembrane product data sheet.
- D. Warranties regarding quality of materials, workmanship, and long-term performance of the completed geomembrane and photovoltaic system.

1.6 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's requirements for surface preparation, technical data, and tested physical and performance properties of geomembrane.
- B. Qualification Data: For Installer and geomembrane manufacturer's Field Representative.
- C. Delegated Design of System:
 - 1. Shop Drawings: Indicate extent, panel sizes, panel identification number, panel orientation, details of penetrations and seams, anchorage method, materials and spacing as required to maintain warranty.
 - a. Assign each geomembrane panel and seam a simple and logical identification number or letters. Correlate seam identification system with panel identification system.
 - b. Panel layout. Indicate seam orientation and roll sizes.
 - 1) Design layout to utilize largest panel sizes possible, minimize seams, and to minimize horizontal field seams on slopes.
 - c. Details
 - 1) Termination of material at perimeter of membrane areas.
 - 2) Penetration sealing procedures.
 - 3) Anchoring procedures and materials.
 - 4) Temporary Construction Access Roads.
 - d. Installer's preferred sequence of panel placement.
 - 2. Design Calculations: Document the adequacy of the proposed anchoring system to prevent uplift or shear displacement of geomembrane under sustained wind speeds of 120 mph.
 - 3. Installation Procedures: Include manufacturer's requirements and detailed quality control procedures.

1.7 INFORMATIONAL SUBMITTALS

- A. Material Quality Control Certificate: Provide for each geomembrane roll delivered to the site. List specified material properties. Clearly label with distinctive code number.
- B. Manufacturer's Quality Control Test Data: Provide test data collected in accordance with the requirements of GRI Test Method GM17, dated June 2003, including test frequencies and physical/chemical properties listed in Tables 1(a) and 2(a) thereof.
- C. Samples: As requested by the Quality Assurance Consultant.

- D. Daily Examination Report: Before proceeding with membrane installation, complete and submit to Owner "Letter of Surface Confirmation," which states observation and acceptance of surface area to receive membrane, signed by Installer and QAC.
- E. Trial Seam Test Report: Submit on a weekly basis. Installer shall record date, time, weather conditions, test results, operator, and equipment number for each trial seam tested.
 - 1. Trial Seam Sample: Submit properly identified unused section of trial weld seam to Owner.
- F. Record Drawings: Include panel layout and identification, seam type and identification, repair locations and identifications, and destructive test sample locations and identification.
 - 1. Record the roll number, location, and date of installation of each panel placed.
 - 2. Submit working copies when requested by the Quality Assurance Consultant.
 - 3. Submit final Record Drawings prior to demobilizing from the site.
- G. Installation Certificate: Installer's Final "Certificate of Acceptance" stating that installation procedures and required testing have been completed in accordance with the specifications.

1.8 QUALITY ASSURANCE

- A. Geomembrane Manufacturer: Manufacturer that has successfully supplied a minimum of 10,000,000 s.f. of geomembrane for landfill applications.
- B. Geomembrane Manufacturer's Field Representative Qualifications: Competent, field technical representative that has personally supervised and directed the installation of a minimum of 2,000,000 s.f. of the specified geomembrane product.
- C. Installer: An experienced Installer that has successfully completed projects similar in size and scope but no less than 20 geomembrane landfill closures totaling a minimum of 2,000,000 s.f.
 - 1. Also authorized or certified by system Manufacturer for installing product and system in accordance with Manufacturer's installation procedures.
 - 2. Seaming Personnel: Experienced in projects of similar nature, material, and installation method, with at least one seamer having a minimum of 1,000,000 s.f. installation experience.
- D. Source Limitations:
 - 1. Obtain each type of geomembrane through one source from a single manufacturer.
 - 2. If geomembrane and photovoltaic membrane/solar panel system materials are provided by two manufacturers, obtain approval and acceptance of each material from the other manufacturer.
 - a. Provide warranty from single source.
- E. Pre-installation Conference: Conduct conference at Project site.

1. Review manufacturer requirements including surface condition, forecasted weather conditions, seam details, installation and repair procedures, testing and inspection procedures, and protection of installed geomembrane.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Upon delivery of geomembrane rolls to the site, assist QAC with inspection and provide labor, equipment, and incidentals as needed for inspection.
 1. Folded geomembrane is not acceptable. Any evidence of folding or other shipping damage is cause for rejection of the material.
 2. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until documentation has been received, approved and accepted.
 3. Immediately remove from the site damaged or defective material as directed by the QAC, and at no additional cost to the Owner.
 - a. Temporarily store rejected material at a location separate from accepted geomembrane.
- B. Store membrane rolls on a prepared surface approved by the QAC, no more than 3 rolls high. Protect rolls from dirt, grease, water, abrasions, excessive heat or cold, or other damage.
- C. Handle geomembrane rolls with appropriate equipment, designed to handle sheet materials. Use spreader bars and cloth chokers when loading and transporting to prevent damage or stressing of the geomembrane material.

1.10 PROJECT CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit system to be installed according to manufacturer's written instructions and warranty requirements.
 1. Install material when ambient air temperature is within the temperature range as specified and as required by the manufacturer.
- B. Do not allow vehicular traffic directly on geomembrane panels without the prior approval of the Engineer. Only rubber tire/track ATV and trucks with ground pressure less than manufacture's recommendations will be allowed.
- C. Do not allow personnel working with geomembrane panels to wear shoes that will damage the panels.
- D. During installation of the geomembrane liner, the Installer shall provide facilities, access, time, labor, tools, equipment and other incidentals as necessary for the QAC and their representatives to perform installation inspection and testing of materials and equipment, all at no additional cost to the Owner.

1.11 WARRANTY

- A. Manufacturer's Warranty: Provide written warranty as it relates to the quality of the material, for a period of not less than 20 years.
- B. Installer: Provide written, standard general contractor's warranty as it relates to performance for a period of not less than 5 years.

PART 2 - PRODUCTS

2.1 LANDFILL MEMBRANE

- A. TPO Geomembrane: conforms to ASTM D6878 and US EPA Toxic Leachate Test (40 CFR Part 16).
 - 1. Thickness: 60-mil.
 - 2. Color: As selected by Owner from manufacturer's full selection.
- B. Membrane Seams

Properties

Requirement

Peel Adhesion
ASTM D6392

25 lb/in (min.), 55 lb/in (average)
and Film Tear Bond

Bonded Seam Strength
ASTM D6392

25 lb/in (min.), 55 lb/in (average)
and Film Tear Bond

- C. Manufacturers:
 - 1. Firestone Energy Solutions: Firestone Solar Geomembrane
 - 2. Approved equal

2.1 GEOTEXTILE

- 1. Non-Woven Geotextile: Form 816, Section M.08.01-26.

2.2 WALKWAYS

- A. Manufacturer's standard product manufactured of new or recycled TPO required to protect TPO membrane from vehicular and walking traffic, at the following locations.
 - a. Bench areas used to access the landfill.
 - b. Areas that will see consistent traffic such as servicing wells, leachate pipes, etc. Provide for both protection and increased traffic.

2.3 PENETRATIONS

- A. Penetrations shall be made as shown on the Drawings and in accordance with liner manufacturer's instructions.
 - 1. Geomembrane Liner Boots: Manufactured by the liner manufacturer for such use or field fabricated of Geomembrane Liner material in accordance with manufacturer's instructions.
 - 2. Banding: Stainless steel, Type 304, 3/4-inches wide with adjustable screw-type clasp, or approved equal.
 - 3. Gasket: Neoprene, closed cell medium, 1/4-inch thick, 2-inches wide with adhesive on one side as supplied by geomembrane liner manufacturer, or approved equal.
 - 4. Sealant: 100 percent silicone.

PART 3 - EXECUTION

3.1 GENERAL

- A. Owner's QAC will observe the complete installation of the geomembrane system including delivery to site, handling, deploying, seaming, testing, and repair work.
 - 1. Do not install geomembrane without QAC being present.
 - 2. No additional compensation will be provided for possible delays that may be caused due to inspection and testing of materials and workmanship.
- B. Inform QAC on a daily basis of proposed work schedule, including changes.
- C. Mark geomembrane panels by their identification number or letters.
- D. The Installer shall be responsible for field handling, storing, placing, seaming, plus any other processes required to assemble a continuous secure geomembrane system.

3.2 PREPARATION

- A. See Division 02 Section "Landfill Earthwork" for subgrade preparation and bedding placement.
 - 1. Surfaces shall be smooth and free of rocks, stones, sticks, roots, sharp objects, and debris, and provide a firm, unyielding foundation for the geomembrane with no sudden, sharp or abrupt changes or break in grade.

3.3 EXAMINATION

- A. Installer and QAC: On a daily basis, simultaneously inspect the prepared subgrade. Immediately inform the Contractor of unsatisfactory conditions and remedial work required for the subgrade to meet the specified criteria before placement of geomembrane.

1. Upon satisfactory subgrade condition, the Installer and QAC will issue a joint "Letter of Surface Confirmation."

3.4 GEOMEMBRANE INSTALLATION

- A. Install and seam membrane panels when the ambient air temperature is between 40 degrees F and 104 degrees F, as measured 6 inches above subgrade surface elevation.
 1. Do not install, seam, or repair membrane panels during precipitation, excessively high winds, or in areas of ponded water or excessive moisture.
 2. Do not install and seam geomembrane panels in ambient temperatures below 40 degrees F unless approved by the Quality Assurance Consultant, and only if trial seams demonstrate the ability to meet seaming specifications.
- B. Before deploying geomembrane panels, Installer shall repair subgrade or other underlying surface disturbed or damaged after issuance of "Letter of Surface Confirmation."
- C. Place material over prepared subgrade with minimum handling. Place rolls in accordance with approved panel layout.
 1. Install only rolls of material that can be anchored and sealed by end of each day's operation.
- D. Properly secure geomembrane during installation with sandbags, rubber tires or other means approved by the QAC. Do not use large or sharp rocks, or other sharp objects.
- E. Install geomembrane material in relaxed condition. Provide excess material for each panel as per requirements. Do not stretch material to fit area; keep material free from stress and tension during installation.
 1. Unroll geomembrane panels in a manner that will not stretch, crimp, abrade, or otherwise damage panels. Place panels in a manner that minimizes wrinkles and differential wrinkles between adjacent panels.
- F. Overlap geomembrane panels to facilitate drainage of water. All panels deployed during a single day shall be seamed or tack welded together that same day to the extent practicable.
- G. Anchor perimeter of geomembrane panels in trench as indicated on the Drawings.

3.5 GEOMEMBRANE FIELD SEAMING

- A. Lay out the geomembrane seams parallel to the line of maximum slope.
 1. Minimize the use of cross or butt seams on slopes, seams located in corners, and unusual geometric panel shapes.
- B. The seam identification system shall be related to and compatible with the panel identification system.

- C. Equipment: Include temperature gages and readout devices that allow continuous monitoring of apparatus temperatures during seaming. Electric generators shall be capable of providing constant voltage under load and shall be underlain with a splash pad to collect spilled fuel or oil when located on the membrane.
- D. Overlap geomembrane surfaces a minimum of 4 inches and clean surfaces of moisture, grease, dust, dirt, debris and foreign material.
 - 1. Do not use solvent or adhesive for seaming without approval from the manufacturer and the QAC.
 - 2. Install a protective sheet of plastic below the geomembrane material being seamed when needed and where moisture or dirt causes seaming difficulty. As seaming progresses, pull the protective sheet along beneath the seaming apparatus.
 - a. Do not permanently leave the protective plastic sheet beneath the geomembrane.
 - 3. For extrusion welding, clean surfaces to be seamed of oxidation by disc grinder not more than one hour before extruding the seam. Abrasion of the seam area with the disc grinder shall not extend more than one-half inch beyond the extrusion bead area. Tack welding of the panels to be seamed shall not damage the membrane or adversely affect the seaming operation. The top membrane of the seam overlap shall be beveled and the extrusion apparatus shall be purged of heat-degraded extrudant before seaming.
 - 4. Fish mouths shall be cut along the ridge of the wrinkle and laid flat to overlap the edges of the cut. The overlap shall be seamed and any portion of the seam with less than 3 inches of overlap shall be patched with a circular or oval patch extending a minimum of 6 inches beyond the cut in all directions.
- E. The Installer shall log the ambient air temperature 6 inches above the membrane elevation, extruded temperatures in extruder barrels and nozzles, and operating temperatures of hot wedge seamers at intervals of 2 hours or less.

3.6 GEOMEMBRANE CAP PENETRATIONS

- A. Any penetrations in the liner required by a pipe, vent, utility pole, fence post, concrete structure or other constructed feature shall be connected to the liner as shown on the drawings and in accordance with the geomembrane Manufacturer's recommendations as approved by the Engineer.
 - 1. The connection to the geomembrane shall be made to assure the permeability of the liner at the connection has not been increased.
 - 2. Test all penetrations for air-tightness using methods recommended by the manufacturer.
 - 3. Each penetration shall be inspected and approved by the Engineer prior to being covered.

4. Any damage to the liner materials shall be repaired in accordance with the specifications.

3.7 GEOMEMBRANE INSPECTION

- A. Visually inspect seams and panels for holes, crimps, abrasions, or defects, and mark suspect locations. Clearly mark repair locations on the membrane panel and assign an appropriate identifying label
 1. Clearly mark and record repair locations and non-destructively test data on the Record Drawings.
 2. Do not cover repairs until passing results of non-destructive tests are achieved and accepted by the QAC.
- B. Remove large wrinkles in geomembrane panels. Cut wrinkle, reseam and test until an acceptable seam is obtained.

3.8 GEOMEMBRANE REPAIRS

- A. Remove or repair damaged geomembrane panels damaged during installation at no additional cost to Owner.
- B. Repair geomembrane panels as follows:
 1. Preparation. Abrade surface of geomembrane in the seam/repair area no more than one hour before the repair is made. Keep repair/seam areas clean and dry at the time of the repair.
 2. Spot weld small tears, pinholes or over-abraded areas where thickness of the geomembrane has been reduced by more than 4 mils (0.004 inches).
 3. Abrade and re-weld small sections of defective welds.
 4. Remove defective seam and replace with a new strip of material. Defective hot wedge seams may be abraded and welded providing the top membrane overlap is carefully cut off.
 5. Patch larger holes and defects. Extend patch material a minimum of 6 inches beyond the edges of the defect. Round corners of patches with a radius of at least 3 inches.

3.9 FIELD QUALITY CONTROL TESTING

- A. Seam Testing. Record locations and results of seam tests on the Record Drawing. Keep records on site for inspection by the Owner and QAC.
- B. Trial Seams
 1. Sample Quantity: For each seaming apparatus, for the following instances.
 - a. At the beginning of each shift.

- b. After apparatus has been turned off or disconnected from its power source.
 - c. When apparatus has been idle for 60 minutes (hot air wedge welder).
 - d. Change in operator personnel.
 - e. When deemed necessary by the QAC.
2. Sample Size: 3 feet long and 12 inches wide (perpendicular to the seam), minimum.
 - a. Cut 1-inch-wide samples perpendicular to the seam for testing. Provide at a minimum, six for peel test and three for shear test.
 3. Shear (Bonded Seam Strength) and Peel (Adhesion) Tests: In accordance with ASTM D6392. Installer shall provide tensiometer, calibrated within one year from start of geomembrane installation.
 4. Conduct trial seams under the same physical conditions as permanent seaming.
 - a. For double-fusion hot wedge seams, both seams in each sample shall be tested for peel adhesion.
 - b. All six peel tests and all three shear tests are required to pass for the trial seam to be acceptable.
 - c. Each sample failure must consist of a ductile break that is film tearing bond.
 5. If either test sample fails (shear or peel), repeat trial seam test procedure. If any test seams fail on the second trial seam, the seaming apparatus shall not be used until it is repaired or faulty conditions are corrected, and two trial seams pass the destructive tests.

C. Non-destructive Seam Testing

1. Acceptable Methods. Vacuum box testing, air-pressure testing of double-fusion seams, or other methods approved by the manufacturer and QAC.
2. Perform non-destructive testing over the full length of each seam. Perform testing as work progresses. Do not wait to perform testing until the completion of large segments of field seaming.
3. Vacuum Box Testing: In accordance with ASTM D5641. Utilize vacuum box approved by the Quality Assurance Consultant. Vacuum box shall include rigid housing, transparent viewing window, a soft rubber gasket on the bottom edge, and a valve assembly with a vacuum gage.
 - a. Mark geomembrane seamed areas when soap bubbles are visible in the viewing window.
 - b. Repair marked locations and retest.
4. Air Pressure Testing: In accordance with ASTM D5820. Perform air –pressure test on double-fusion seams having an air channel between the seams. Mark results on the geomembrane adjacent to the test location.

5. If a seam is located where non-destructive testing cannot be performed, the seam shall, at the discretion of the QAC, be cap-stripped. Installer shall perform cap-stripping operation only in presence of QAC.

D. Destructive Seam Testing

1. Samples: The Installer shall cut and remove destructive test samples from the installed geomembrane material, assign the sample an identification number, and record the sample location on the Record Drawings.
 - a. Perform one series of destructive seam tests per 1,000 l.f. of seam, minimum. One test must be performed per welding machine per day.
 - b. Locations: As determined by the QAC.
 - c. Sample Size: 12 inches wide and 40 inches long with the seam centered lengthwise.
 - d. Perform destructive seam strength testing as work progresses in order to obtain test results before seams are covered.
 - e. The Installer shall immediately repair the geomembrane at the destructive test sample location, and perform non-destructive test.
2. Destructive Seam Series Test: In accordance with ASTM D6392.
 - a. Field Testing. Installer shall provide field tensiometer, calibrated within one year from start of geomembrane installation.
 - 1) Shear (Bonded Seam Strength)
 - a) One 1-inch strip cut from sample.
 - 2) Peel (Adhesion) Tests:
 - a) Laboratory Test: Five 1-inch strips cut from samples.
 - b. Laboratory Testing. Coordinated by the Quality Assurance Consultant and performed by an independent geosynthetic testing laboratory paid for by the Owner.
 - 1) Shear (Bonded Seam Strength)
 - a) Laboratory Test: Five 1-inch strips cut from samples.
 - 2) Peel (Adhesion) Tests:
 - a) Laboratory Test: Five 1-inch strips cut from samples.
 - 3) Double-fusion Hot Wedge Seams. Test both seams in each sample for peel. Testing shall include, but not necessarily be limited to, thickness (ASTM D 5199/D 5594)

E. Failure of Seam Tests.

1. If either field destructive test seams or laboratory test seams do not pass, reconstruct the seam between two passing test seam locations. Intermediate tests may be

performed on each side of the failed test sample location to further isolate the defective seam area.

2. If intermediate field test seams pass, laboratory test seams shall be performed on samples from the same locations.
3. If laboratory test seams also pass, then the seam shall be reconstructed between the intermediate sample locations.
4. If the intermediate or laboratory test seams fail, repeat the process with intermediate samples located further away from the original failing seam area to determine the defective seam area.

F. Acceptable Seams.

1. Each seam shall be bounded by two locations where samples passed the laboratory destructive tests.
2. Whenever a reconstructed seam exceeds 200 feet, an additional sample shall be obtained for destructive testing along the reconstructed seam.
3. At the QAC's discretion, the Installer may be directed to take additional samples from seams welded on the same day by a seaming apparatus that welded a failed seam, at no additional cost to the Owner.

3.10 TEMPORARY CONSTRUCTION ACCESS ROADS

- A. Install Temporary Construction Access Roads whenever vehicular traffic must traverse any portion of the installed liner system.
- B. Temporary Construction Access Road shall be installed in accordance with liner manufacturer's instructions and shall be capable of supporting vehicular and equipment loads of 60 psi.
- C. Clearly delineate limits of roadways to prevent vehicles or equipment from travelling off roadway.
- D. Remove all components of Temporary Construction Access Road and repair any damage caused by installation, use, and/or removal of roadway.

3.11 CLEANING

- A. Clean the work area at the end of each work day of unnecessary scrap material, sand bags, tools and other materials used during geomembrane installation.

3.12 INSTALLER DEMOBILIZATION

- A. Identified problem areas must be repaired by Installer and accepted by QAC before final inspection is performed by Installer, QAC, and Owner.
- B. Installer will not demobilize capping crew or equipment from site until final "Certificate of Acceptance" has been completed.

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SECTION 02 66 73 - UNDERDRAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes subdrainage systems for the following:
 - 1. Landfills.
- B. Related Sections include the following:
 - 1. Division 02 Section "Landfill Earth Moving" for sand drainage layer material.

1.3 DEFINITIONS

- A. PE: Polyethylene plastic.
- B. PP: Polypropylene plastic.
- C. Subdrainage: Drainage system that collects and removes subsurface or seepage water.
- D. NPS: Nominal pipe size.

1.4 SUBMITTALS

- A. Product Data and Certification: For the following:
 - 1. Perforated-and Solid wall pipe and fittings.
 - 2. Filter fabric sock.
 - 3. Geotextile.

PART 2 - PRODUCTS

2.1 PERFORATED PIPES AND FITTINGS

- A. Perforated and Solid Wall PE Pipe and Fittings:
 - 1. NPS 6 and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
 - 2. NPS 8 and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.

3. Couplings: Manufacturer's standard, band type.

2.2 SOIL MATERIALS

- A. Drainage Sand Layer material is specified in Division 02 Section "Landfill Earth Moving."

2.3 STONE

- A. Form 816, Section M.02.01
- B. Grading as depicted on in Section M.01.01. "No. 4"

2.4 FILTER FABRICS

- A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.
 1. Structure Type: Nonwoven, needle-punched continuous filament.
 2. Style: Sock.

2.5 GEOTEXTILE

1. Geotextile: Form 816, Section M.08.01-26.

2.6 MISCELLANEOUS

- A. Bird Screening: Galvanized steel, 1/2-inch-square mesh, 0.041-inch wire.
- B. Underdrain Pipe Clamp for Bird Screening: Stainless steel.
- C. Detectable warning tape: As specified in Section 31 22 03

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.
- B. Locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PIPING APPLICATIONS

- A. Landfill Subdrainage Piping:
 1. Perforated PE pipe and fittings wrapped in filter fabric.

2. Solid wall pipe and fittings.

3.3 PIPING INSTALLATION, GENERAL

- A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Install tees, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
 1. Lay perforated pipe with perforations down.
- B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
- C. Install PE piping according to ASTM D 2321.

3.4 LANDFILL UNDERDRAIN INSTALLATION

- A. Layout underdrain piping as shown on the drawings. Provide couplings and fittings where necessary.
- B. Install stone drainage material over underdrain piping to indicated depth.
- C. Install geotextiles and stone over underdrain piping in accordance with Division 2 Section "Landfill Earthwork."
- D. Daylighting Requirements:
 1. Extend underdrain piping horizontally a minimum of 6 inches beyond final grade elevation at invert of pipe.
 2. Install bird screen on daylighted pipe and secure with pipe clamp.

3.5 IDENTIFICATION

- A. Arrange for installation of detectable green warning tape directly over piping.

3.6 FIELD QUALITY CONTROL

- A. Testing: After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

3.7 CLEANING

- A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

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SECTION 02 66 81 – LANDFILL GAS VENT SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Supplemental gas venting system.
- B. Related Sections include the following:
 - 1. Division 02 Section "Closure Turf™ Alternative".
 - 2. Division 02 Section "Exposed TPO Alternative".
 - 3. Division 31 Section "Landfill Earth Moving" for earthwork associated with landfill subgrade preparation, and varying earth material layers for landfill cap and cover.

1.3 QUALITY ASSURANCE

- A. This work may include, but is not limited to providing material, samples and revising work to meet the intent of the plans and specifications.
- B. Coordinate and assist with testing and inspection performed by the Engineer as directed.
 - 1. This work may include, but is not limited to, providing material samples, excavating and backfilling sections of pipe, and replacing pipe as required to assure that construction complies with these specifications.

1.4 SUBMITTALS

- A. Material Certification. For each product, certifying material meets the Specification requirements. Materials include the following:
 - 1. Piping,

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

- A. Perforated and Solid Wall PE Pipe and Fittings:
 - 1. NPS 6 and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.

2. NPS 8 and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
3. Fernco couplings, adjustable, stainless steel.

B. PVC Pipe and Fittings: ASTM D3350, SDR 26 minimum.

1. Couplings: Manufacturer's standard, band type.

2.2 SOIL MATERIALS

A. Drainage Sand Layer material is specified in Division 02 Section "Landfill Earth Moving".

2.3 FILTER FABRICS

A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.

1. Structure Type: Nonwoven, needle-punched continuous filament.
2. Style: Sock.

PART 3 - EXECUTION

3.1 NEW VENT CONSTRUCTION AND EXISTING VENT EXTENSION

- A. Install and extend pipes a minimum of 4 feet above proposed finish grade.
- B. See Division 2 Section "Closure Turf Alternative" and "Exposed TPO Alternative" for installation of geomembrane liner and geomembrane boot for casing.
- C. See Division 2 Sections "Landfill Earth Moving" and "Vegetative Support Material" for installation of earthwork over geomembrane liner/cap and geomembrane boot for steel casing.

END OF SECTION

SECTION 02 66 87 – LANDFILL LIMIT MARKER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Concrete filled, metal posts to act as landfill limit markers delineating the lateral limits of the geomembrane liner at locations shown on the Contract Drawings.
 - 2. Concrete filled steel post bollards.

1.3 SUBMITTALS

- A. Material Certification. For each product, certifying material meets the Specification requirements. Materials include the following:
 - 1. Steel posts.
 - 2. Concrete components and mix.
 - 3. Paint.
 - 4. Vehicle guard cover.

1.4 QUALITY ASSURANCE

- A. Where "Form 816 is referenced, it shall mean "State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 816," and issued supplements.

PART 2 - PRODUCTS

2.1 STEEL POST

- A. Limit Marker Posts: Black steel; ANSI/ASME B36.10/19; Schedule 40.
 - 1. Diameter: 6 inches or as indicated.

2.2 CONCRETE

- A. General: Comply with ACI 301 for cast-in-place concrete.

- B. Materials: Portland cement complying with ASTM C 150, aggregates complying with ASTM C 33, and potable water for ready-mixed concrete complying with ASTM C 94. Measure, batch, and mix Project-site-mixed concrete according to ASTM C 94.

1. Concrete Mixes: Normal-weight concrete air entrained with not less than 3,000 psi compressive strength (28 days), 3-inch slump, and 1-inch maximum size aggregate.
2. Maximum Water-Cementitious Materials Ratio: 0.45.
3. Air Content: 5.5 percent plus or minus 1.5 percent.

2.3 VEHICLE GUARD COVER

- A. Polyethylene thermoplastic bumper post sleeve.

1. Available Manufacturer(s):
 - a. Ideal Shield, LLC, Detroit, MI or approved equal.
2. Color: As indicated or as selected by Owner from manufacturer's standard range.

2.4 PAINT

- A. Enamel Paint System: Form 816, Article M.18.08.

1. Color: As indicated.
2. Coats:
 - a. Primer: One Coat
 - b. Finish Coat: Two coats.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Set edge of concrete footing adjacent to limit of landfill geomembrane cap.
- B. Install landfill limit marker posts as indicated. Set posts plumb and fill with concrete. Rod concrete to remove air pockets.
- C. Remove spilled concrete from post and adjacent surfaces and clean surface.
- D. Use excess excavated material as fill or dispose of off-site.

3.2 PAINTING

- A. Paint landfill limit marker post with one coat of primer and two finish coats.

END OF SECTION

SECTION 02 66 91 - LANDFILL VEGETATIVE SUPPORT LAYER

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Vegetative support soil
2. Soil amendments.
3. Seeding.

B. Related Sections include the following:

1. Division 02 Section "Landfill Cover Material" for cover material requirements.
2. Division 31 Section "Site Earth Moving" for excavation, filling and backfilling, and rough grading.

1.2 DEFINITIONS

A. Finish Grade: Elevation of finished surface of vegetative support soil.

B. Manufactured Soil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce vegetative support soil.

C. Vegetative Support soil: Imported or manufactured soil or surface soil modified to become vegetative support soil; mixed with soil amendments.

D. Subgrade: Top surface of a fill immediately beneath vegetative support soil.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

C. Product Certificates: For soil amendments, fertilizers and mulch, signed by product manufacturer.

D. Material Test Reports: For vegetative support soil.

E. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of seeded areas during a calendar year. Submit before expiration of required maintenance periods.

- F. Hydroseed Procedure, including application rates.

1.4 QUALITY ASSURANCE

- A. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- B. Vegetative Support Soil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of soil. Obtain one composite soil sample for every 5,000 cu. yds. of material with at least one sample from each borrow source location.
 - 1. Report suitability of soil for growth. State recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce a satisfactory soil.
- C. Vegetative Support Soil Chemical Analysis: Obtain one composite soil sample for every 10,000 cu. yds. of material with at least one sample from each borrow source location. Analyze each for RCRA 8 Metals (EPA Method 6010 / 7421 / 7470), Polychlorinated Biphenyls (EPA Method 8082), Total Volatile Organic Compounds (EPA Method 8260), Semi-Volatile Organic Compounds/Polyaromatic Hydrocarbons (EPA Method 8270), Pesticides (EPA Method 8081), Chlorinated Herbicides (EPA Method 8151), and Total Petroleum Hydrocarbons (CTETPH method). Owner reserves the right to disqualify the source based on the results of the chemical testing.
 - 1. Soil/material shall not exceed any GB pollutant mobility criteria (GB PMC) or residential direct exposure criteria (RES DEC) established in Sections 22a-133k-1 through 22a-133k-3 of the regulations of Connecticut state agencies.
- D. Organic Soil Amendment Chemical Analysis: Obtain one composite soil sample from each borrow source location. Analyze each for RCRA 8 Metals (EPA Method 6010 / 7421 / 7470), Polychlorinated Biphenyls (EPA Method 8082), Total Volatile Organic Compounds (EPA Method 8260), Semi-Volatile Organic Compounds/Polyaromatic Hydrocarbons (EPA Method 8270), Pesticides (EPA Method 8081), Chlorinated Herbicides (EPA Method 8151), and Total Petroleum Hydrocarbons (CTETPH method). Owner reserves the right to disqualify the source based on the results of the chemical testing.
 - 1. Soil/material shall not exceed any GB pollutant mobility criteria (GB PMC) or residential direct exposure criteria (RES DEC) established in Sections 22a-133k-1 through 22a-133k-3 of the regulations of Connecticut state agencies.
- E. Owner reserves the right to disqualify the source based on the results of the chemical testing.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Seed, Lime, and Fertilizer: Deliver in original sealed, labeled, and undamaged containers.

1.6 SCHEDULING

- A. Planting Restrictions: Plant during one of the following periods. Perform seeding at other times when acceptable to the Engineer.
 - 1. Spring Seeding: April 15 to June 15.
 - 2. Fall Seeding: August 15 to October 15.
- B. Weather Limitations: Proceed with seeding only when existing and forecasted weather conditions permit.

1.7 MAINTENANCE

- A. Begin maintenance immediately after each area is planted and continue until acceptable turf area is established, but for not less than the following periods:
 - 1. Seeded Areas: 365 days from the date of Substantial Completion.
 - a. When full maintenance period has not elapsed before end of planting season, or if lawn is not fully established, continue maintenance during next planting season.
 - B. Maintain and establish seeded areas by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and mulch to produce a uniformly smooth lawn.
 - C. Mow seeded area when grass reaches a height of 10 inches. Repeat mowing to maintain specified height without cutting more than 40 percent of grass height. Remove no more than 40 percent of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
 - 1. Mow grass to 6 inches high.

PART 2 - PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species: Seed of grass species as follows:

	<u>Proportion by Weight (Percent)</u>	<u>Minimum Purity (Percent)</u>	<u>Minimum Germination (Percent)</u>
Orchard Grass	30	85	75
Creeping Red Fescue	10	98	85
K.31 Tall Fescue	50	98	85

Domestic Ryegrass 10 98 90

2.2 SOIL

- A. Vegetative Support Soil: ASTM D 5268, pH range of 6 to 7, a minimum of 6 percent and a maximum of 20 percent organic material content; free of stones 1-1/4 inch or larger in any dimension and other extraneous materials harmful to plant growth.
1. Minimum Internal Friction Angle: Shall be 29 degrees when tested in accordance with ASTM D 3080. Specimen shall be prepared with moderate compactive effort and moisture content as received from the source. Tests will be performed with normal stresses of 1 and 5 psi via the large scale direct shear method.
 2. Minimum In-place Wet Unit Weight: Shall be 110 pounds per cubic foot when with a moisture content as received from the source.
 3. Vegetative Support Soil Source: Reuse surface soil stockpiled on-site. Existing soil that does not meet the minimum internal friction angle and in-place wet unit weight requirements above can be used only on slopes less than 10% (i.e. top of the landfill). Verify suitability of stockpiled surface soil to produce vegetative support soil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
 - a. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from agricultural land, bogs or marshes.

2.3 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural limestone containing a minimum 90 percent calcium carbonate equivalent and as follows:
1. Provide lime in form of dolomitic limestone, with a minimum of 95 percent passing a No. 100 sieve.
 2. Liquid lime will not be allowed.
- B. Perlite: Horticultural perlite, soil amendment grade.
- C. Sand: Clean, washed, natural or manufactured, free of toxic materials.

2.4 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings.
1. Organic Matter Content: 50 to 60 percent of dry weight.

- a. State of Connecticut, Department of Environmental Protection approved when derived from food and agricultural residues, animal manures, and sewage sludge.
 2. Approved Products: Agresource, Inc., 100 Main Street, Amesbury, MA 01913 (1-800-313-3320), or equal.
- B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.5 FERTILIZER

- A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.6 MULCHES

- A. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic; free of plant-growth or germination inhibitors; with maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
1. Product and Manufacturer:
 - a. Mat-Fiber by Mat, Inc. (formerly Silva-Fiber Mulch by Weyerhaeuser).
 - b. Approved equal.
- B. Straw Mulch: Air-dry, clean, mildew- and seed-free, hay or threshed straw of wheat, rye, oats, or barley; free of weeds, reeds, and twigs; maximum moisture content of 15 percent. Do not use salt hay.
- C. Non-Asphaltic Tackifier:
1. Model and Manufacturer:
 - a. Soilmaster WR, by Environmental Soil Systems, Inc.
 - b. Approved equal.

2.7 WATER

- A. Potable water will be supplied by the owner via an existing MDC hydrant meter in the vicinity of the landfill scalehouse.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive seed for compliance with requirements and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding overspray.
- B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 INSTALLATION

- A. Place vegetative material in one continuous lift and spread using tracked equipment weighing equivalent to or less than that of a Caterpillar D-8 bulldozer, or equal. Equipment must have a ground pressure less than 15 psi.

3.4 SEEDED AREA PREPARATION

- A. Limit subgrade preparation to areas to be planted.
- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Spread planting soil mix to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
- C. Finish Grading: Grade seeded areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future.
- D. Moisten prepared seeded areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- E. Restore areas if eroded or otherwise disturbed after finish grading and before planting.

3.5 SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 - 1. Do not use wet seed or seed that is moldy or otherwise damaged.
- B. Sow seed at the rate of 200 lb/1 acre.
- C. Rake seed lightly into top 1/8 inch of topsoil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes exceeding 1:3 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
- E. Protect seeded areas with slopes not exceeding 1:10 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.
 - 1. Bond straw mulch by spraying with non-asphaltic tackifier at manufacturer's recommended rate. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.
 - 2. Install cellulose fiber mulch, erosion control blanket, or other stabilization measure, as directed by the Engineer, if straw mulch does not provide adequate erosion protection to a disturbed area.

3.6 HYDROSEEDING

- A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 - 1. Mix slurry with tackifier.
 - 2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a minimum rate of 175-lb/acre dry weight but not less than the rate required to obtain specified seed-sowing rate.

3.7 SATISFACTORY SEEDED AREAS

- A. Satisfactory Seeded Area: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 3 by 3 inches.
 - 1. Replant areas and spots that do not show a prompt catch at 15 day intervals, or as directed by the Engineer.
- B. Reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

3.8 IRRIGATION

- A. Irrigate newly seeded areas as required to establish newly seeded lawn areas.
 - 1. Owner shall incur no additional cost for the operation of irrigation systems.
 - 2. Convey potable water to the temporary irrigation system using trucks suitable for this purpose.
 - 3. Obtain potable water from approved source.
- B. Operate the irrigation system during the maintenance period. The irrigation system shall provide a minimum of 1 inch of water per week, unless adequate rainfall occurs.
- C. Monitor the system during operation and discontinue operation, as necessary, to prevent excess water from running off the landform or causing erosion.
- D. Remove temporary irrigation system when vegetation has been established to the satisfaction of the engineer.

3.9 FIELD QUALITY CONTROL

- A. Depth Test Hole. Confirm depth of vegetative support material after final grading.
 - 1. Hand excavate test holes at 100 feet on-center, maximum.
 - 2. Record depth of layer at each test hole on site plan.
 - 3. Refill test hole and compact material as required.
 - 4. Engineer shall review depth readings and determine extent of areas that contain an insufficient depth of material. Provide additional material as required to meet minimum layer thickness at no additional cost. Repeat test hole process until satisfactory results are obtained.

3.10 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades throughout maintenance period and remove after grass is established.

END OF SECTION

SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section specifies cast-in-place concrete, including reinforcement, concrete materials, mix design, placement procedures, and finishes.
- B. Cast-in-place concrete applications include the following:
 - 1. Concrete lined ditches.
 - 2. Fencepost, bollard and limit marker footing.
 - 3. Utility pads.
 - 4. Channel armoring.
 - 5. Culvert headwall.
- C. Related Sections include the following:
 - 1. Division 31 Section "Site Earth Moving" for subgrade preparation, grading, and subbase course.

1.3 SUBMITTALS

- A. Material Certificates: Signed by manufacturers certifying that each of the following items complies with requirements:
 - 1. Design mixes.
 - 2. Cementitious materials and aggregates.
 - 3. Form materials and form-release agents.
 - 4. Steel reinforcement and reinforcement accessories.
 - 5. Admixtures.
 - 6. Curing materials.
 - 7. Bonding agents.
 - 8. Joint-filler strips.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed concrete work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- C. Source Limitations: Obtain each type of cement of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.
- D. Comply with ACI 301, "Specification for Structural Concrete," including the following, unless modified by the requirements of the Contract Documents.
 - 1. General requirements, including quality assurance, acceptance of structure, and protection of in-place concrete.
 - 2. Formwork and form accessories.
 - 3. Steel reinforcement and supports.
 - 4. Concrete mixtures.
 - 5. Handling, placing, and constructing concrete.
- E. Form 816: State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, and issued supplements.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle steel reinforcement to prevent bending and damage.

1.6 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 FORMWORK

- A. Furnish formwork and form accessories according to ACI 301.

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

- B. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, plain, fabricated from as-drawn steel wire into flat sheets.

2.3 CONCRETE MATERIALS

- A. General: Use the same brand and type of cementitious material from the same manufacturer throughout the Project.
- B. Portland Cement: ASTM C 150, Types I or II or Type I/II.
- C. Normal-Weight Aggregate: ASTM C 33, uniformly graded, not exceeding 1-inch nominal size.
- D. Water: Potable and complying with ASTM C 94.

2.4 ADMIXTURES

- A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cement and to be compatible with other admixtures. Do not use admixtures containing calcium chloride.
- B. Air-Entraining Admixture: ASTM C 260.
- C. Water-Reducing Admixture: ASTM C 494, Type A.

2.5 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.

2.6 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.
- C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- D. Water: Potable.
- E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
- F. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

2.7 CONCRETE MIXES

- A. Comply with ACI 301 requirements for concrete mixtures.
- B. Prepare design mixes, proportioned according to ACI 211.1 and ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mix or field test data bases, as follows:
 - 1. Compressive Strength (28 Days): As indicated.
 - 2. Slump: 4 inches.
 - 3. Slope Paving: In accordance with Form 816, Section M.03.01, Slope Paving.
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content of 5.0 percent within a tolerance of plus 1.0 or minus 1.5 percent.

2.8 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with ASTM C 94.
 - 1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Proceed with pavement only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.
- B. Remove loose material from compacted subbase surface immediately before placing concrete.

3.2 FORMWORK

- A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads.
- B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
- C. Construct forms tight enough to prevent loss of concrete mortar.
- D. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces.

Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood inserts for forming keyways, reglets, recesses, and the like, for easy removal.

1. Do not use rust-stained steel form-facing material.
- E. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required lines, grades, elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.
 - F. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
 - G. Chamfer exterior corners and edges of permanently exposed concrete.
 - H. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
 - I. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
 - J. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
 - K. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.3 EMBEDDED ITEMS

- A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use Setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 1. Install anchor bolts, accurately located, to elevations required.

3.4 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials.
- C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
- D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

3.5 JOINTS

- A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
 - 1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.
- B. Construction Joints: Locate and install so as not to impair strength or appearance of concrete, at locations indicated or as approved by Engineer.
- C. Isolation (Expansion) Joints: Install joint-filler strips at junctions with slabs-on-grade and vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
 - 1. Extend joint fillers full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.

3.6 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcement steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.
- D. Comply with recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery, at Project site, or during placement.
- F. Consolidate concrete with mechanical vibrating equipment.
- G. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation.
- H. Deposit concrete in forms in horizontal layers no deeper than 24 inches and in a manner to avoid inclined construction joints. Place each layer while preceding layer is still plastic, to avoid cold joints.
 - 1. Consolidate placed concrete with mechanical vibrating equipment. Use equipment and procedures for consolidating concrete recommended by ACI 309R.

2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the vibrator. Place vibrators to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mix constituents to segregate.
- I. Deposit and consolidate concrete for slabs in a continuous operation, until placement is complete.
 1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 2. Maintain reinforcement in position on chairs during concrete placement.
 3. Screed slab surfaces with a straightedge and strike off to correct elevations.
 4. Slope surfaces uniformly to drains where required.
 5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, free of humps or hollows, before excess moisture or bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.
 - J. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
 2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators, unless otherwise specified and approved in mix designs.
 - K. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows, when hot-weather conditions exist:
 1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.7 FINISHING FORMED SURFACES

- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched, and fins and other projections exceeding 1/4 inch in height rubbed down or chipped off.
 - 1. Apply to concrete surfaces not exposed to public view.
- B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defective areas. Completely remove fins and other projections.
 - 1. Apply to concrete surfaces exposed to public view or to be covered with a coating or covering material applied directly to concrete, such as waterproofing, dampproofing, veneer plaster, or painting.
 - 2. Apply the following rubbed finish, defined in ACI 301, to smooth-formed finished concrete.
 - a. Smooth-rubbed finish.
- C. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.8 FINISHING UNFORMED SURFACES

- A. General: Comply with ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Screed surfaces with a straightedge and strike off. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane before excess moisture or bleedwater appears on the surface.
 - 1. Do not further disturb surfaces before starting finishing operations.
- C. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots, and fill low spots. Refloat surface immediately to uniform granular texture.

3.9 TOLERANCES

- A. Comply with ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
- B. Comply with the additional requirements for pavements.
 - 1. Elevation: 1/4 inch.

2. Thickness: Plus 3/8 inch, minus 1/4 inch.
3. Surface: Gap below 10-foot- long, unlevelled straightedge not to exceed 1/4 inch.
4. Joint Spacing: 3 inches.
5. Contraction Joint Depth: Plus 1/4 inch, no minus.
6. Joint Width: Plus 1/8 inch, no minus.

3.10 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection, and follow recommendations in ACI 305R for hot-weather protection during curing.
- B. Begin curing after finishing concrete, but not before free water has disappeared from concrete surface.
- C. Curing Methods: Cure formed and unformed concrete for at least seven days by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
 3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to sample materials, perform tests, and submit test reports during concrete placement. Tests will be performed according to ACI 301.
 1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mix exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.

3.12 REPAIRS AND PROTECTION

- A. Remove and replace concrete that does not comply with requirements in this Section.
- B. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.
- C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

SECTION 31 22 03 – SITE EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Preparing subgrades for slabs-on-grade, walks, and pavements.
 - 2. Base course for drainage ditches, structures, and swales.
 - 3. Base course for bituminous concrete paving.
 - 4. Excavating and backfilling trenches for buried mechanical and electrical utilities and pits for buried utility structures.
 - 5. Disposal of unsuitable material.
 - 6. Disposal of surplus suitable material, if required.
- B. Related Sections include the following:
 - 1. Division 02 Section "Landfill Earth Moving" for earthwork associated with landfill subgrade preparation, and various earth material layers for landfill cap and cover.

1.3 DEFINITIONS

- A. Backfill: Soil materials used to fill trench, structure or pit excavations.
- B. Base Course:
 - 1. Layer placed between the subgrade course and bituminous concrete paving.
 - 2. Layer placed between subgrade and surface materials including riprap.
- C. Bedding Course: Layer placed over the excavated subgrade in a trench before laying pipe.
- D. Excavation: Removal of material encountered above subgrade elevations.
 - 1. Additional Excavation: Excavation below subgrade elevations as directed by Engineer. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 - 2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated dimensions without direction by Engineer. Unauthorized excavation, as

well as remedial work directed by Engineer, shall be without additional compensation.

- E. General Fill: Soil materials used to raise existing grades where indicated on the Drawings.
- F. Structures: Utility appurtenances, or other man-made stationary features constructed above or below the ground surface.
- G. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below base, drainage fill, or topsoil materials.

1.4 SUBMITTALS

- A. Product Data:
 - 1. Each type of warning tape listed in paragraph 2.2.B.
 - 2. Material certifications for general fill, base material, bedding course material, and trench backfill.
- B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated. Prepare separate reports for each type and application of material.
 - 1. General Fill
 - a. Refer to Division 02 Section "Landfill Earth Moving" for testing requirements.
 - 2. Base, Bedding, Backfill Material
 - a. Classification according to ASTM D 2487, prior to delivery to the site and one per 5,000 CY delivered.
 - b. Gradation and particle size analysis according to ASTM D 422, prior to delivery to the site and one per 5,000 CY delivered.
 - c. Laboratory compaction test results according to ASTM D 1557, prior to delivery to the site and one per 5,000 CY delivered.
 - d. Soil Chemical Analysis Reports: RCRA 8 Metals (EPA Method 6010 / 7421 / 7470), Polychlorinated Biphenyls (EPA Method 8082), Total Volatile Organic Compounds (EPA Method 8260), Semi-Volatile Organic Compounds/Polyaromatic Hydrocarbons (EPA Method 8270), Pesticides (EPA Method 8081), Chlorinated Herbicides (EPA Method 8151), and Total Petroleum Hydrocarbons (CTETPH method): prior to delivery and one report for each 10,000 cu. yd., or portion thereof, delivered. Owner reserves the right to disqualify the source based on the results of the chemical testing.
 - 1) Soil/material shall not exceed any GB pollutant mobility criteria (GB PMC) or residential direct exposure criteria (RES DEC) established in Sections 22a-133k-1 through 22a-133k-3 of the regulations of Connecticut state agencies.

e. On-Site Soil Material

- 1) Classification, gradation, and laboratory compaction curve in accordance with the requirements specified for General Fill material, when requested by the Engineer.

1.5 QUALITY ASSURANCE

- A. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil material testing, as documented according to ASTM D 3740 and ASTM E 548.
- B. Where "Form 816" is referenced, it shall mean "State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 816," and issued supplements.

1.6 PROJECT CONDITIONS

- A. Extent of trench excavation and excavated areas will be controlled by site conditions and Owner's requirements.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. All soil shall be free of debris, waste, frozen materials, vegetation, clay and other deleterious matter; adequately graded for satisfactory compaction.
- C. General Fill: Refer to Division 02 Section "Landfill Earth Moving" for material requirements.
- D. Base: Naturally or artificially graded mixture of natural or crushed gravel, broken or crushed stone:
 1. Drainage Ditch and Swales: Form 816, Section M.02.03, Grading B.
 2. Processed Aggregate Base: Form 816, Section M.05.01.
- E. Bedding:
 1. Sand: Form 816, Section M.03.01-2.
 2. Stone: Form 816, Section M.01.01, No. 6.
- F. Backfill:
 1. Sand: Form 816, Section M.03.01-2.

2.2 ACCESSORIES

- A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, minimum 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep.
- B. Identifying Colors for Utilities:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
 - 5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding or damaging Project site and surrounding area.
- B. Protect excavations, backfills, fills and subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches. Provide positive drainage of backfill and fill.

3.3 EXPLOSIVES

- A. Explosives: Do not use explosives.

3.4 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavation to subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, and obstructions.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.5 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.

3.6 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
- B. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.
 - 1. Clearance: 12 inches on each side of pipe or conduit.
 - 2. Clearance: As indicated.
- C. Trench Bottoms: Excavate trenches 6 inches deeper than bottom of pipe elevation to allow for bedding course. Hand excavate for bell of pipe.
 - 1. Excavate trenches 12 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.7 APPROVAL OF SUBGRADE

- A. Notify Engineer when excavations have reached required subgrade.
- B. If Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
 - 1. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
- C. Proof roll subgrade with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof roll wet or saturated subgrades.
- D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Engineer.

3.8 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill may be used when approved by Engineer.
 - 1. Fill unauthorized excavations under other construction or utility pipe as directed by Engineer.

3.9 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow materials and satisfactory excavated soil materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Prevent windblown dust. Provide erosion control measures.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.10 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Construction below finish grade.
 - 2. Inspecting and testing underground utilities.
 - 3. Removing trash and debris.
 - 4. Removing temporary shoring and bracing, and sheeting.

3.11 UTILITY TRENCH BACKFILL

- A. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- B. Place and compact initial backfill of subbase material, free of particles larger than 1 inch, to a height of 12 inches over the utility pipe or conduit.
 - 1. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
- C. Coordinate backfilling with utilities testing.
- D. Fill voids with approved backfill materials while shoring and bracing, and as sheeting is removed.
- E. Place and compact final backfill of satisfactory soil material to final subgrade.

- F. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.
 - 1. Install detectable warning tape over non-ferrous piping.

3.12 FILL

- A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface before placing fills.
- B. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 3 horizontal so fill material will bond with existing material.
- C. Place and compact fill material in layers to required elevations.

3.13 MOISTURE CONTROL

- A. General Application: Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 2 percent of optimum moisture content.
 - 1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air-dry, otherwise satisfactory soil material that exceeds optimum moisture content and is too wet to compact to specified dry unit weight.

3.14 COMPACTION OF BACKFILLS AND FILLS

- A. Place fill material in loose lifts not exceeding 12 inches in depth for material compacted by heavy compaction equipment.
- B. Place backfill and fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:
 - 1. Under structures, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill material.
 - 2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill material at 95 percent.
 - 3. Under lawn or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill material at 85 percent.

3.15 GRADING

- A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
1. Lawn or Unpaved Areas: Plus or minus 1 inch, however, not consistently in one direction.
 2. Walks: Plus or minus 1 inch.

3.16 SUBBASE AND BASE COURSES

- A. Under pavements and walks, place and compact materials on prepared subgrade as follows:
1. Place and compact subbase and base courses at optimum moisture content to required grades, lines, cross sections, and thickness (within 3/4 inch, plus or minus) to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.
 2. Shape subbase and base to required crown elevations and cross-slope grades.
 3. When thickness of compacted subbase or base course is 6 inches or less, place materials in a single layer.
 4. When thickness of compacted subbase or base course exceeds 6 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.

3.17 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.
- B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
- C. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
1. Paved Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 square feet or less of paved area or building slab, but in no case fewer than three tests.
 2. Trench Backfill: At each compacted initial and final backfill layer, at least one test for each 150 feet or less of trench length, but no fewer than two tests.
- D. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.18 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.19 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Engineer.
 - 1. Remove waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

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SECTION 31 25 01 – TEMPORARY EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes furnishing, placing, and maintaining sedimentation control measures as shown on the Drawings, as directed by the Engineer, and where necessary to reduce sediment content of runoff. Measures include the following:
 - 1. Silt fence.
 - 2. Erosion control haybales.
 - 3. Construction entrance.
 - 4. Catch basin inserts.
 - 5. Temporary pipe slope drain with riprap apron.
 - 6. Temporary erosion control blankets.
 - 7. Temporary Sediment Traps
 - 8. Polyacrylimide Erosion Control Blocks.
 - 9. Dust control.
- B. Related Sections include the following:
 - 1. Division 31 Section "Site Earth Moving."
 - 2. Division 31 Section "Permanent Erosion and Sedimentation Control" for permanent erosion control measures including permanent turf reinforcement matting.

1.3 SUBMITTALS

- A. Product Data
 - 1. Silt fence.
 - 2. Catch basin inserts.
 - 3. HDPE pipe.
 - 4. Erosion control blanket.
 - 5. Polyacrylimide Erosion Control Blocks.

6. Geotextile.

B. Certificate of Compliance

1. Erosion Control bales.
2. Riprap
3. Stone.
4. Calcium chloride.

C. Material Test Reports

1. Compost

1.4 QUALITY ASSURANCE

- A. Where "Form 816" is referenced, it shall mean "State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 816," and issued supplements.
- B. Connecticut Guidelines for Soil Erosion and Sediment Control by the Connecticut Council on Soil and Water Conservation.
- C. Compost Chemical Analysis Reports: Obtain one composite soil sample for each source of material. Analyze for pesticides (EPA Method 8081), chlorinated herbicides (EPA Method 8151), Total Petroleum Hydrocarbons (CTETPH method), Total RCRA 8 Metals (EPA Method 6010 / 7421 / 7470).

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver calcium chloride to site in manufacturers sealed bags.

PART 2 - PRODUCTS

2.1 SILT FENCE

- A. Synthetic Filter Fabric: Woven geotextile, 36 inches maximum height, conforming to the following:

<u>Properties</u>	<u>Requirement</u>	<u>Unit</u>
Grab Tensile Strength (ASTM D4632):	124	Lbs
Grab Tensile Elongation (ASTM D4632):	15	Percent
Puncture Strength (ASTM D4833):	65	Lbs
Flow Rate (ASTM D4491):	20	Gal/Min/Sq. Ft.

<u>Properties</u>	<u>Requirement</u>	<u>Unit</u>
UV Resistance(at 500 hours) (Retained strength) (ASTM D4355):	80	Percent

B. Posts

1. Hardwood Stakes: 1.5-inch by 1.5-inch by 42-inch minimum.

C. Product and Manufacturer:

1. Harris Silt Fence by Amoco Fabrics and Filters.
2. Mutual MISF 1855 by Mutual Industries, Inc.
3. Or equal.

2.2 HAY BALES

- A. Bales: Hay, weighing 40 to 120 pounds per bale.

- B. Stakes: Wood, 1.5-inch by 1.5-inch by 36-inch minimum.

2.3 CONSTRUCTION ENTRANCE

- A. Stone: Article M1.01 of Form 816, size No.3 or as indicated.

2.4 DRAINAGE STRUCTURE PROTECTION

- A. Catch Basin Inserts: Woven polypropylene fabric, prefabricated to a cone-shape, with loops for lifting the insert with reinforcing steel during removal, and the following.

<u>Properties</u>	<u>Requirement</u>	<u>Unit</u>
Grab Tensile Strength (ASTM D4632):	300	Lbs
Grab Tensile Elongation (ASTM D4632):	20	Percent
Puncture Strength (ASTM D4833):	120	Lbs
Mullen Burst (ASTM D3786):	800	PSI
Trapezoid Tear (ASTM D4533):	120	Lbs
Flow Rate (ASTM D4491):	40	Gal/Min/Sq. Ft.
Permittivity (ASTM D4491)	0.55	Sec-1
UV Resistance(at 500 hours) (Retained strength) (ASTM D4355):	80	Percent
Apparent Opening Size (ASTM D4751):	#40	US Sieve

1. Manufacturer: ACF Environmental, 1801-A Willis Road, Richmond, VA 23237 (800-844-9223), or equal.

a. Product: Silt Sack

B. Catch Basin Fabric: Geotextile filter fabric, meeting the requirements above, wrapped around non-standard size catch basin grates.

2.5 TEMPORARY SLOPE DRAIN

A. Corrugated HDPE Drainage Tubing and Fittings NPS 4 to NPS 10: AASHTO M 252, Type S, with smooth waterway for coupling joints.

B. Riprap: Broken, irregular size and shape, graded stone conforming to Form 816, Section M.12.02, size as indicated.

2.6 EROSION CONTROL BLANKET

A. Blanket: Minimum width of 6 feet.

1. Mat: Machine-produced of 100 percent coconut fiber with colored line or thread along outer edges to indicate material overlap limits.

a. Weight: 0.50 lb./sq.yd.

b. Overlap: Approximately 2 to 5 inches.

2. Top and Bottom Cover: Heavy-weight polypropylene netting with ultraviolet additives to delay breakdown.

a. Mesh Size: 0.625-inch by 0.625 inch.

b. Weight: 3 lbs/1000 sq. ft.

B. Sew blanket and covers together on 1.5 inch center at 50 stitches per roll width with UV stable polypropylene thread.

C. Blanket: North American Green S150, Bon Terra S2, or approved equal.

2.7 TEMPORARY SEDIMENT TRAP

A. Core (Riprap): Broken, irregular size and shape, graded stone conforming to Form 816, Section M.12.02, size as indicated.

B. Face (Stone): Article M1.01 of Form 816, size No.3 or as indicated.

2.8 POLYACRYLIMIDE EROSION CONTROL BLOCKS

A. APS 700 Series Flocc Log, or approved equal

B. Formulation as recommended by the manufacturer.

2.9 DUST CONTROL

A. Water: Potable.

- B. Calcium Chloride: ASTM D98, Type 1 or Type 2.

PART 3 - EXECUTION

3.1 GENERAL

- A. Minimize environmental damage during construction. Prevent discharge of fuel, oil, lubricants, and other fluids. Mitigate effects of discharge.
- B. Install erosion and sediment control measures prior to clearing, demolition or construction.
- C. Construct erosion and sediment control measures in accordance with standards and specifications of the Owner, state regulations and guidelines, and the following.
 - 1. Provide additional sedimentation and erosion controls as required by the Engineer to address field conditions at no additional cost.
 - 2. Do not discharge turbid water from dewatering to inland wetlands or watercourses.
 - 3. Inspect site weekly and prior to any anticipated rain event. Ensure that erosion controls are properly maintained and functioning.
 - 4. Inspect site after any storm generating 0.1 inches of rain in a 24-hour period.
 - 5. Supply a 24-hour contact name and telephone number as part of the erosion control plan.
- D. Install additional control measures, if deemed necessary by the Owner, Engineer, or authorities having jurisdiction.
- E. Protect catch basins with bale filters or inserts throughout construction until disturbed areas are stabilized.
 - 1. Remove and dispose of sediment from control structures.
- F. Control dust and wind erosion. Control dust to prevent a hazard to traffic on adjacent roadways. Dust control includes sprinkling of water or calcium chloride application.
- G. Do not discharge directly into wetlands or watercourses where dewatering is necessary. Utilize methods and devices as permitted by authorities having jurisdiction and appropriate regulations to minimize and retain suspended solids including pumping water into a temporary sedimentation basin, providing surge protection at inlet and outlet of pumps, floating pump intake.
 - 1. If pumping operation results in turbidity problems, stop pumping until means of controlling turbidity are determined and implemented.
- H. Where control measures are required for longer than 60 days, use silt fence instead of hay bales.
- I. Cut Areas

1. Establish an erosion control line (haybale check or filter fabric) at toe of slope in cut areas and slope stabilization with mulch or grass within 30 days of start of cut operations.
- J. Fill Areas
1. Establish an erosion control line (silt fence) approximately 10 feet from toe of slope of proposed fill areas, or where indicated, prior to beginning fill installation.
 2. Initiate slope stabilization with mulch or grass within 30 days of start of fill installation.
- K. Within 7 days of completing slope construction, stabilize slopes with vegetation or matting to minimize exposure.
- L. Stockpiles
1. Side Slopes: 2:1 maximum.
 2. Surround stockpiles by a sediment barrier.
 3. Stabilize stockpiles left bare for more than 15 days with temporary vegetation or mulch.
- M. Final Grading
1. If final grading is delayed for more than 30 days after land disturbances cease, stabilize soils with temporary vegetation or mulch.
- N. Planting Season for Temporary Vegetation
1. March 1 to June 15 and August 1 to October 1.
 2. After September 15, stabilize areas with haybales or silt fence.
- O. Areas to Be Left Bare Prior to Finished Grading and Seeding
1. Within Planting Seasons
 - a. Temporarily seed with Perennial Ryegrass
 - b. Apply at a rate of 2 pounds per 1000 sq. ft. at a depth of 1/2 inch.
 - c. Where grass predominates, fertilize according to a soil test at a minimum application rate of one pound per acre.
 2. Outside of Planting Seasons
 - a. Apply air-dried wood chip mulch, free of coarse matter.
 - b. Apply at a rate of 185 to 275 pounds per 1000 sq. ft.

3.2 CONTROL SYSTEMS

- A. Prevent damage to geomembrane liner resulting from control system installation. Repair damaged geomembrane liner in accordance with manufacturer's requirements, at no additional cost to Owner.
- B. Construct erosion and sediment control structures prior to site clearing and grubbing operations.
- C. Silt Fence.
 - 1. Install fencing at locations indicated or where directed by the Engineer. Maintain pitch of 2 to 20 degrees, with inclination toward potential silt source.
 - 2. Install bottom 6 inches of fabric by trenching and burying the fabric into the notched ground.
 - 3. Drive posts into ground a minimum of 12 inches. Additional care should be taken when installing posts above the geomembrane liner.
 - 4. Locate fabric splices at posts only. Provide 6-inch overlap and seal.
- D. Sedimentation Control Hay Bales.
 - 1. Install bales at locations indicated or where directed by the Engineer. Place bales lengthwise with ends tight, abutting one another. Install bales with bindings located on the sides.
 - 2. Entrench bales 4 inches and backfill. Place backfill toward potential silt source.
 - 3. Secure in place with two stakes per bale and insert straw in voids between bales. Additional care should be taken when installing stakes above the geomembrane liner.
- E. Catch Basin Insert
 - 1. Inspect after each major precipitation event. Inspect every two weeks if no major rain events have occurred.
 - 2. Remove, clean, and reinstall silt sack when sediment accumulates to half capacity of sack.
- F. Pipe Slope Drains and Aprons
 - 1. Install, relocate, and maintain as required to allow work to progress.
- G. Temporary Sediment Trap
 - 1. Install were indicated or as directed by the engineer
 - 2. Remove and reinstall as required to allow installation of geomembrane liner and final cover material below trap.

H. Polyacrylimide Erosion Control Blocks

1. Install at locations, and in quantities recommended by the manufacturer.
2. Replace as needed during the duration of the project.

I. Dust Control.

1. Apply water uniformly over the surface when dust becomes a nuisance and when directed by the Engineer.
 - a. Apply water from trucks capable of uniform distribution over the surface. Provide suitable devices for positive shut-off and for regulating flow of water.
2. Apply calcium chloride at locations only when directed by Engineer at no additional cost to Owner. Spread calcium chloride by approved devices and methods for uniform distribution.
 - a. Engineer shall determine application rate based upon site conditions.
3. Provide sweeping equipment with provisions for water application ahead of sweeping brooms to prevent dusting.

3.3 MAINTENANCE

A. Silt Fence and Bale Control Systems

1. Inspect control system immediately after each rainfall and daily during prolonged rainfall. Make repairs immediately.
2. Remove and dispose of accumulated sediments when sediment reaches approximately one-third the height of the control system, or when directed by the Engineer.
3. Replace control system promptly if fabric decomposes or system becomes ineffective prior to the expected usable life.
4. Maintain or replace system until no longer necessary for the intended purpose.

B. Construction Entrance Pad

1. Maintain in good condition throughout construction period. Clean or replace stone when pad has accumulated sediment.

C. Erosion Control Blanket

1. Repair damaged portions of erosion control blanket until the area stabilizes with new growth or as directed by the Engineer.
2. Spray-Applied Bonded Fiber Mat Alternative: Reapply product to areas damaged by erosion until the area stabilizes with new growth or as directed by the Engineer.

D. Dust Control

1. Keep paved surfaces free of tracked sediment. Sweep adjacent paved areas throughout hauling operations, and at the end of each day's construction operation. Conduct sweeping at locations and times as directed by the Engineer at no additional cost.

3.4 REMOVAL

- A. Remove and dispose of control systems off-site after area stabilizes with new growth or as directed by the Engineer.
 1. After removal of system, restore disturbed areas to original condition or better.

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SECTION 31 25 02 - PERMANENT EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Riprap for swales and protection for drain inlets and outlets including stilling basins.
- B. Related Sections include the following:
 - 1. Division 02 Section "Landfill Earth Moving" for excavation and backfill.
 - 2. Division 02 Section "Underdrains" for piped subdrainage systems.
 - 3. Division 31 Section "Site Earth Moving" for excavation and backfill.
 - 4. Division 31 Section "Temporary Erosion and Sedimentation Control" for temporary site measures.
 - 5. Division 33 Section "Storm Drainage" for enclosed, piped drainage systems.

1.3 DEFINITIONS

- A. HDPE: High-density polyethylene plastic.
- B. NPS: Nominal pipe size.

1.4 SUBMITTALS

- A. Product Data and Material Certifications: For the following:
 - 1. Riprap
 - a. Origin of material, prior to delivery.
 - b. Sample
 - 2. Pipe Outlet bedding material.
 - a. Origin of material, prior to delivery.
 - b. Gradation according to ASTM D 422 and classification according to ASTM D 2487, prior to delivery and at a rate of one per 5,000 cu. yd.
 - 3. Geotextile fabric.

1.5 QUALITY ASSURANCE

- A. Where "Form 816" is referenced, it shall mean "State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 816," and issued supplements.

PART 2 - PRODUCTS

2.1 PIPE OUTLETS

- A. Riprap: Broken, irregular size and shape, graded stone conforming to Form 816, Section M.12.02, size as indicated.
- B. Crushed Stone Bedding Material: Granular fill conforming to Form 816, Section M.02.01-1 or M.02.01-2.

2.2 MISCELLANEOUS

- A. Geotextile: Form 816, Section M.08.01-26.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Site Earth Moving."

3.2 INSTALLATION, GENERAL

- A. General Locations and Arrangements: Drawing plans and details indicate general location of permanent erosion and sedimentation control systems. Lengths are approximate.

3.3 RIPRAP INSTALLATION

- A. Place bedding material and geotextile where indicated on accurately shaped subgrade.
- B. Construct riprap of broken stone, to the lines and grades indicated. Prevent displacement of bedding material.
- C. Place riprap to full course thickness in one layer. Rearrange individual stones by hand or equipment as required to produce a reasonably well-graded distribution of rock, free from pockets of small stones and clusters of larger stones.
- D. Place bedding material and filter fabric where indicated on accurately shaped subgrade.

3.4 STORM DRAINAGE INLET AND OUTLET INSTALLATION

- A. Construct inlet head walls, aprons, and sides of precast, or cast-in-place reinforced concrete, as indicated.
- B. Construct riprap of broken stone, as indicated. Prevent displacement of base material.
- C. Place riprap in one layer and rearrange individual stones by hand or equipment as required to produce a reasonably well-graded distribution of rock, free from pockets of small stones and clusters of larger stones.
- D. Install outlets that spill onto grade, anchored with concrete, where indicated.
- E. Install outlet flared end sections, where indicated.

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SECTION 32 12 16 – BITUMINOUS CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Bituminous concrete paving.
2. Bituminous concrete patching.
3. Bituminous concrete paving overlay.
4. Bituminous concrete curbing.
5. Precast concrete wheel stops.
6. Pavement-marking paint.
7. Cold milling of existing bituminous concrete pavement.

B. Related Sections include the following:

1. Division 31 Section "Site Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.

1.2 DEFINITIONS

A. Bituminous Concrete Base Course: Asphalt-aggregate layer placed over subgrade, aggregate subbase course, or aggregate base course; and beneath bituminous concrete surface course.

B. Bituminous Concrete Surface Course: The asphalt-aggregate top course of a bituminous concrete pavement, sometimes called a wearing course.

C. DOT: Department of Transportation.

1.3 SYSTEM DESCRIPTION

A. Provide bituminous concrete paving according to materials, workmanship, and other applicable requirements of standard specifications of state or local DOT.

1. Standard Specification: State of Connecticut, Standard Specifications for Roads, Bridges and Incidental Construction, Form 816.
2. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.4 SUBMITTALS

A. Job-Mix Design Certification: For each job mix proposed for the Work, signed by the supplier.

- B. Qualification Data: For bituminous concrete supplier.
- C. Material Certificates: For each paving material, signed by manufacturers.
- D. In-Place Density Testing Reports

1.5 QUALITY ASSURANCE

- A. Supplier Qualifications: A qualified supplier, registered with and approved by CT DOT.
- B. Regulatory Requirements: Comply with CT DOT Form 816 for bituminous concrete paving work.
- C. Asphalt-Paving Publication: Comply with AI MS-22, "Construction of Hot Mix Asphalt Pavements," unless more stringent requirements are indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.
- C. Transport bituminous concrete mixture in tight body trucks that have been previously cleaned of foreign material.
 - 1. Tightly cover trucks with waterproof canvas or other suitable covers.
- D. Deliver mixture within 25 deg F of approved job mix formula temperature.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp or if the following conditions are not met:
 - 1. Prime and Tack Coats: Minimum surface temperature of 60 deg F.
 - 2. Bituminous Concrete Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
 - 3. Bituminous Concrete Surface Course: Minimum surface temperature of 60 deg F at time of placement.
- B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 50 deg F and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 BITUMINOUS CONCRETE

- A. Materials: Section M.04 and M.05.02 of Form 816.
- B. Tack Coat: AASHTO M 140 Grade SS-1 or SS-1H, emulsified asphalt or AASHTO M 208 Grade CSS-1 or CSS-1H, cationic emulsified asphalt, slow setting, diluted in half with water.

2.2 AUXILIARY MATERIALS

- A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.
- B. Waterborne Pavement-Marking Paint:
 - 1. Hot-Applied: Article M.07.21 of Form 816, with a 2 minute drying time.
 - 2. Non-Heat-Applied: Article M.07.20 of Form 816, with a 15 minute drying time.
 - a. Color: As indicated.
- C. Wheel Stops: Precast, air-entrained concrete, 4000 psi minimum compressive strength. Provide chamfered corners and drainage slots on underside and holes for anchoring to substrate.
 - 1. Dowels: Galvanized steel.

2.3 MIXES

- A. Bituminous Concrete: Dense, hot-laid, bituminous concrete plant mixes approved by authorities having jurisdiction and complying with the following requirements:
 - 1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
 - 2. Course Depth and Class: As indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that surface to receive paving is dry and in suitable condition to support paving and imposed loads.
- B. Proof-roll subbase or aggregate base course using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction.
- C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 COLD MILLING

- A. Utility Structures: Identify, adjust and protect utility structure frames, grates and covers.
- B. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Prevent milled pavement particles from entering drainage system. Remove existing bituminous concrete pavement by cold milling to grades and cross sections indicated.
 - 1. Mill to indicated depth.
 - 2. Mill to a uniform finished surface free of gouges, grooves, and ridges.
 - 3. Control rate of milling to prevent tearing of existing bituminous concrete course.
 - 4. Repair or replace curbs, manholes, and other construction damaged during cold milling.
 - 5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled bituminous concrete.
 - 6. Keep milled pavement surface free of loose material and dust.
 - 7. Clean adjacent roads, parking areas, and grass areas of milled pavement particles.

3.3 REPAIRS

- A. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, bituminous concrete paving at a rate of 0.05 to 0.15 gal./sq. yd.
 - 1. Allow tack coat to cure undisturbed before applying bituminous concrete paving.
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
- B. Temporary Repair: Fill excavated pavement area with bituminous concrete base mix to indicated thickness and, while still hot, compact flush with adjacent surface.
- C. Permanent Repair: Partially fill excavated pavement area with bituminous concrete base mix and, while still hot, compact. Cover bituminous concrete base course with compacted, bituminous concrete surface layer finished flush with adjacent surfaces.

3.4 SURFACE PREPARATION

- A. General: Immediately before placing bituminous concrete, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
 - 1. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.
- B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

- C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
 - 1. Allow tack coat to cure undisturbed before applying bituminous concrete paving.
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.5 BITUMINOUS CONCRETE PLACING

- A. Machine place hot bituminous concrete on prepared surface, spread uniformly, and strike off. Place by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
 - 1. Place bituminous concrete base course in number of lifts and thicknesses indicated.
 - 2. Place bituminous concrete surface course in single lift.
 - 3. Spread mix at minimum temperature of 250 deg .
 - 4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes, unless otherwise indicated.
 - 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in bituminous concrete paving mat.
 - 6. In areas inaccessible to pavers, use staked forms to maintain indicated line and grade. Prevent segregation of mix when placing mix by hand.
- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
 - 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of bituminous concrete base course before placing bituminous concrete surface course.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot bituminous concrete to prevent segregation of mix; use suitable hand tools to smooth surface.

3.6 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions with same texture and smoothness as other sections of bituminous concrete course.
 - 1. Clean contact surfaces and apply tack coat to joints.
 - 2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
 - 3. Offset transverse joints, in successive courses, a minimum of 24 inches
 - 4. Construct transverse joints as described in AI MS-22, "Construction of Hot Mix Asphalt Pavements."

5. Compact joints as soon as bituminous concrete will bear roller weight without excessive displacement.
6. Compact material at joints to a density within 2 percent of specified course density.

3.7 COMPACTION

- A. General: Begin compaction as soon as placed paving material will bear roller weight without excessive displacement. Compact material with hot, hand tampers or vibratory-plate compactors in areas inaccessible to rollers.
 1. Complete compaction before mix temperature cools to 185 deg .
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while bituminous concrete is still hot enough to achieve specified density. Continue rolling until course has been uniformly compacted to the following density:
 1. Average Density: 95 percent of reference maximum theoretical density according to AASHTO T 209, but not less than 92 percent nor greater than 97 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while bituminous concrete is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while material is still hot; compact thoroughly.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh material. Compact by rolling to specified density and surface smoothness.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.8 INSTALLATION TOLERANCES

- A. Thickness: Compact each course to produce the thickness indicated within the following tolerances:
 1. Base Course: Plus or minus 1/2 inch.
 2. Surface Course: Plus 1/4 inch, no minus.

- B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
 - 1. Base Course:
 - a. Roadways and Parking Lots: 3/8 inch.
 - b. Sidewalks and Driveways: 1/4 inch.
 - 2. Surface Course: 1/4 inch.
 - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.
- C. Variation from Design Elevation: 1/4 inch.
- D. Curb Alignment: Place curbing to produce an alignment within 1/4 inch tolerance as determined by using a 10-foot straight edge along front face of curb.

3.9 BITUMINOUS CONCRETE CURBS

- A. Construct bituminous concrete curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of 250 deg F.
- B. Place bituminous concrete to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after bituminous concrete has cooled.
- C. Protect curbing for a minimum of 24 hours and until mixture has cooled so as not to become marked.

3.10 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Engineer.
- B. Allow paving to age for 30 days before starting pavement marking.
- C. Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.11 WHEEL STOPS

- A. Securely attach wheel stops into pavement with not less than two galvanized steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.12 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and to prepare test reports.
 - 1. Testing agency will conduct and interpret tests and state in each report whether tested Work complies with or deviates from specified requirements.
- B. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- C. Thickness: In-place compacted thickness of bituminous concrete courses will be determined according to ASTM D 3549.
- D. Surface Smoothness: Finished surface of each bituminous concrete course will be tested for compliance with smoothness tolerances.
- E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to AASHTO T 168.
 - 1. Reference maximum theoretical density will be determined by averaging results from four samples of bituminous concrete mixture delivered daily to site, prepared according to AASHTO T 209, and compacted according to job-mix specifications.
 - 2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
 - a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than 3 cores taken.
 - b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
- F. Remove and replace or install additional bituminous concrete where test results or measurements indicate that it does not comply with specified requirements.

3.13 DISPOSAL

- A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an approved landfill.
 - 1. Do not allow excavated materials to accumulate on-site.

END OF SECTION

SECTION 32 15 00 – AGGREGATE SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. One course gravel wearing surface (Gravel Access Road).
 - 2. Restoration of existing gravel road or drive as indicated or as directed by the Engineer.
 - 3. Geogrid.
- B. Related Sections include the following:
 - 1. Division 02 Section "Landfill Earth Moving" for landfill cap material beneath roadway.

1.3 SUBMITTALS

- A. Traffic Bound Gravel Surface Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance with requirements indicated. Prepare separate reports for each type and application of soil material.
 - 1. Gradation according to ASTM D 422 and classification according to ASTM D 2487, prior to delivery and at a rate of one per 5,000 cu. yd.
 - 2. Modified Proctor Testing according to ASTM D 1557, prior to delivery and at a rate of one per 5,000 cu. yd.
 - 3. Origin of material, prior to delivery.
 - 4. Soil Chemical Analysis Reports:
 - a. RCRA 8 Metals (EPA Method 6010 / 7421 / 7470), Polychlorinated Biphenyls (EPA Method 8082), Total Volatile Organic Compounds (EPA Method 8260), Semi-Volatile Organic Compounds/Polyaromatic Hydrocarbons (EPA Method 8270), Pesticides (EPA Method 8081), and Total Petroleum Hydrocarbons (CTETPH method): prior to delivery and one report for each 10,000 cu. yd., or portion thereof, delivered. Owner reserves the right to disqualify the source based on the results of the chemical testing.
 - 1) Soil/material shall not exceed any GB pollutant mobility criteria (GB PMC) or residential direct exposure criteria (RES DEC) established in

Sections 22a-133k-1 through 22a-133k-3 of the regulations of Connecticut state agencies.

B. Geogrid

1. Material Certification: Signed by manufacturers or suppliers certifying that the material complies with requirements.
2. Shop Drawings: Indicate proposed roll layout and indicate direction of geogrid. Show roll sizes. Include details showing termination of the rolls at perimeter of lined areas; and methods of connecting, overlapping, and anchoring geogrid.
 - a. Lay out geogrid to minimize field connections.
3. Sample: One per each lot of geogrid to be used. Label samples with manufacturer's name, product identification, lot number, and roll number.
4. Inventory tickets, roll numbers or batch identifications, packing papers, and invoices.
5. Installation Certification: By installer and manufacturer's Technical Representative, stating the geogrid was installed in an acceptable manner per manufacturer's requirements.

1.4 QUALITY ASSURANCE

- A. Form 816: State of Connecticut, Department of Transportation, Standard Specifications for Roads, Bridges and Incidental Construction, Form 816.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Traffic Bound Gravel Surface: Form 816, Section M.02.03, Traffic Bound Gravel Surface.
 1. Single Course: Form 816, Section M.02.06, Grading C.
- B. Geogrid Reinforcement: Integrally formed bi-axial grid structure manufactured from first quality virgin high-density polyethylene.

<u>Property</u>	<u>Test Method</u>	<u>Requirement</u>
Carbon Black Content (min. percentage)	ASTM D4218	2
Tensile Strength (5% strain)	ASTM 6637	920 lb/ft machine direction 1,350 lb/ft cross direction

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Confirm subgrade is in conformance with Division 31 Section "Site Earth Moving." Maintain subgrade or subbase true to line and grade.
- B. Proof-roll subgrade or subbase using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction.
- C. Proceed with surfacing only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Stabilization Geotextile: See Division 02 Section "Landfill Earth Moving" for requirements.

3.3 GEOGRID

- A. Keep geogrid clean before installation. Unpackage, install and join together only enough geogrid material that can be completely installed in the same day.
- B. Provide manufacturer's Technical Service Representative during start of geogrid installation activities.
- C. Verify that subgrade is dry and in suitable condition to begin installation of geogrid.
- D. Geogrid Installation
 - 1. Install geogrid on prepared surface and in the presence of a manufacturer's Technical Representative. Minimize handling and movement of product. Overlap layers in accordance with manufacturer's requirements.
 - 2. Do not allow materials or equipment to be dragged or travel over installed geogrid.
 - 3. Place overlying materials to prevent damage to geogrid. Install 9 inch minimum layer over geogrid before allowing tracked vehicles to traverse over locations containing the geogrid.

3.4 GRAVEL SURFACE INSTALLATION

- A. Spread surfacing material uniformly over geogrid.
- B. Spread material to the lines, depth, and shape indicated. If required, wet material and blade, drag, or scrape to conform to typical cross section.
- C. Compact to a firm and uniform surface satisfactory to the Engineer. Compact and bound each course of material with equipment specifically designed for compaction.
 - 1. Rollers:

- a. Weight: 10 tons minimum.
 - b. Ground Pressure: Not less than 300 pounds per linear inch of contact width.
 2. Vibratory Units: Static weight of not less than 4 tons.
 3. Water. Water may be used during compacting and binding operations when applied from an approved watering device. Direction and intensity of water stream shall be as ordered by the Engineer.
- D. Perform compacting and binding operation at outside edges, overlapping for a distance not less than 6 inches, and progressing towards the middle of the surfacing area, parallel with the centerline of the road.
- E. Remove areas of segregated coarse or fine materials and replace with well-graded material.
1. Provide additional material to fill irregularities in surface course. Evenly incorporate material with in-place gravel by scarifying, harrowing, or brooming.

3.5 RESURFACING

- A. Confirm existing surface is in conformance with subgrade requirements in Division 31 Section "Site Earth Moving."
- B. Pre-fill ruts with material before installing overlay.
- C. Install overlay in conformance with installation requirements specified herein.

3.6 INSTALLATION TOLERANCES

- A. Variation from Design Elevation
 1. Traffic Bound Gravel Surface: 1 inch plus or minus.

3.7 FIELD QUALITY CONTROL

- A. Surface Installation: Measure finished surface for compliance with Installation Tolerances.
 1. Course Thickness.
 - a. Roads, Drives, Walks: Take measurements at intervals of 500 feet or less, along each edge of road lane.
 2. If measurements indicate a deficient or excess thickness, take additional measurements to determine the longitudinal limits of the deficiency. Correct areas found to be deficient or in excess of Installation Tolerances.

3.8 REPAIRS AND PROTECTION

- A. Protecting Gravel Surfacing Roads and Areas: Protect newly graded roads and areas from traffic, freezing, and erosion. Keep free of trash and debris.

- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace material to depth as directed by Engineer; reshape and recompact.

- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

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SECTION 32 31 13.03 - CHAIN LINK FENCE

PART 1 - GENERAL

1.1 SUMMARY

- A. Work under this Section shall consist of furnishing and installing woven wire fencing/gates, supported by metal posts, erected where indicated on the Drawings or as ordered, and in conformity with these Specifications.

1.2 QUALITY ASSURANCE

- A. Where "Form 816" is used, it shall mean "State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 816" and issued supplements.

1.3 SUBMITTALS

- A. Submit manufacturer's certification demonstrating compliance with specifications for Chain Link Fence and Gates.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Materials for this Work shall conform to the requirements of Form 816, Article M.10.05, and shall be aluminum coated steel fabric with galvanized posts, rails and hardware.

PART 3 - EXECUTION

3.1 GENERAL

- A. Space posts as indicated.
 - 1. Provide pull posts with two braces for changes in horizontal or vertical alignment of 10 degrees or more.
- B. Fasten braces to posts by suitable connections, and truss from line post back to post requiring bracing with 3/8-inch round rod, having a turnbuckle adjustment.
- C. Pass top rail through base of line post cap and form a continuous brace from end to end of fence. Provide rail with couplings approximately every 20 feet.
 - 1. Couplings: Outside-sleeve type, 7 inches long minimum, with one in every five couplings having a heavy spring to take up expansion and contraction in top rail.

- D. Fasten fabric to line posts with bands or wire clamps of No. 6 gage aluminized steel wire 4-3/4 inches long. Space bands approximately 14 inches apart.
 - 1. Fasten fabric to top and bottom rail with tie wires, 6-1/4 inches long, spaced approximately 24 inches apart.

END OF SECTION

SECTION 33 41 23 - STORM DRAINAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section specifies enclosed storm drainage system for landfill closure and includes the following:
 - 1. Enclosed, underground piping systems.
- B. Related Sections include the following:
 - 1. Division 02 Section "Underdrains" for subdrainage systems.
 - 2. Division 31 Section "Site Earth Moving" for excavation and backfill.
 - 3. Division 31 Section "Permanent Erosion and Sedimentation Control" for exposed drainage swales and outlets.

1.3 DEFINITIONS

- A. HDPE: High-density polyethylene.
- B. PVC: Polyvinyl chloride plastic.
- C. RCP: Reinforced concrete pipe.
- D. NPS: Nominal pipe size.

1.4 SUBMITTALS

- A. Product Data and Material Certifications.
 - 1. Piping.
 - 2. Precast concrete manholes and other structures.
 - 3. Structure frames, covers, and grates.
- B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.5 QUALITY ASSURANCE

- A. Where "Form 816" is referenced, it shall mean "State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 816," and issued supplements.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic structures, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle precast concrete manholes and other structures according to manufacturer's written rigging instructions.

1.7 PROJECT CONDITIONS

- A. Site Information: Perform site survey, research public utility records, and verify existing utility locations.
- B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Engineer not less than 2 days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Engineer's written permission.

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

- A. HDPE: Corrugated PE Pipe and Fittings NPS 12 to NPS 48: AASHTO M 294M, Type S, with smooth waterway for coupling joints.
 - 1. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

2.2 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318, ACI 350R, and the following:
 - 1. Cement: ASTM C 150, Type II.
 - 2. Fine Aggregate: ASTM C 33, sand.
 - 3. Coarse Aggregate: ASTM C 33, crushed gravel.
 - 4. Water: Potable.
- B. Portland Cement Design Mix: 4,000 psi minimum, with 0.45 maximum water-cementitious ratio.

1. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.
- C. Ballast and Pipe Supports: Portland cement design mix, 4,000 psi minimum, with 0.58 maximum water-cementitious ratio.
 1. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

2.3 MISCELLANEOUS

- A. Grout: Form 816, Section M.03.01-14.
- B. Filter Fabric: Form 816, Section M.08.01-26.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Site Earth Moving."

3.2 IDENTIFICATION

- A. Materials and their installation are specified in Division 31 Section "Site Earth Moving." Arrange for installing green warning tapes directly over piping and at outside edges of underground structures.
 1. Use warning tape or detectable warning tape over ferrous piping.
 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.3 INSTALLATION, GENERAL

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line, and pull past each joint as it is completed.
- C. Install gravity-flow piping and terminate piping as indicated.
 1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.

3.4 PIPE JOINT CONSTRUCTION AND INSTALLATION

- A. General: Join and install pipe and fittings according to installations indicated.
- B. Corrugated PE Piping: Join according to CPPA 100.
- C. System Piping Joints: Make joints using system manufacturer's couplings, unless otherwise indicated.
- D. Join piping made of different materials or dimensions with couplings made for this application. Use couplings that are compatible with and that fit both systems' materials and dimensions.

3.5 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318 and ACI 350R.

3.6 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 - 1. Submit separate reports for each system inspection.
 - 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 - 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 - 4. Reinspect and repeat procedure until results are satisfactory.

3.7 CLEANING

- A. Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed.
 - 1. In large, accessible piping, brushes and brooms may be used for cleaning.
 - 2. Place plug in end of incomplete piping at end of day and when work stops.
 - 3. Flush piping between manholes and other structures to remove collected debris, if required by authorities having jurisdiction.

- B. Existing Piping, Culverts, Drainage Flows, and Structures. Clean interiors of drainage systems located within the limits of the Work of accumulated sediment and debris.

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SECTION 48 14 15 – SOLAR ENERGY ELECTRICITY GENERATION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Exhibit B General Requirements, apply to this Section.

1.2 SUMMARY

- A. This Section includes designing, providing, commissioning and maintaining a complete and operational grid-connected Solar Photovoltaic (PV) electrical generation system as indicated herein and on the Drawings. This includes the following:
 - 1. Designing a complete and operational Solar PV electrical generation system, including:
 - a. Design and engineering of a PV Generation System
 - 1) Selection and integration of system components
 - 2) Configuration of Sub-array packages
 - 3) System layout.
 - 4) D/C electrical distribution system.
 - 5) Structural design of racking and support systems (as required).
 - 6) Racking system ballast (as required)
 - b. Design and engineering of a "behind the meter" A/C Distribution System
 - 1) Connecting PV system to required on-site A/C electric distribution system.
 - 2) Monitoring system
 - 3) PV-backfed sub-panel.
 - 4) Main service panel.
 - 5) Overhead wiring connection.
 - 6) Above ground conduit with supports and wiring.
 - 2. Providing a complete and operational Solar PV electrical generation system, including:
 - a. A number of PV Sub-Arrays, as determined by the Owner
 - 1) Minimum number of Sub-Arrays: 2
 - 2) Maximum number of Sub-Arrays: 4

- 3) Owner shall notify Contractor of their elected number of Sub-Arrays upon issuing Notice to Proceed.
- b. On-site A/C Electric Distribution System, including:
 - 1) Above-ground conduit
 - 2) Overhead electrical lines, and associated poles, strain relief, etc.
 - 3) Conduit attached to existing site buildings, as required.
 - 4) Connection of A/C Distribution System to utility interconnection point.
 - 5) Coordination with Utility and compliance with Utility Interconnection requirements.
3. Commissioning and testing of new grid-tied PV generation system.
4. Solar PV System Operation and Maintenance Program
 - a. The PV System Installer will be expected to enter into a separate agreement with the Owner for the operation and maintenance of the system for a period of five years following system commissioning.
- B. Related Sections:
 1. Division 02 Section – Closure Turf™ Alternative.
 2. Division 02 Section – Exposed TPO Alternative.

1.3 DEFINITIONS

- A. A/C Distribution System: Includes but is not limited to the A/C combiner box, A/C disconnect switch, monitoring system components (DAS), and the required A/C service upgrades at the point of interconnection.
- B. Delegated-Design Submittals: Documents, including drawings, calculations, and material and product specifications prepared as a responsibility of Contractor to obtain acceptance by Owner and authorities having jurisdiction.
- C. PV: Photovoltaic.
- D. Sub-Array Package: PV generation system capable of providing 301.84 kW D/C and required components up to the starting point of the A/C Distribution System at the proposed inverter location including but not limited to modules, racking, inverters, and wiring.

1.4 COORDINATION

- A. Coordinate with geomembrane capping system manufacturer to ensure that geomembrane liner warranty coverage will be maintained subsequent to installation of PV.

- B. Coordinate with Owner on the locations and appearance of all exposed equipment, including but not limited to PV modules, mounting structure, conduit, inverters, wire ways, and control and monitoring equipment.
 - 1. All locations must be approved by Owner before final delegated-design drawings are completed.
 - 2. Obtain Owner's approval of final delegated-design drawings and equipment specifications before ordering equipment.
- C. Coordinate with trades needed for a complete installation including all required controls, electrical services, civil work, and clearances.

1.5 SUBMITTALS

- A. Delegated-Design Submittal: For PV Generation System, structural support systems, and A/C Distribution System and grid connection, as indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Number of Copies for each element listed below: Six (6).
 - 2. Submittal Contents
 - a. Design Drawings for construction of PV Generation system:
 - 1) Schematic System Layout: Preliminary PV system configuration, indicating location of major system components.
 - a) Engineer will provide an electronic project base map in AutoCAD format for use in preparing Layout plans.
 - b) Obtain approval from Owner before proceeding with final design and layout.
 - 2) Final System Layout: Equipment layout drawing showing location of all PV equipment and conduit runs.
 - a) Indicate distances, if applicable, of PV system equipment from the nearest property lines and setback lines.
 - b) Show locations and sizes of all PV equipment, wiring, and conduit
 - 3) One-line Electrical Diagram: Showing all D/C and A/C wiring and related electrical equipment in the PV system.
 - 4) Equipment Schedules: For all major system components.
 - 5) Construction Details: Product specific construction details for the following components, at a minimum:
 - a) PV Racking system and module attachment
 - b) Racking system ballast
 - c) Above-ground conduit supports

- d) Conduit connections and joints
 - e) Concrete-encased conduit duct bank
 - f) Inverter pad and mounting hardware
 - g) Utility Pole
 - h) Weather-head
 - i) Conduit brackets
 - j) Building envelope penetration
 - k) PV Panel configuration
 - l) System grounding details
- b. Design Calculations and System Specifications:
- 1) Site-specific analysis of shading used to establish system layout
 - 2) Calculation of anticipated system output based on cumulative losses from D/C electrical distribution, A/C electrical distribution, efficiency rating of selected equipment, system orientation and shading
 - 3) Electrical distribution system design calculations for the following:
 - a) D/C electrical distribution system
 - b) A/C electrical distribution system
 - 4) System grounding design calculations
 - 5) Wiring requirements, including required conductors and cables and wiring methods
 - 6) Structural design of racking and support systems
 - 7) System Ballast design calculations
 - 8) Structural analysis data and calculations used for pole selection.
- c. Product Data: Manufacturer's specification and cut sheets for all equipment, accessories, and monitoring devices.
- d. Additional Items: As required by Authorities Having Jurisdiction.
- B. Operations and Maintenance Manual: Include operating and maintenance instructions for the system as a whole, performance curves, warranty information, approved shop drawings, recommended and complete parts lists, wiring diagrams, and all other bulletins and brochures pertinent to the operation and maintenance of equipment.
- C. As-built Drawings: Include PV Generation System Components on the final project As-Built drawings, specified elsewhere.
- 1. Submit prior to Substantial Completion.
- D. Qualification Data:

1. Professional Engineer: a Connecticut Licensed Professional Engineer with experience and knowledge in the engineering discipline required to perform the specific services required.
2. Testing agency: A testing Laboratory licensed and approved by a state agency to perform the specific quality assurance tests indicated.
3. Installer: Licensed solar or electrical contractor with a NABCEP-certified PV installer on staff.

1.6 QUALITY ASSURANCE

A. Regulatory Agencies:

1. Electric
 - a. Comply with utility requirements for interconnection approval and system commissioning.
 - b. An interconnection application has been submitted. Amend application as required to accommodate final approved design and equipment.

B. Engineering Responsibility: Preparation of delegated-design submittals and comprehensive engineering analysis by a qualified professional engineer.

C. Work shall comply with all applicable codes; standards; relevant local, state and federal regulations; local authorities; utilities; and manufacturer's instructions/recommendations.

1. All work, including equipment, materials, and installation, shall conform to CT State Building Code, CT State Fire Prevention Code, and CT State Fire Safety Code; editions currently adopted by the authorities having jurisdiction.
2. The minimum requirement of the more stringent code or standard shall govern where more than one code or standard is applicable to any component or condition.
3. Any work at variance with the applicable codes and completed without prior written approval of the Owner shall be corrected as required without additional cost to the Owner.

D. Comply with manufacturer specification, instructions, and recommendations for all equipment and materials.

1.7 WARRANTY

A. System Performance Warranty: Provide minimum 5-year system performance warranty, or longer if required by the state or federal incentive programs in effect at the time of application, against breakdown or degradation of electrical output.

1. System Performance Warranty shall cover all PV Generating System components with breakdown or degradation in electrical output of more than 10 percent of their originally rated electrical output.

2. Warranty shall include full cost to repair and/or replace defective components or systems.
3. The selected proposer is expected to correct any defective materials or workmanship during installation and/or the System Performance Warranty period to the satisfaction of CRRRA and without additional cost.

B. Manufacturer's Materials Warranties:

1. PV Modules: 25-year minimum.
2. Solar Inverters: 10 year minimum.
 - a. The Owner will request that the selected proposer submit additional pricing for solar inverter warranty extensions to 20 years.
3. Racking System Components: 10 year minimum.

PART 2 - PRODUCTS

2.1 EQUIPMENT - GENERAL

- A. All materials, fixtures, and equipment required for the work shall be new and shall be furnished, delivered, erected, connected, and finished in every detail, and shall be selected and arranged as to fit properly into the allocated spaces. Where no specific kind or quality of material is given, a first-class standard article as approved by CRRRA shall be furnished.
- B. All equipment shall be listed and labeled per recognized electrical testing laboratories and installed per the listing requirements and the manufacturer's instructions.
- C. All equipment shall be properly grounded per the requirements of the National Electric Code, Article 250.

2.2 PV MODULES

- A. Mono- or poly-crystalline 72 cell modules with a capacity rating of 280 watts or greater.
- B. All modules shall be supplied by qualified PV manufacturers. Acceptable manufacturers include:
 1. SolarWorld
 2. Suntech
 3. SunPower
 4. Trina Solar
 5. Yingli Solar
 6. Canadian Solar
 7. Or approved equal

- C. Substitute module sizes and technologies (including flexible thin film) will be considered, so long as they meet the requirements of an investment grade technology.

2.3 SOLAR INVERTER

- A. 250 kVA inverters with or without transformers that output at 480V. All inverters shall be IEEE 929 compliant, listed to UL Standard 1741, and inspected by utility before commissioning, testing, and operation of system.
- B. Acceptable inverter manufacturers include (but are not limited to):
 - 1. Advanced Energy (PV Powered and Solaron)
 - 2. PowerOne
 - 3. SMA
 - 4. Or approved equal.

2.4 RACKING SYSTEM

- A. Required for crystalline PV systems. Provide ballasted (non-penetrating) system with a nominal module tilt of 30 degrees.
 - 1. Racking system design must be compliant with exposed geomembrane manufacturer's material and landfill design and grading.
 - a. Constructed of galvanized structural steel or aluminum.
 - b. The racking system design shall be adjustable to accommodate landfill settling overtime:
 - 1) Module tilt: adjustable over a range of 25-35 degrees from horizontal
 - 2) Vertical alignment: adjustable over a range of minus two 2 inches to plus two inches from initial installation.
 - 3) Provide a minimum 0.5-inch spacing between PV array modules.
 - c. A sacrificial geotextile is required under racking system touch points to satisfy geomembrane manufacturer requirements.
 - 2. Acceptable racking system manufacturers include:
 - 1) Panel Claw
 - 2) PV Hardware
 - 3) Schletter
 - 4) Sunlink
 - 5) Unirack
 - 6) Or approved equal

3. Additional tilts and racking configurations such as flexible thin-film laminates will also be considered.

2.5 MONITORING SYSTEM

- A. Inverter-level monitoring components, including a weather station, and a 5-year renewable subscription providing web-based performance data on the PV system.
 1. Monitor the following system parameters, at a minimum:
 - a. Current System Status
 - b. Instantaneous system output ($\text{kW}_{A/C}$)
 - c. Cumulative system output (kWh)
 - d. Graphical representation of daily, weekly, monthly and yearly system output
 - e. Cumulative system environmental benefits: Avoided emissions of CO_2 , NO_x and SO_2
 - f. Current ambient temperature
 - g. Current solar irradiance levels
 2. Acceptable monitoring system manufacturers include:
 - a. Deck
 - b. Draker Labs
 - c. Energy Recommerce
 - d. Solar Magic
 3. Display Monitor: Provide and install a minimum 42-inch high-definition (1080p), energy star certified, LCD computer display in the CRRR Trash Museum showing real-time data from the monitoring system.
 - a. Panasonic TH-42LF25U
 - b. Sharp LC42D69U
 - c. LG 42LV5500
 - d. Sony KDL-42V4100
 4. A computer capable of running a web interface for the selected monitoring solution shall also be provided and installed as inconspicuously as possible.
 5. Provide all equipment and connections for PV system monitoring, including a 5-year renewable subscription providing web-based performance data on the PV system. A weather station must also be included in the monitoring package.

2.6 A/C DISTRIBUTION SYSTEM

- A. Includes but is not limited to the A/C combiner box, A/C disconnect switch, conduit, conductors, and the required A/C service upgrades at the point of interconnection.

- B. Provide conduit(s) between the main electrical service panel location and the PV array site.
 - 1. Conduit shall be minimum 2" rigid metal
 - 2. Installed with pull wires, fittings and weatherproof caps that facilitate easy pulling of wires in the future when the PV system is serviced.
- C. Provide a PV backfed breaker in an oversized main service panel
- D. Include the installation of ground fault protection devices suitable for PV systems.

PART 3 - EXECUTION

3.1 LINER SYSTEM PROTECTION

- A. Prevent damage to the geomembrane cap system during installation of the PV System.
 - 1. Geomembrane Installer shall inspect geomembrane system with in the presence of the PV Installer prior to commencement and after the completion of the PV System installation.
 - a. Take photographs of any areas in questions and document each location with suspected damage.
 - 2. The Contractor shall be responsible for all damage from leaks or breaks in equipment, ductwork, pipes or fixtures caused by their work on site during construction. The Contractor will also be responsible for all damages caused by leaks or breaks in new materials installed under this specification for the duration of the System Performance Warranty period.
- B. Correct damages to the satisfaction of Owner at no additional cost.

3.2 PERMITS, FEES, TRANSPORTATION AND INSPECTIONS

- A. The selected proposer shall give all necessary notices, obtain all permits, and pay all government sales taxes, fees and other costs, including utility connections or extensions, in connection with this work; file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments having jurisdiction; obtain all required certificates of inspection for this work and deliver same to the Owner before request for acceptance and final payment for the work. Construction cannot begin until the proper permits and approvals have been obtained and posted.
- B. The selected proposer shall include in the work, without additional cost to CRRA, any labor, materials, services, transportation, disposal, apparatus, and drawings needed, in order to comply with all applicable laws, ordinances, rules and regulations, whether or not shown on drawings or specified.

3.3 INCENTIVE PROGRAMS

- A. As necessary and upon receipt of final inspection approval, the selected proposer shall assist CRRA in immediately filing all forms and paperwork required to claim any relevant state and local incentives.

3.4 PV SYSTEM DESIGN CRITERIA

A. General

1. The Drawings indicate the general equipment locations and sizes for the major PV system equipment. Comply with these criteria and incorporate these parameters into the proposed design. Obtain approval before altering any of the criteria set forth in these performance specifications or the Drawings.
2. Provide access to equipment for maintenance and service as required by the manufacturer's instructions and/or applicable codes.
3. The following components shall comply with NEC Article 690:
 - a. Over-current protection
 - b. Interconnection to the utility grid
 - c. Panel bussing
 - d. Labeling
 - e. Conductors
4. If equipment cannot be properly concealed, notify CRRA. Any patching and cutting done as a result of error or neglect on the part of the Contractor shall be done at the expense of the Contractor.
5. Attachments: Support all work adequately and per code. All equipment shall be securely attached to structures in an approved manner. Attachments shall be of a strong and durable nature.
6. Shoring: Provide permanent and temporary shoring, anchoring and bracing required by the nature of this work in order to make all parts absolutely stable and rigid, even when shoring, anchoring and bracing are not explicitly called for.
7. Training: Instruct the Owner's personnel regarding operation and maintenance of PV equipment and apparatus.
8. Keep work areas in a clean and safe condition. Remove all equipment, tools, vehicles, rubbish, waste, and debris from the site upon completion of the job. Pay fees for recycling and disposal.

B. System Operation

1. When sufficient sunlight and the electrical grid are both present and the solar array is thus operational and generating power, solar power output is used to run A/C loads on site and provide excess generation to the grid (in this order of priority).

2. Any serviced electrical loads will be powered directly by the solar array with any excess power flowing back to the grid, spinning the bidirectional meter backwards, and crediting the respective electric account via net metering regulations (as per the State of Connecticut's net metering laws). Any net excess generation accumulated on an annual basis will be treated as per these same regulations.
 3. When the electrical load on site exceeds the solar output, then the grid supplies the balance seamlessly.
 4. The PV system shall be anti-islanding. If the utility grid fails, the solar power output also ceases. No power is available until grid power returns. When utility power returns, the system automatically switches back to normal grid-intertie mode, and solar power production resumes.
- C. Individual PV System Sub-Array Packages. Each package includes the following:
1. PV Modules
 - a. 280-Watt D/C STC rated, 72 cell, PV crystalline modules tilted at 30 degrees, arranged in a grid as approved by the Owner, with the long dimensions of the modules parallel with long dimensions of the array (i.e. landscape).
 - b. Other module arrangements, tilts, and sizes, including laminate thin-film modules, will be considered.
 - c. Locate the PV array approximately as indicated on the Drawings on the graded landfill plateau.
 - d. Measure shading effects from any potential sources of shade and evaluate in order to determine optimum location for modules.
 - 1) Group strings and arrange system components so that no modules are shaded between the hours of 9 am – 3 pm solar time on the winter solstice.
 - e. Arrange in appropriate series strings for optimum inverter performance.
 - f. Independently protect each series string of PV modules with an isolation fuse or breaker before it is connected in parallel with other string(s) on that PV output circuit.
 - 1) The current rating of this isolation fuse or breaker shall be less than the de-rated ampacity of the wiring that it is protecting and greater than 1.56 times the short circuit current rating of the PV modules in that PV source circuit.
 - 2) Isolation fuses shall also be rated no greater than the modules series fuse rating.
 2. Solar Inverter: 250 kVA rated solar inverter, installed on a concrete pad adjacent to the landfill service road as indicated.
 3. Wiring:

- a. All D/C conductors shall be sized such that there is a maximum of 1.5% voltage drop measured at the short circuit current rating of that circuit over the entire length of each circuit from PV module to inverter and back to PV module.
- b. Hide wiring from view and locate wiring beneath modules where possible.

D. A/C Distribution System

1. All A/C conductors shall be sized for a maximum of 2% voltage drop measured at the continuous A/C current rating of the inverter between the inverter and the point of interconnection with the grid.

3.5 TESTING AND INSPECTION

- A. Inspection of Concealed Work. Notify Owner a minimum of 5 days before covering work that will be concealed.
 1. Do not proceed with covering of work until Owner has completed inspection.
- B. Before starting or operating system, check continuity of all conductors and grounding conductors to verify that there are no faults and that all equipment has been properly installed. Check factory instructions to see that installations have been made accordingly. Check equipment for any damage that may have occurred during shipment, after delivery, or during installation; repair damaged equipment or replace with new equipment of like kind. Megger testing on the insulation of all conductors must also be performed prior to system operation.
- C. Before starting or operating the system, obtain a final inspection approval from the local Building Department and final inspection approval from the interconnecting utility. Coordinate and attend both of these inspections.
- D. Once building department and interconnecting utility final approvals have been received, the Contractor shall test all equipment to ensure specified capacity and performance of the system. The Contractor shall notify CRRA a minimum of 5 days prior to the test so that a representative may witness the test. The Contractor shall replace or revise any equipment, systems, or work found deficient during the test.
- E. Make final adjustments to all inverters and monitoring equipment for acceptable operating condition. Adjustable parameters shall be set so that the PV system will produce the maximum possible amount of energy on an annual basis.

3.6 OPERATION AND MAINTENANCE (O&M) SERVICE

- A. Provide ongoing O&M service for the installed solar system for a total of 5-years. Include the following services:
 1. PV Modules & Mounting System:
 - a. Visually inspect modules for damage and corrosion

- b. Inspect tightness of modules and fasteners in mounting system
 - c. Visually inspect mounting system (including ballast and synthetic turf area) for signs of damage and/or degradation
 - d. Note any shading issues or concerns
2. Inverters:
 - a. Perform IR/temperature checks on all breakers, fuses, connections, and associated controls
 - b. Tighten all connections as necessary
 - c. Check condition of A/C and D/C surge suppressors
 - d. Test operation of all safety devices
 - e. Physically exercise all switches and disconnects for proper operation and position
 - f. Clean interior of inverters removing dust and debris from heat sinks and air vents
 - g. Replace air filter elements (according to Manufacturer's Specifications)
 - h. Visually inspect fittings and cables for tightness and corrosion
 - i. Visually inspect all internally mounted equipment
 - j. Conduct other inverter maintenance per manufacturer requirements
3. Combiner Boxes:
 - a. Visually inspect fuses
 - b. Check the tightness of all wiring connections as well as the fuse holder and grounding buss
 - c. Check tightness of conduit fittings and combiner enclosure
4. Wiring:
 - a. Visually inspect all wiring for wear, corrosion, and strain
 - b. Check all connections, both A/C and D/C, for tightness
 - c. Verify all labeling for correctness
 - d. Measure and record positive and negative D/C connections with reference to neutral
 - e. Check polarity of each home run circuit
5. Monitoring System & Weather Station:
 - a. Visually inspect all sensors and meters for signs of damage and/or corrosion
 - b. Physically exercise all switches and disconnects for proper operation and position

- c. Check all outdoor enclosures for weather tightness
- 6. Full System:
 - a. A re-commissioning test should be completed once per year
- B. All Operations and Maintenance tasks listed above shall be conducted by a qualified and licensed electrical contractor or solar professional.
- C. After annual inspection, provide written report with results of tests and with photographs documenting areas of potential concern and areas requiring immediate action/repair.

END OF SECTION