

Cow Palace Dairy Facility Project Specifications

Facilities Covered:

Northwest Catch Basin

*EPA Region 10
Administrative Order on Consent
Docket No. SDWA-10-2013-0080*

Prepared for:

Cow Palace, LLC
1631 Liberty Road
Granger, WA 98932

Prepared by:



Moonlight Professional Building
480 East Park Street, Suite 200
Butte, MT 59701

May 2016

Table of Contents

DIVISION 1 – SITE PREPARATION

CS-01 – MOBILIZATION AND DEMOBILIZATION	1
CS-02 – POLLUTION CONTROL.....	2
CS-04 – CLEARING AND GRUBBING.....	5
CS-06 – STRIPPING.....	6
CS-07 – REMOVAL OF WATER.....	7

DIVISION 2 - EARTHWORK

CS-11 – EXCAVATION, COMMON.....	10
CS-13 – EXCAVATION AND BACKFILL OF TRENCHES FOR CONDUITS AND PIPELINES ..	12
CS-14 – EARTHFILL, CLASS A.....	14

DIVISION 3 - CONCRETE

CS-41 – REINFORCED CONCRETE.....	18
CS-42 – REINFORCED CONCRETE FOR MINOR STRUCTURES.....	25

DIVISION 4 - MISCELLANEOUS

CS-52 – CONDUITS AND PIPELINES.....	30
CS-64 – FENCING OF CONSTURCTION SITES	32
CS-67 – CONSTRUCTION FABRICS.....	33
CS-68 – HDPE AND LLDPE LINER.....	35
CS-70 – CONTRACTOR QUALITY CONTROL	41

DIVISION 5 – MATERIAL SPECIFICATIONS

MS-201 – CONCRETE AGGREGATES	45
MS-202 – PORTLAND CEMENT	46
MS-203 – CONCRETE	47
MS-209 – WOVEN AND NON-WOVEN FABRICS	50
MS-210 – AGGREGATE FILTERS	52
MS-211 – BEDDING	53
MS-213 – STEEL REINFORCEMENT	54
MS-222 – HDPE AND LLDPE FLEXIBLE MEMBRANE LINER	56

Table of Contents (cont.)

DIVISION 6 – SUPPLEMENTARY SPECIFICATIONS

SECTION 02100 – SUBGRADE PREPARATION	60
SECTION 02200 – BASE COURSE.....	63
SECTION 02300 – COURSE AGGREGATE	67
SECTION 03100 – NONWOVEN GEOTEXTILE	70
SECTION 03200 – GEOCOMPOSITES.....	75
SECTION 03300 – HDPE GEOMEMBRANES	82
SECTION 03500 – HDPE PIPE.....	94
SECTION 04100 – LEACHATE EXTRACTION PUMPS	98
SECTION 04200 – CONTROL SYSTEMS	104
SECTION 04300 – ELECTROMAGNETIC FLOW METER	109

DIVISION 1 – SITE PREPARATION

NRCS Construction Specifications

CS-01

MOBILIZATION & DEMOBILIZATION

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

1. The work shall consist of mobilizing equipment, supplies and securing bonds and permits necessary to do the work as stated in the contract and/or agreement and demobilization of excess materials and equipment from the work site.

B. FORCES AND EQUIPMENT

1. Mobilization may include costs for transporting personnel, equipment, operating supplies to the site, establishment of necessary facilities for the contractors operation and any permits, insurance and/or bonds required to do the work.
2. Demobilization may include the removal of equipment and facilities that were necessary to do the work.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

PART 4 MEASUREMENT AND PAYMENT

4.01 PAYMENT

- A. Payment for mobilization and demobilization shall be a lump-sum bid prices.
- B. Payment will be made under "Mobilization/Demobilization – Lumps Sum".

END OF SECTION

CS-02

POLLUTION CONTROL

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of performing work to control soil erosion, sedimentation, petroleum, dust and smoke from becoming air and/or water pollutants during construction.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 MATERIAL SPECIFICATIONS

- A. All permanent works shall meet the requirements of the applicable Washington Material Specifications. Temporary works which are to be removed may be of a lesser quality.

3.02 EROSION AND SEDIMENT CONTROL MEASURES AND WORKS

- A. In addition to the measures shown on the drawings, erosion and sedimentation shall be controlled at the work site by use of a single or a combination of the following measures:

1. **Staging of Earthwork Activities**

The excavation and moving of soil materials shall be scheduled so that the smallest possible areas will be unprotected during construction activities.

2. **Seeding**

Seedlings to protect all disturbed areas shall be done in a timely manner in accordance with the methods common to the geographic area.

3. **Mulching**

Mulching may be used to provide temporary protection to soil surfaces from erosion.

4. **Diversions**

Diversions can be used to divert water away from work areas and/or to collect runoff from work areas for treatment and safe disposition.

5. **Stream Crossings**

Culverts or bridges shall be used where equipment is not allowed to ford streams.

6. **Sediment Basins**
Sediment basins can be used to collect and store sediment from eroding areas to protect properties and streams down slope from the construction site.
7. **Sediment Filters**
Straw bale filters or geotextile sediment fences shall be installed to trap sediment on-site from areas subject to soil erosion. Sediment filters shall be anchored with 2x2 stakes and shall have a minimum burial depth of 6 inches to control erosion under or around them. The sediment filters shall be removed when permanent measures are installed.
8. **Burning**
Local and state regulations concerning the burning of brush or slash or disposal of other materials shall be adhered to. Fire prevention measures shall be taken to prevent the start or spreading of fires which result from construction activities.
9. **Dust Control**
All public access or haul roads used by the contractor during construction activities project shall be sprinkled or otherwise treated to fully suppress dust.
10. **Staging Equipment**
All construction equipment shall be staged in a location and manner to minimize air, soil and water pollution.
11. **Storage of Fuel and Lubricants**
All fuel and lubricants shall be stored in containers and areas that are in conformance with the Washington State Department of Ecology and local regulations.
12. **Servicing and Refueling Equipment**
All fuel and lubricants used in the servicing of construction equipment shall be done in a manner that avoids spills and over filling. The Washington State Department of Ecology shall be notified immediately of any spill and the operator shall contain the spillage.
13. **Sanitary Facilities**
Sanitary facilities such as chemical toilets shall be located to prevent contamination of surface or subsurface water.

3.03 MAINTENANCE, REMOVAL, AND RESTORATION

- A. All pollution control measures shall be adequately maintained in a functional condition as long as needed during the construction operation. All temporary measures shall be removed and the site restored to the original conditions as practicable.

3.04 PERMITS AND REGULATIONS

- A. All pollution control measures shall be consistent with all permits issues for the practice(s) being installed. The CONTRACTOR is responsible for obtaining and complying with all required permits prior project execution.

PART 4 MEASUREMENT AND PAYMENT

4.01 PAYMENT

- A. Pollution control measures, unless otherwise directed, are considered incidental to the work. No separate payment for pollution control measures will be made.

END OF SECTION

CS-04

CLEARING AND GRUBBING

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of the clearing and grubbing of designated areas by removal and disposal of trees, snags, logs, stumps, shrubs, vegetation and rubbish.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 REMOVAL

- A. All trees, snags, logs, brush, stumps, and shrubs not marked for preservation and rubbish shall be removed from within the limits of the construction areas. Unless otherwise specified, all stumps, roots and root clusters having a diameter of 1 inch or larger shall be grubbed out to a depth of at least 2 feet below subgrade elevation for concrete structures and 1 foot below the ground surface for earth fills.

3.02 SALVAGE

- A. Trees to be salvaged for saw logs shall be trimmed and cut to planned lengths and hauled to the loading area.
- B. Brush piles for wildlife shall be established as shown on the drawings.

3.03 DISPOSAL

- A. Where brush piles for wildlife are not specified on the drawings, cleared and grubbed materials shall be disposed of by burning or burying at selected locations approved by the owner and the technical representative in accordance with all local, state and federal regulations. Materials to be buried shall be placed at least 2 feet below the surrounding ground line and have a minimum of 2 feet of cover with the finished surface graded to drain.

PART 4 MEASUREMENT AND PAYMENT - NOT USED

END OF SECTION

CS-06 STRIPPING

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of removing vegetation, topsoil and other undesirable materials from borrow areas and foundations for structures and earth fills.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

3.01 GENERAL STRIPPING

- A. The stripping shall extend to a depth as shown on the drawings. Excavated earth material deemed satisfactory by the technical representative may be used for earth fill. All waste material shall be disposed of in areas shown on the drawings or as approved by the landowner and technical representative. Stripped material suitable for topsoil shall be stockpiled and spread over disturbed areas as shown on the drawings or as approved by the technical representative.

3.02 STRIPPING FOUNDATIONS

- A. All foundations for structures and/or earth fill shall be stripped of vegetation, roots and unconsolidated soil. The technical representative shall approve all stripped foundations prior to placement of earth fill and/or structures. The stripped surfaces shall be reasonably smooth and free of unconsolidated or loose soil. Unless otherwise shown on the drawings, the side slopes for foundations shall be 1:1, or flatter.

3.03 STRIPPING BORROW AREAS

- A. The areas from which borrow is to be taken shall be stripped of vegetation, roots and other unsuitable material to a sufficient depth to expose material suitable for the earth fill.

PART 4 MEASUREMENT AND PAYMENT – NOT USED

END OF SECTION

CS-07

REMOVAL OF WATER

PART 1 GENERAL

1.01 SCOPE

A. **DESCRIPTION**

The work shall consist of the removal of surface water and ground water as needed to perform the required construction. This also includes the dewatering of borrow sites. It shall include furnishing, construction and operation of all temporary facilities and equipment. This construction specification also includes removal of temporary facilities.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 DIVERTING SURFACE WATER

- A. Protective measures needed to divert stream flow and other surface water shall be built, maintained and operated during construction.

3.02 DEWATERING CONSTRUCTION AND BORROW SITES

- A. The construction site shall be dewatered and kept free of standing water or excessively muddy conditions as needed for proper execution of the construction work. Dewatering shall include furnishing, installing, operating and maintaining all equipment including such as pumps as needed.

3.03 REMOVAL OF TEMPORARY WORKS

- A. After the temporary works have served their purposes, they shall be removed or graded to present a sightly appearance without interfering with permanent drainage systems or stream flows.

3.04 EROSION AND POLLUTION CONTROL

- A. All temporary works shall be accomplished in such a manner that erosion and the transmission of sediment and other pollutants are minimized in accordance with CS-02 "Pollution Control".

PART 4 MEASUREMENT AND PAYMENT

4.01 PAYMENT FOR TESTING

- A. Payment for removal of water will be a lump-sum bid price under “Removal of Water – Lump Sum”.

END OF SECTION

DIVISION 2 – EARTHWORK

NRCS Construction Specifications

CS-11

EXCAVATION, COMMON

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of all common excavations to the lines and grade as shown on the drawings.

1.02 CLASSIFICATION

- A.** Common excavation applies to all materials that can be removed and transported by heavy duty construction equipment including boulders and loose rock less than 1 cu. yd. in volume.

1.03 SAFETY LAWS

- A.** The owner and/or contractor are responsible for compliance to all Washington State and local safety laws, ordinances and regulations applicable for excavation.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 USE OF EXCAVATED MATERIALS

- A.** Excavated materials that conform to the material requirements for earth fill, as stated in the drawings and approved by the technical representative may be used to the extent as needed.

3.02 DISPOSAL OF WASTE MATERIAL

- A.** All surplus or waste material shall be disposed of in areas shown on the drawings or as approved by the landowner and the technical representative in accordance with all local, state and federal regulations. The disposal site shall be left in a neat, sightly condition, free of depressions and sloped to drain.

3.03 BRACING AND SHORING

- A.** Unstable excavated surfaces and/or other excavations as defined by state and federal regulations shall be supported to prevent soil movement.

3.04 STRUCTURE AND TRENCH EXCAVATION

- A. Structure or trench excavation shall be approved by the technical representative before the placement of any structure or earth fill.

3.05 EXCAVATION OF BORROW MATERIAL

- A. All borrow sites shall be left in a final condition with stable side slopes, removal of hazards, sloped to drain, free of depressions and other unsightly conditions. If specified in the plan, borrow areas and haul roads shall be fertilized and seeded.

PART 4 MEASUREMENT AND PAYMENT

4.01 GENERAL

- A. Payment for common excavation will be made under “Excavation – per Bank Cubic Yard”.
- B. Measurement of common excavation will be made from topographic survey.

END OF SECTION

CS-13

EXCAVATION AND BACKFILL OF TRENCHES FOR CONDUITS AND PIPELINES

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

This specification applies when trench excavation is necessary for installation of a conduit and/or pipeline for spillways, irrigation systems, drainage systems, animal waste systems and other installations where liquid is conveyed and discharged in an underground conduit or pipeline.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 EXCAVATION

- A. The bottom width, side slopes, and gradeline of the trench excavation shall be to the dimensions and lines shown on the drawings.
- B. Excavated trenches shall be within state and local laws and regulations for trenching. Trenches shall be supported as necessary to safeguard the work and workers. Trench supports shall prevent sliding or settling of the adjacent ground and avoid damage to improvements. The width of the excavation shall be increased, if necessary, to provide space for sheeting, bracing, shoring, and other supporting installations.

3.02 BACKFILL

- A. The initial backfill shall be select material, placed and compacted around and above the conduit to the specified depth and density, taking care not to displace or damage the conduit or its protective coating.
- B. The final backfill shall be the material from the trench excavation and shall be compacted to the density of the surrounding material.
- C. Backfill material shall contain no frozen soil, sod, brush, roots, or other perishable material.
- D. Rock fragments greater than 3 inches shall not be placed within 2 feet of the pipe.

- E. The minimum depth of cover on all pipelines shall be as shown on the drawings.

3.03 FINAL GRADING

- A. All disturbed areas shall be graded without surface depressions to blend with the surrounding area.

PART 4 MEASUREMENT AND PAYMENT

4.01 PAYMENT

- A. No separate measurement and payment is made for Trench Excavation and Backfill. Include all costs for this item in the unit price bid for pipe complete in-place.

END OF SECTION

CS-14

EARTH FILL, CLASS A

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of the construction of compacted earth fills where the amount of compaction is to be checked and controlled by standard compaction tests and continuous inspection.

PART 2 PRODUCTS –NOT USED

PART 3 EXECUTION

3.01 MATERIALS

- A. All fill material shall be obtained from the approved excavation or borrow areas. The selection, blending, routing and disposition of materials within the embankment shall be subject to the approval of the technician. Fill materials shall contain no frozen material and shall be free of all organic and foreign material. The maximum size of rock fragments incorporated in the compacted earth fill shall be **three-eighths (3/8) inches**, provided that such rock fragments are completely imbedded in the matrix of the compacted earth fill.

3.02 FOUNDATION PREPARATION

- A. After stripping, the foundation shall be scarified or plowed to a minimum depth of 2 inches. The foundation area shall be bonded with the first layer of fill and compacted to the density and moisture specified for the fill. No foundation and abutment surface shall be steeper than 1:1 unless otherwise specified on the drawings.

3.03 PLACEMENT

- A. All foundation excavation and/or preparation shall be completed before placing fill. The fill shall be placed such that the distribution of materials is essentially uniform throughout the entire fill and is free from lenses, pockets, streaks, frozen material or layers of material differing substantially from surrounding material. No fill shall be placed on a frozen surface.
- B. Equipment weighing 400 pounds or more per foot of width shall not be operated within 2 feet of any structure.

- C. Fill shall be placed in approximately equal horizontal layers. Fill layer thickness before compaction shall not exceed nine (9) inches for machine compaction. The foundation area shall be bonded with the first layer of fill. Fill layer thickness adjacent to structure walls shall not exceed four (4) inches before compaction by hand directed power tampers.

3.04 MOISTURE CONTENT

- A. Moisture content for the fill matrix at the time of compaction shall be specified within the range of $\pm 2\%$ of the optimum moisture as determined using ASTM D-698. Adequate moisture to control dust shall be maintained at all work areas.
- B. The fill material shall be brought to the specified moisture range before compaction. Material that is too wet for compaction shall be allowed to dry before compaction or be removed from the fill.
- C. If the top surface of a preceding layer or foundation is too dry, the surface shall be scarified and moistened prior to placement of the next layer of fill material.

3.05 COMPACTION

- A. The compacted fill shall have a density of not less than 95% of the standard proctor density as determined by ASTM D-698.
- B. Compaction of backfill adjacent to structures is governed by Construction Specification CS-17, Structural Backfill.

3.06 STRUCTURES OR CONDUITS

- A. The passage of heavy equipment shall not be allowed over cast-in-place conduits until 14 days after placement of the concrete. The passage of heavy equipment over conduits shall not be allowed until the height of the compacted backfill above the top surface of the conduit equals one-half of the clear span width of the conduit, or two (2) feet, whichever is greater.

3.07 TESTING

- A. The in-place density of the compacted fill shall be determined during the course of the work by the contractor using test procedures ASTM D-1556, "Density of Soil in Place by the Sand-Cone Method," ASTM D-2167, "Density of Soil in Place by the Rubber Balloon Method," or ASTM D-2922, "Density of Soil in Place by Nuclear Methods," using the direct Transmission Method.
- B. Field tests to determine the moisture content of compacted earth fill shall be conducted during the course of the work by the contractor following methods described in ASTM D-2216 "Overnight Oven Drying", ASTM D-3017 "Nuclear Method", ASTM D-4643 "Microwave Oven Heating". or ASTM D-4944 "Calcium Carbide Gas Pressure Tester".

Moisture readings from ASTM D-3017, ASTM D-4643, or ASTM D-4944 from at least one liner material sample shall be verified by the oven-dry method described in ASTM D-2216.

- C. Test procedures and records shall be maintained for the installation.

PART 4 MEASUREMENT AND PAYMENT

4.01 PAYMENT

- A. Payment for Class A fills will be considered incidental to the work. No separate payment will be made for Class A fills.

END OF SECTION

DIVISION 3 – CONCRETE

NRCS Construction Specifications

CS-41

REINFORCED CONCRETE

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of furnishing, forming, placing, finishing, and curing Portland cement concrete. The structures shall be constructed at the location and to the line and grades as shown in the plan.

1.02 MATERIALS

- A. The materials required for reinforced concrete are detailed in material specification MS-201, Concrete Aggregates; MS-202, Portland Cement; MS-203, Concrete; and MS-213, Steel Reinforcement.

1.03 HANDLING AND STORAGE

- A. Materials shall be stored and handled in a manner that will minimize degradation, segregation, contamination or intermixing of materials.

1.04 MIXERS AND MIXING

- A. Mixers shall be capable of thoroughly mixing the concrete ingredients into a uniform mass within the specified mixing time and discharge without segregation. Each mixer or agitator shall bear a manufacturer's rating plate indicating the rated capacity and recommended speeds of rotation, and shall be operated in accordance with the manufacturer's recommendations.
- B. Concrete shall be uniform and thoroughly mixed when placed.
- C. Water in excess of the amount specified in the mix design shall not be permitted. This includes any water added at the site.

1.05 TRUCK-MIXED CONCRETE

- A. When concrete is mixed in a truck mixer loaded to its maximum capacity, the number of revolutions of the drum or blades at mixing speed shall not be less than 70, or more than 100 RPM.

- B. The resultant concrete mix must produce a dense and durable concrete during curing. The ready-mix concrete shall be mixed and delivered in accordance to ASTM C-94, “Standard Specification for Ready-Mix Concrete”.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 SITE PREPARATION

- A. Prior to placement of concrete, the forms, reinforcing steel, and subgrade shall be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, rust or other harmful substances and/or coatings. Rock surfaces shall be cleaned by wire brushing, wet sand-blasting, air water jets or other means satisfactory to the technical representative. Earth surfaces shall be firm and damp before placing concrete. Placement of concrete on mud, dried earth, un-compacted fill or frozen subgrade will not be permitted.

3.02 FORMS

- A. Forms shall be wood, plywood, steel or other approved materials and shall be mortar tight. The forms and associated false work shall be substantial and unyielding conforming to dimensions of the finished grade. Form surfaces shall be smooth and free from holes, dents, sags, or other irregularities. Forms shall be coated with a non-staining form release agent before being set into place.
- B. All permanently exposed concrete edges shall be chamfered 3/4” unless otherwise indicated on the drawings.
- C. Items to be embedded in concrete shall be positioned accurately and anchored firmly.
- D. Metal ties or anchorages within the forms shall be equipped with cones, she-bolts or other devices that permit their removal without injury to the concrete. Ties designed to break off below the surface of the concrete shall have removable cones.
- E. Steel tying and form construction adjacent to fresh concrete shall not be started until the concrete has cured at least 12 hours.

3.03 STEEL REINFORCEMENT

- A. The steel reinforcement shall be grade 40 deformed steel bars unless otherwise specified on the drawings. The steel shall be securely tied and positioned to prevent movement during the placement of concrete. The reinforcing steel in slabs on grade shall be supported on blocks or chairs. All blocks shall have a compressive strength equal to or greater than the 28-day compressive strength of the concrete.

- B. The length of splices shall be 30 diameters of the steel bar unless otherwise specified on the drawings. Welded splices are not permitted.
- C. The bends shall be standard bends with the length and radius as specified by the Concrete Reinforcing Steel Institute, CRSI, and/or the Portland Cement Association, PCA.

3.04 CONVEYING

- A. The maximum length of time between introduction of the cement to the aggregates and placement of the concrete in the forms shall not exceed 1-1/2 hours for concrete temperatures below 85°F or 45 minutes for concrete temperatures above 85°F.
- B. Concrete shall not be dropped more than 5 feet vertically unless suitable equipment is used to prevent segregation.

3.05 PLACING

- A. Concrete shall not be placed until the subgrade, forms, and steel reinforcement have been inspected and approved by the technical representative.
- B. The person responsible for construction shall have all equipment and materials required for proper consolidation and curing, available at the site ready for use before placement of concrete begins.
- C. The technical representative shall be notified a minimum of 24 hours prior to placement to inspect the reinforcing steel, forms, subgrade, curing preparation, vibrating equipment and plans for placement.
- D. The depositing of concrete shall be regulated so that concrete may be consolidated with a minimum of lateral movement, segregation, laitance, or honey-combing. Hoppers and chutes shall be used as necessary to prevent segregation and the splashing to mortar on the forms and reinforcing steel above the placing level. Temporary stays and braces can be removed when no longer needed.

3.06 LAYERS

- A. Slab concrete shall be placed to design thickness in one continuous layer. Formed concrete in walls and columns shall be placed in horizontal layers not to exceed 20 inches.
- B. Successive layers shall be placed at a fast enough rate to prevent the formation of “cold joints”. If a successive layer cannot be placed in a timely manner, a standard type construction joint shall be used between layers.

3.07 CONSOLIDATION

- A. Each concrete layer shall be completely consolidated by spading, hand tamping, or mechanical vibrators as necessary to ensure smooth, dense concrete along form surfaces, in corners and around embedded items without segregation or laitance. Vibration shall extend into the previously placed layers of fresh concrete and laterally to ensure effective bond between layers.
- B. The use of vibrators to transport concrete in the forms shall not be permitted.
- C. Vibration shall not be applied directly to the reinforcement steel, forms, or to concrete that has begun to set.

3.08 CONSTRUCTION JOINTS

- A. Construction joints shall be made at locations with the dimensions shown on the drawings.
- B. Surfaces of construction joints shall be cleansed of all unsatisfactory concrete, laitance, coatings, stains, or debris by washing and scrubbing with a wire brush or wire broom and kept moist for at least one hour prior to placement of new concrete.
- C. In addition, the top surfaces of walls and columns shall be immediately and carefully protected from any condition that might adversely affect curing of concrete.
- D. Where lap joints are used on horizontal slabs, the width on each side of the joint shall not be less than 6 inches and the depth shall be equal to one-half the slab thickness.

3.09 EXPANSION AND CONTRACTION JOINTS

- A. Expansion and contraction joints shall be made only at locations shown on the drawings. Exposed edges on these joints shall be carefully tooled, chamfered and free of mortar and concrete spillage.
- B. Preformed expansion joint filler shall be held firmly in the correct position as the concrete is placed and shall be left exposed for its full length with clean and true edges.

3.10 REMOVAL OF FORMS

- A. Forms shall not be removed before the expiration of the following minimum time intervals after placement of the concrete, exclusive of days when the minimum temperature of air adjacent to the concrete is below 40 degrees Fahrenheit.

ELEMENT	TIME
Beams, Arches – supporting forms and shoring	14 days
Conduits, deck slabs – supporting (inside forms) and shoring	7 days
Conduits, (outside forms), side of beams, small structures	24 hours
Columns, walls, spillway riser – with side or vertical load	7 days
Concrete supporting not more than 20 feet of wall in place above it	24 hours

- B. Age of stripped concrete shall be at least 7 days before any load is applied other than the weight of forms, scaffolds and succeeding lifts.

3.11 FINISHING FORMED SURFACES

The following shall be done immediately after removal of forms.

- A. Removal of all fins and other surface irregularities which affect appearance or function.
- B. Removal all form bolts and ties to the depth of their cone.
- C. All cavities, holes and honey-combing shall be thoroughly cleaned, wetted and filled with dry pack mortar.
 - 1. The area to be patched shall be kept damp for three hours immediately prior to patching.
 - 2. The patching mortar shall be one part cement to three parts sand passing the number 16 sieve.
- D. The patching mortar shall be compacted to form a dense, well-bonded unit that is free from shrinkage cracks.
- E. All patched areas shall be cured as specified in paragraph 41.19.

3.12 FINISHING UNFORMED SURFACES

- A. All exposed surfaces of the concrete shall be accurately screened to grade and then wood float finished, except slip form lining which is finished by travel of the form.
- B. All exposed concrete edges and joints shall be chamfered or finished with molding tools.
- C. Excessive floating or toweling while the concrete is soft shall not be permitted. The addition of dry cement or water to the surface of the screened concrete shall not be permitted.

3.13 CURING

- A. Concrete shall be prevented from drying for a period of at least 7 days after placement.
- B. Exposed surfaces shall be kept continuously moist for the entire period or until curing compound is applied. Formed surfaces shall be kept wet until patching or repairs are made. Curing compound shall not be used on areas that are to be bonded to other concrete or mortar. Curing compound when used shall be sprayed on the moist concrete structure as soon as free water has disappeared, but shall not be applied to any surface until patching, repairs, and finishing of that surface are completed.
- C. Curing compound shall meet the minimum requirements of ASTM C-309, Type 2, unless otherwise specified on the drawing.
- D. The curing compound shall be thoroughly mixed immediately before applying, and shall be applied at a uniform rate of not less than one gallon per 150 square feet of surface. It shall form a uniform, continuous, adherent film over the entire surface.
- E. Curing compound shall not be applied to surfaces requiring bond with concrete remaining to be placed, construction joints, reinforcing steel, and embedded items. These areas shall be wet cured.
- F. Concrete surfaces subjected to heavy rainfall, running water and/or other moisture damage within 3 hours after curing compound has been applied shall receive a second application.

3.14 REMOVAL OR REPAIR

- A. Concrete that is honeycombed, damaged, or otherwise defective, shall be removed or repaired and approved by the technical representative.

3.15 CONCRETING IN HOT WEATHER

- A. The temperature of the concrete shall be less than 90°F during mixing, conveying and placing. Concrete surfaces exposed to the air shall be kept continuously wet for the first 24 hours of the curing period or until curing compound is applied. White pigmented coloring compound shall be used when the air temperature exceeds 90°F.

3.16 CONCRETING IN COLD WEATHER

- A. Prior to placement of concrete, all ice, snow and frost shall be completely removed from all surfaces to be in contact with the concrete.

- B. The temperature of the concrete at the time of placement shall not to be less than 50°F, nor more than 90°F. Heated water of 140°F or less may be used when cement is added to the mix.
- C. The use of antifreeze or accelerator compounds is not allowed.
- D. When the daily minimum ambient air temperature at the site is less than 40°F, the concrete shall be protected for a minimum of three days following placement with insulated blankets or housing and heating.

3.17 DELIVERY TICKETS

- A. The delivery tickets for the mix delivered to the site shall identify all ingredients by weight except water and admixtures which may be measured by volume.
- B. Delivery Tickets for each load of Ready-Mix concrete shall be furnished to the technical representative.

PART 4 MEASUREMMENT AND PAYMENT

4.01 PAYMENTS

- A. Payment for concrete will be considered incidental to the work. No separate payment will be made for concrete.
- B. Payment for work requiring concrete will be made under CONCRETE SLAB – PER SQ. FT. and will include all labor, forms, and other materials required to complete the work.

END OF SECTION

CS-42

REINFORCED CONCRETE FOR MINOR STRUCTURES

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of proportioning, forming, placing, finishing, and curing Portland cement concrete for minor structures. A minor structure is defined as one of low hazard where strength control is not critical for function and safety.

B. The structures shall be constructed to the line and grades as shown in the plan.

1.02 MATERIALS

A. Cement shall be Type II or Type IIA Portland cement. Cement that is partially hydrated or otherwise damaged shall not be used.

B. Concrete aggregate is defined in Material Specification, MS-201. Fine aggregate shall be between 35 and 45 percent and coarse aggregate shall be between 55 and 65 percent of the total aggregate volume by weight. The aggregate shall not contain more than 1 percent clay lumps and a total of 4 percent of material smaller than the 200 sieve.

C. Maximum size of the coarse aggregate shall not exceed:

1. 1 inch - Concrete thickness of 4 inches or less
2. 1-1/2 inch - Concrete thickness of 4 inches or more

D. Reinforcing steel shall be woven wire fabric or deformed steel bars as described in Material Specification MS 213, Steel Reinforcement.

E. Water shall be of a potable quality free from harmful chemicals.

1.03 DESIGN OF CONCRETE MIX

A. The person in charge of construction shall be responsible for designing a high quality concrete mix conforming to this specification. The technical representative prior to placement shall approve the concrete mix.

B. The mix shall contain no more than 6 gallons of water per 94 pound bag of cement, and at least 6 bags of cement per cubic yard of concrete.

- C. The air entrainment shall be between 4 and 7 percent by volume, and the slump shall be between 3 and 5 inches.
- D. The following table is a guide for developing a satisfactory mix intended to produce approximately 3000 PSI compressive strength for air entrained concrete:

Max. Size Aggregate Inches	Gal. Water per sack of cement	Cement per CY Sacks	Pounds Fine Aggregate per Sack Cement	Pounds Coarse Aggregate per Sack Cement
1	6.0	6.0	190-200	300-310
1-1/2	6.0	6.0	180-190	330-340

- E. Measurement of materials shall be by weight where suitable scales are available. Volume measurements may be used provided volume-weight relationships are carefully determined. Admixtures including calcium chloride or antifreeze compounds shall not be used.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 SITE PREPARATION

- A. Prior to placement of concrete, the forms, reinforcing steel, and subgrade shall be free of chips, sawdust, debris, water, ice, snow, extraneous oil, mortar, rust or other harmful substances and/or coatings. Rock surfaces shall be cleaned by wire brushing, wet sand-blasting, air water jets or other means satisfactory to the technical representative. Earth surfaces shall be firm and damp before placing concrete. Placement of concrete on mud, dried earth, un-compacted fill or frozen subgrade will not be permitted.

3.02 FORMS

- A. Forms shall be made of wood, plywood, or metal. The form surfaces are to be clean and free from holes and other irregularities. The type, size, shape, quality and strength of forms will be subject to approval by the technical representative. The forms shall be moist when the concrete is placed. Forms shall be mortar tight and non-yielding. All form work shall be in place for at least 24 hours after concrete placement.
- B. Metal ties that break off below the surface of the concrete shall have removable cones that permit their removal without damage to the concrete.

3.03 REINFORCING STEEL

- A. The reinforcement shall be the size and grade shown on the drawings and securely fastened in place to prevent movement during placement of the concrete. The reinforcing steel in slabs on grade shall be supported on blocks or chairs. All blocks shall have a compressive strength equal to or greater than the 28-day compressive strength of the concrete.

3.04 PLACING CONCRETE

- A. The technical representative shall be notified a minimum of 24 hours prior to the placement of concrete to inspect the reinforcing steel, forms, subgrade, preparation for curing, and vibrating equipment.
- B. Concrete shall be placed in final position within one and one-half hours after mixing with cement. Concrete may be consolidated by either hand spading and tamping or mechanical vibration.
- C. All concrete placed on earth shall be placed on clean, damp surface, free of frost, ice, or running water.
- D. Concrete shall not be dropped more than 5 feet vertically unless suitable equipment is used to prevent segregation.
- E. Uniformed exposed surfaces in the completed work shall have a wood float or broomed finish. Concrete edges shall be chamfered 3/4 inch or finished with molding tools.

3.05 CURING CONCRETE

- A. The air temperature shall be between 40 and 90°F. During the curing period, the concrete shall be kept moist or covered for at least 7 days after placement.
- B. An approved curing compound may be used provided it is applied by pressure sprayer at a uniform rate of not less than 150 sq. ft. per gallon.

3.06 DEFECTIVE CONCRETE

- A. Honeycombed areas and other voids in concrete will be promptly repaired with mortar patching immediately upon discovery.
- B. Concrete subjected to damage and/or other violations of this specification will be rejected.

3.07 DELIVERY TICKETS

- A. The delivery tickets for the mix delivered to the site shall identify all ingredients by weight except water and admixtures which may be measured by volume.
- B. Delivery Tickets for each load of Ready-Mix concrete shall be furnished to the technical representative.

3.08 ACCEPTANCE

- A. The acceptance of concrete made under this specification will depend upon adherence to the procedures set forth herein and the appearance of the finished structure.

PART 4 MEASUREMENT AND PAYMENT

4.01 PAYMENTS

- A. Payment for concrete will be considered incidental to the work. No separate payment will be made for concrete.
- B. Payment for work requiring concrete will be made under CONCRETE SLAB – PER SQ. FT. and will include all labor, forms, and other materials required to complete the work.

END OF SECTION

DIVISION 4 – MISCELLANEOUS

NRCS Construction Specifications

CS-52

CONDUITS AND PIPELINES

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of furnishing and placing circular, arched or elliptical pipe and necessary appurtenances.

1.02 MATERIALS

- A. Pipe and fittings shall conform to the requirements of the applicable NRCS Material Specifications for the type and grade of material being used. Where connecting bands are used, they shall withstand the internal pressure of the installation without leakage.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 MATERIAL HANDLING

- A. The material shall be delivered and handled in a manner that will not damage or reduce its strength or damage the coating. All special handling requirements of the manufacturer shall be adhered to. When handling and placing coated or plastic pipe, care shall be taken to prevent damage resulting from metal surfaces or rocks.

3.02 LAYING AND BEDDING

- A. Unless otherwise specified, the pipe shall be installed in accordance with the manufacturer's recommendations. The pipe shall be laid with bells or the outside laps of circumferential joints pointing upstream.
- B. Perforated pipe shall be laid with the perforations down and oriented symmetrically about a vertical center line. Perforations shall be clear of any obstructions at the time the pipe is laid.
- C. Elliptical pipe and pipe with elliptical or quadrant reinforcement shall be laid so that the vertical axis, as indicated by markings on the pipe, is in the vertical position.
- D. During backfilling the pipe shall be sufficiently loaded around the sides to prevent is separation from the bedding. The pipe shall be laid so the pipeline barrel is uniformly supported, which may require special excavation for bells and/or couplings.

3.03 STRUTTING

- A. When required, struts or horizontal support ties shall be installed as specified on the drawings. Struts and ties shall remain in place until the backfill has been placed to a height of 5 feet above the top of the pipe, or has been completed if the finished height is less.

3.04 JOINTS

- A. Pipe joints shall conform to the details prescribed by the manufacturer and shown on the drawings. Pipe joints shall be sound and watertight at the pressure specified on the drawings. The joints shall be made in a manner so that the inside of the pipe is free from obstructions.

3.05 COATINGS

- A. All coatings shall be inspected after final placement and just prior to backfill. Any pinholes and/or damage shall be repaired with a material that is recommended by the manufacturer.

PART 4 MEASUREMMENT AND PAYMENT

4.01 PAYMENTS

- A. Payment for conduits and pipelines will be made under PIPING – PER LINEAR FOOT.

END OF SECTION

CS-64

FENCING OF CONSTRUCTION SITES

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of furnishing and installation of the fencing at the locations as shown on the drawings.

1.02 MATERIALS

- A. The wire, posts, fasteners and all other appurtenances shall be new materials of a quality that is commonly used for farm fences and is approved by the owner.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 INSTALLATION

- A. The fence shall be installed as detailed on the drawings or as specified by the manufacturer.

PART 4 MEASUREMMENT AND PAYMENT

4.01 PAYMENTS

- A. Payment for fences will be made under FENCING – PER LINEAR FOOT.

END OF SECTION

CS-67

CONSTRUCTION FABRICS

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

This construction specification is applicable for furnishing and installation of woven and non-woven construction fabrics to the lines and grades as shown in the drawings.

1.02 MATERIALS

- A. The materials will conform to the type specified on the drawings and shall meet or exceed material specification MS-209 for the type of fabric to be installed. Additional requirements beyond MS-209 may be required if documented in these Specifications. The bedding and covering shall be of the material quality and depth as shown on the drawing.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 SITE PREPARATION

- A. The final grading of the earthwork shall be completed before installation. The site shall be free from depressions, ridges and rocks greater than 1 inch. The area shall be free from all sharp objects and foreign material such as wood, wire and metal. Bedding shall be in place prior to the installation of fabric material.

3.02 INSTALLATION

- A. If bedding is shown on the drawing, it shall be installed prior to placement of the fabric. In channels, the fabric shall be installed in the direction of flow. On slopes, the fabric may be installed across the slope or perpendicular to the slope. The ends and edges shall be overlapped or shingled a minimum of 4 inches in the direction of flow and anchored. The fabric shall be covered, seeded and/or fertilized as shown on the drawings.

3.03 ANCHORING

- A. Unless otherwise shown on the drawings, the upper and lower ends of fabric on slopes that exceed 5:1 shall be anchored by burial in a twelve-inch deep trench and covered and/or stapled. If the fabric is not covered, it shall be secured by stapling in a diamond pattern with a minimum of two staples per square yard which includes all edges and ends

stapled at a maximum spacing of four foot on center.

PART 4 MEASUREMMENT AND PAYMENT – NOT USED

END OF SECTION

CS-68

HDPE AND LLDPE LINER

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work shall consist of furnishing and installing an HDPE or LLDPE liner and the necessary mechanical attachments as shown in the drawings or as specified herein.

1.02 MATERIALS

- A. The liner, welding rod, gaskets, metal battens, clamps, embed channel, and sealant shall conform to the requirements of Material Specification 222, the applicable provisions in this specification, and those shown on the drawings.
- B. Subgrade soils and their surface conditions shall conform to the requirements in this specification and as shown in the drawings.
- C. Cover soils, if applicable, shall conform to this specification and as shown on the drawings.

1.03 SHIPPING AND STORAGE

- A. Liner rolls shall be shipped to the job site in a manner not to damage the rolls. The rolls shall be stored and protected from puncture, dirt, grease, excessive heat, or other damage. They shall be stored on a prepared smooth surface (not wooden pallets) and shall be stacked no more than two rolls high.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 SUB-GRADE PREPARATION

- A. Sub-grade soil shall be compacted to provide a firm, unyielding foundation for the liner. All surfaces shall be smooth, free of foreign and organic material, rocks larger than 3/8 inch, any angular rocks, and any sharp objects. Standing water or excessive moisture shall not be allowed.

3.02 ANCHOR TRENCH

- A. The anchor trench shall provide permanent anchoring for the liner and shall be in accordance with the drawings. The trench shall be excavated according to a daily schedule for liner installation. It shall be backfilled incrementally as needed. Backfill soil shall be compacted by rolling with rubber-tired equipment or a manually directed power tamper to provide a stable anchor trench for the liner.

3.03 LINER PLACEMENT

- A. Liner rolls shall be deployed using a spreader bar assembly attached to a front-end loader bucket or by other methods approved by the liner manufacturer. The liner shall be placed in the general direction of maximum slope. All of the placed liner shall be adequately ballasted by sandbags to protect it from wind uplift forces. The liner shall be placed on a daily basis and seamed and secured by the end of the workday. No construction equipment shall be allowed directly on the liner except for light ATVs and generators to power the seaming machines.
- B. The liner shall not be placed during fog, precipitation, in the presence of excessive winds, or in temperatures less than 50 degrees Fahrenheit. The liner shall be loosely laid over the foundation with sufficient slack (about 2 percent) to accommodate thermal expansion and contraction encountered during construction. Each panel shall be laid out and positioned to minimize the number and length of the geomembrane field joints and to be consistent with accepted installation practice. The methods used to place panels shall minimize wrinkles especially along field seams. When necessary, a geosynthetic rub sheet will be used under the membrane to prevent damage when dragging or moving the panels.

3.04 SEAMING

- A. The primary method of seaming shall be hot shoe fusion welding. Fillet extrusion welding shall be used for repairs, T-seams, and detail work. Before fusion welding or extrusion welding, all areas that are to become seam interfaces shall be cleaned of dust and dirt. Seam joining shall not take place unless the sheet is dry and shall not be attempted when the ambient sheet temperature is below 45 degrees Fahrenheit or above 90 degrees Fahrenheit.
 - 1. **Hot Shoe Welding**

Hot shoe welding shall be accomplished by a double-wedge fusion welder that produces a double track weld. All accessories shall be approved by the liner manufacturer. To produce acceptable seams for the site-specific condition, the welder shall be calibrated at the beginning of each seaming period. Seaming procedures shall be in accordance with liner manufacturer specifications.

2. **Fillet Extrusion Welding**

Extrusion welding equipment and accessories shall be approved by liner manufacturer. To produce acceptable seams for the site-specific condition, the extrusion welder shall be calibrated once per day at the beginning of each seaming period. Seaming procedures shall be in accordance with liner manufacturer specifications.

3. **Seam Overlap**

Liner panels shall have a minimum overlap of 4 inches for hot shoe welding and 3 inches for extrusion welding. Upslope panels shall overlap downslope to provide a shingle effect for drainage.

4. **Seaming Equipment and Accessories:**

- a. Hot shoe welder, 110 or 220 volts
- b. Extrusion welder, 220 volts
- c. Grinder, 10,000 rpm, 4.5-inch side grinder with 80-grit discs
- d. Generator, 6.5 kW, 110/220 volt output
- e. Power cord, OSHA approved cords and twist-type plugs and connections
- f. Vacuum box test equipment, approved by the liner manufacturer
- g. Air pressure test equipment, approved by the liner manufacturer
- h. Tensiometer, capable of performing quantitative shear and peel tests

3.05 SEAM TESTING

Seams shall be tested under field conditions at the beginning of each seaming period and once in the morning and once in the afternoon. Three specimens shall be tested by a tensiometer in shear and peel modes. Test seams shall meet the requirements of Material Specification 594. Each specimen shall be 1 inch wide with the grip separation rate of 2 inches per minute. All peel tests shall result in film tear bond (FTB) value. The FTB is defined as a failure of one of the bonded sheets before complete separation in the bonded area.

A. **Nondestructive Seam Testing**

1. Air pressure tests shall be performed on all double-wedge fusion seams. The air pressure test equipment and procedures shall conform to this specification and the liner manufacturer's specifications. Seal both ends of the seam to be tested. Insert the pressure needle into the seam's air channel. Pressurize the air channel through the needle to 25 to 30 pounds per square inch.
2. Monitor any pressure drops for 5 minutes. A loss of pressure in excess of 4 pounds per square inch or a continuous loss of pressure is an indication of a leak. Terminate the test by relieving the pressure from the opposing end of the seam. The pressure shall immediately drop to zero upon opening the opposing end of

the seam. If this does not occur, the seam channel shall be checked for obstructions and retested. All defects shall be marked for repair.

3. Vacuum box tests shall be performed on all extrusion welds. The vacuum box equipment and test procedure shall conform to this specification and the liner manufacturer's specifications. Apply soapy water solution to the seam area to be tested. The vacuum box, equipped with a transparent viewing window, shall be centered over the seam area and a vacuum of 3 pounds per square inch shall be drawn. The seam area shall be visually monitored for any soap bubbles for 15 seconds. Seam testing shall continue by overlapping a minimum of 3 inches between each test interval. All defects shall be marked for repair.

B. Destructive Seam Testing

1. If required, seam samples shall be cut at no more than one sample per 500 feet of weld for destructive seam testing. All destructive seam samples shall be tested by a tensiometer in shear and peel modes to verify seams meet the requirements of Material Specification 222.

3.06 REPAIRS

All defective liner areas and bad seams shall be repaired and tested before the installation is completed.

A. Tears, Punctures, and Material Defects

All tears, punctures, and material defects in liner shall be repaired by installing a patch over the defective area. Surfaces of the liner to be patched shall be cleaned before the repair. To ensure proper bonding of the extrusion weld, edges of the patch material and the adjacent liner shall be properly abraded by a light grinding. This operation shall be done no more than 15 minutes before the welding operation. The abrasion shall remove no more than 10 percent of the material thickness. All patches shall be of the same liner material and extend a minimum of 6 inches beyond the edges of the defect area. All patches shall have rounded corners and shall be extrusion welded to the liner. Alternatively, a bead of extrudate shall be placed over all holes that are less than 0.25 inch in diameter.

B. Seam Repair

All failed seams shall be repaired by installing a cap strip over the entire length of failed seam. The cap strip shall be of the same liner material and shall extend the failed seam a minimum of 6 inches in all directions. Alternatively, the seam along the upper flap can be extrusion welded to the liner along the entire length of the failed seam.

3.07 MECHANICAL ATTACHMENTS

The liner shall be mechanically attached to pipe, concrete, or steel structure as shown in the drawings and according to the liner manufacturer's specification.

A. Pipe Boots

Pipe boots shall be fabricated in the field from the same liner as that shown in the drawings. The boots shall be welded and clamped to polyethylene pipe. They shall be clamped to non-polyethylene pipe as shown in the drawing to provide a leak-free attachment.

B. Metal Battens

Metal battens shall meet the requirements of Material Specification 222 and shall be installed according to the drawings and the liner manufacturer's specifications. The battens shall be bolted to structure concrete by epoxy coated bolts on 6-inch intervals to create a leak-free connection under submerged conditions. Bolt spacing shall be increased to 12 inches for connections above the fluid level.

C. Embed Channel

HDPE embed channel shall meet Material Specification 222 and be installed according to drawings and the liner manufacturer's specification. The embed channel shall be prefabricated to the dimensions as shown in the drawings. All sections of the channel shall be welded to the next section continuously to prevent gaps between sections or pieces of the embed channel before their installation in the concrete forms. All corners shall be miter cut and welded all around.

3.08 GAS VENTS AND DRAINAGE

- A. When specified, gas vent flaps or vent pipes shall be installed in accordance with the drawings to provide adequate venting for the liner system. Drainage systems will be installed as specified and as shown on the drawings.

3.09 PLACEMENT OF COVER SOIL (OPTIONAL)

- A. Cover soil and its placement method shall be in accordance to the drawings and shall conform to this specification and liner manufacturer's specification. Cover soil material shall not consist of any angular rocks or sharp objects that could damage liner. Placement shall be by a loader or bulldozer. No construction equipment or machinery shall be allowed to drive directly on the liner. A minimum of 12 inches of cover soil is required under the tracks or tires of construction equipment, with ground pressures of less than 5 pounds per square inch, before operating on the liner. The depth of cover soil shall be proportionally higher for heavier equipment. Cover material shall be placed during the cool times of the day or at night to prevent liner folds.

3.10 PLACEMENT OF CONCRETE

- A. Concrete placement for ramps and other appurtenances shall be in accordance to the drawings and specifications. All reinforcement steel shall be placed on flat-footed plastic rebar chairs. All rebar splices shall be fully tied to avoid loose ends. On slopes, concrete shall be placed from the bottom of the slope to the top and have a low slump to prevent sloughing down slope during placement. Only plastic shovels and internal vibrators shall be used to place concrete. Metal shovels and rodding are not allowed. Concrete forms shall be held in place by methods that avoid damaging the liner.

PART 4 MEASUREMMENT AND PAYMENT – NOT USED

END OF SECTION

CS-70

CONTRACTOR QUALITY CONTROL

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

The work consists of developing, implementing, and maintaining a quality control system to ensure that the specified quality is achieved for all materials and work performed.

1.02 EQUIPMENT AND MATERIALS

- A. Equipment and material used for quality control shall be of the quality and condition required to meet the test specifications. Testing equipment shall be properly adjusted and calibrated at the start of operations and the calibration maintained at the frequency specified. Records of equipment calibration tests shall be available to the technical representative at all times. Equipment shall be operated and maintained by qualified operators as prescribed in the manufacturer's operating instructions.
- B. All equipment and materials shall be handled and operated in a safe and proper manner and shall comply with all applicable regulations pertaining to their use, operation, handling, storage, and transportation.

1.03 QUALITY CONTROL SYSTEM

- A. The contractor shall develop, implement, and maintain a system adequate to achieve the specified quality of all work performed, material incorporated, and equipment furnished before use. The system established shall be documented in a written plan developed by the contractor. The system activities shall include the material testing and inspection needed to verify the adequacy of completed work and procedures to be followed when corrective action is required. Daily records to substantiate the conduct of the system shall be maintained by the contractor.
- B. The quality control system shall include, but not be limited to, a rigorous examination of construction material, processes, and operation, including testing of material and examination of manufacturer's certifications as required, to verify that work meets contract requirements and is performed in a competent manner.

1.04 QUALITY CONTROL PERSONNEL

- A. Quality control activities shall be accomplished by competent personnel who are separate and apart from line supervision and who report directly to management. A competent person is one who is experienced and capable of identifying, evaluating, and documenting that material and processes being used will result in work that complies with the contract, and who has authorization to take prompt action to remove, replace, or correct such work or products not in compliance. Offsite testing laboratories shall be certified or inspected by a nationally recognized entity. The contractor shall make available to the technical representative the names, qualifications, authorities, certifications, and availability of the competent personnel who will perform the quality control activities.

1.05 RECORDS

- A. The contractor's quality control records shall document both acceptable and deficient features of the work and corrective actions taken. All records shall be on forms approved by the contracting officer, be legible, and be dated and signed by the competent person creating the record.
- B. Records shall, at a minimum, include the following:
 - 1. Documentation of shop drawings including date submitted to and date approved by the contracting officer, results of examinations, any need for changes or modifications, manufacturer's recommendations and certifications, if any, and signature of the authorized examiner.
 - 2. Documentation of material delivered including quantity, storage location, and results of quality control examinations and tests.
 - 3. Type, number, date, time, and name of individual performing quality control activities.
 - 4. The material or item inspected and tested, the location and extent of such material or item, and a description of conditions observed and test results obtained during the quality control activity.
 - 5. The determination that the material or item met the contract provisions and documentation that the engineer was notified.
 - 6. For deficient work, the nature of the defects, specifications not met, corrective action taken, and results of quality control activities on the corrected material or item.

1.06 REPORTING RESULTS

- A. The results of contractor quality control inspections and tests shall be made available to the technical representative upon request.

1.07 ACCESS

- A. The technical representative shall be given free access to all testing equipment, facilities, sites, and related records.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

PART 4 MEASUREMMENT AND PAYMENT – NOT USED

END OF SECTION

DIVISION 5 – MATERIAL SPECIFICATIONS

NRCS Material Specifications

MS-201

CONCRETE AGGREGATES

PART 5 GENERAL

5.01 SCOPE

A. DESCRIPTION

This specification governs the quality of fine aggregate and coarse aggregate used in Portland cement concrete.

5.02 QUALITY

- A. The coarse and fine aggregate shall conform to the durability and gradation requirements of ASTM Specification C-33.

5.03 REACTIVITY WITH ALKALINES

- A. The potential reactivity of aggregates with the alkalis in cement shall conform to the requirement in ASTM Specification C-33, Appendix A1.

5.04 STORING AND HANDLING

- A. Aggregate of each class and size shall be stored and handled by methods that prevent segregation of particle sizes or contamination by intermixing with other materials.

PART 6 PRODUCTS – NOT USED

PART 7 EXECUTION – NOT USED

PART 8 MEASUREMENT AND PAYMENT – NOT USED

END OF SECTION

MS-202

PORTLAND CEMENT

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

This specification governs the quality of Portland cements.

1.02 QUALITY

- A. Portland cement shall conform to the requirements of ASTM Specification C-150 for the specified types of cement. Type IIA shall be used, unless another type is specified on the drawings.

1.03 STORING AND HANDLING

- A. Cement shall be stored so that it is protected from weather, dampness or other destructive agencies. Cement that is partially hydrated or otherwise will be rejected.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

PART 4 MEAUREMENT AND PAYMENT – NOT USED

END OF SECTION

MS-203 CONCRETE

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

This specification governs the quality of concrete mixes.

1.02 QUALITY

Concrete mixes shall be composed of Portland cement, fine and coarse aggregate and water. An air-entraining admixture may be used.

- A. Portland cement shall conform to the requirements of Material Specification MS-202.
- B. Fine and coarse aggregates shall conform to the requirements of Material Specification MS-201. The aggregates shall be handled in a manner to prevent contamination and segregation.
- C. Water shall be clean and free from harmful chemicals (suitable for drinking).
- D. Air-entraining admixtures shall conform to the requirements of ASTM C-260, Air Entraining Admixtures for Concrete.
- E. Class F fly ash meeting ASTM C-618 may be used in the concrete mix to replace not more than 15% of the cement by weight. An independent testing laboratory shall test pozzolanic materials with test results included with the submittal of design mix.
- F. Water-reducing and set-retarding admixtures may be used upon satisfactory submission of test results using a trial mix design and manufacturer's certification of the admixture. The admixtures shall conform to ASTM C-494.
- G. The concrete mix shall indicate evidence of meeting or exceeding the following criteria unless otherwise shown on the drawings.
 - 1. Minimum compressive strength ($f'c$) = 3000 lb.
 - 2. Slump: ASTM C-143, 3-5 inches.
 - 3. Cement: ASTM C-150, Type I, IA, II, IIA, V or VA.
Minimum content: 6 sacks per CY concrete (94 lb. sacks).
 - 4. Water: Clean potable and free of foreign matter.
Maximum water-cement ratio; 0.45 - 0.55 (6 gallons per sack of concrete).

5. Aggregates: Clean durable and within the grading limits of ASTM C-33.
 - a. Coarse Aggregates; maximum size shall be 3/4 inch unless otherwise stated on the drawing.
 - b. Fine Aggregates; fineness module shall be greater than 2.3 but less than 3.1.
 - c. Fine to Total Aggregate Ratio; greater than 0.35 but less than 0.45.
6. If Air Entrained, concrete mixes shall have 5-8% volume of air using an air entraining admixture.

1.03 INSPECTION AND TESTING

The following is a partial listing of the common American Society for Testing and Materials, ASTM, test requirements for concrete that may be used to verify concrete quality:

- A. ASTM C-31, "Making and Curing Concrete Compressive and Flexure Strength Test Specimens in the Field."
- B. ASTM C-33, "Concrete Aggregates."
- C. ASTM C-39, "Compressive Strength of Cylindrical Concrete Specimens."
- D. ASTM C-94, "Ready-Mix Concrete."
- E. ASTM C-143, "Slump of Portland Cement Concrete."
- F. ASTM C-150, "Portland Cement."
- G. ASTM C-172, "Sampling Freshly Mixed Concrete."
- H. ASTM C-231, "Air Content of Freshly Mixed Concrete by the Pressure Method."
- I. ASTM C-260, "Air Entraining Admixtures for Concrete."
- J. ASTM C-494, "Chemical Admixtures for Concrete."

The technical representative shall have free entry to the plant to review the equipment used for mixing, dispersing, weighing, agitating and delivering concrete. Proper facilities shall be provided for inspecting materials, equipment and processes and to obtain samples of the ingredients and concrete. All tests and inspections will be conducted so as not to unnecessarily interfere with the manufacture and delivery of the concrete.

1.04 HANDLING AND MEASURING MATERIALS

- A. Materials shall be stored and handled in a manner that will prevent degradation, segregation, contamination or intermixing of materials before measurement.

- B. Scales for weighing aggregates and cement shall be beam or springless dial type, clean and operating within 1 percent accuracy for cement and 2 percent accuracy for aggregates.
- C. All materials entering into the concrete shall be mechanically measured by weight except the air entraining admixture and water, which may be measured by volume.

1.05 MIXERS AND MIXING

Concrete may be furnished by batch mixing at the work site or by ready-mix methods.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION – NOT USED

PART 4 MEASUREMMENT AND PAYMENT – NOT USED

END OF SECTION

MS-209 WOVEN AND NON-WOVEN FABRICS

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

This specification governs the quality of structural woven and non-woven fabrics.

PART 2 PRODUCTS

2.01 FABRIC

- A. The fabric material shall be polypropylene material with long chain polymeric filaments or fibers. The material properties are defined in the following tables and the type of material selected is shown on the drawings.

a. Table 1, Non-Woven Fabric Material

Property	Test method	Class I	Class II	Class III	Class IV ^{3/}
Tensile strength (lb) ^{1/}	ASTM D 4632 grab test	180 minimum	120 minimum	90 minimum	115 minimum
Elongation at Failure (%) ^{1/}	ASTM D 4632	≥ 50	≥ 50	≥ 50	≥ 50
Puncture (pounds)	ASTM D 4833	80 minimum	60 minimum	40 minimum	40 minimum
Ultraviolet light (% residual tensile strength)	ASTM D 4355 150-hr exposure	70 minimum	70 minimum	70 minimum	70 minimum
Apparent opening size (AOS)	ASTM D 4751	As specified max. #40 ^{2/}	As specified max. #40 ^{2/}	As specified max. #40 ^{2/}	As specified max. #40 ^{2/}
Permittivity sec ⁻¹	ASTM D 4491	0.70 minimum	0.70 minimum	0.70 minimum	0.10 minimum

1/ Minimum average roll value (weakest principal direction).

2/ U.S. standard sieve size.

3/ Heat-bonded or resin-bonded geotextile may be used for classes III and IV. They are particularly well suited to class IV. Needle-punched geotextiles are required for all other classes.

b. Table 2, Woven Fabric Material

Property	Test method	Class I	Class II & III	Class IV
Tensile strength (pounds) ^{1/} grab test direction	ASTM D 4632 principal direction	200 minimum in any principal direction	120 minimum in any principal direction	180 minimum in any principal
Elongation at failure (percent) ^{1/} grab test	ASTM D 4632	<50	<50	<50
Puncture minimum (pounds) ^{1/}	ASTM D 4833	90 minimum	60 minimum	60
Ultraviolet light minimum (% residual tensile strength)	ASTM D 4355 150-hr exposure	70 minimum	70 minimum	70
Apparent opening size (AOS)	ASTM D 4751 no smaller than 0.212 mm (#70) ^{2/}	As specified, but no smaller than 0.212 mm (#70) ^{2/}	As specified, but no smaller than 0.212 mm (#70) ^{2/}	As specified, but
Percent open area minimum (percent)	CWO-02215-86	4.0 minimum	4.0 minimum	1.0
Permittivity sec ⁻¹ minimum	ASTM D 4491	0.10 minimum	0.10 minimum	0.10

1/ Minimum average roll value (weakest principal direction).

2/ U.S. standard sieve size.

Note: CWO is a USACE reference.

PART 3 EXECUTION – NOT USED

PART 4 MEASUREMENT AND PAYMENT – NOT USED

END OF SECTION

MS-210

AGGREGATE FILTERS

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

This specification governs the quality of aggregates used for filter materials in drainage systems for subsurface field drain lines, structural drains, and/or foundation drains.

1.02 QUALITY

The aggregates shall conform to the durability requirements of ASTM C-33.

PART 2 PRODUCTS

2.01 GRADATION

- A. The gradation shall conform to the requirements for the fine aggregates of ASTM C-33, unless otherwise specified on the drawings or in these specifications.

Gradation for ASTM C-33 fine aggregates:

Standard Sieve Size	Percent Passing
3/8 inch (9.5 mm)	100
#4 (4.75 mm)	95-100
#8 (2.36 mm)	80-100
#16 (1.18 mm)	50-85
#30 (0.60 mm)	25-60
#50 (0.30 mm)	10-30
#100 (0.15 mm)	2-10

2.02 HANDLING

- A. Equipment and methods shall prevent segregation of sizes or intermixing with other materials.

PART 3 EXECUTION – NOT USED

PART 4 MEASUREMENT AND PAYMENT – NOT USED

END OF SECTION

MS-211 BEDDING

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

This specification governs the quality of bedding material used in the foundation of pipelines, conduits and structures.

1.02 QUALITY

Soil material, fine gravel or coarse gravel specified as bedding material shall be durable, non-compressible and be within the grading limits of the Unified Soil Classification System, USCS. The ASTM specifications for classifying soils are: ASTM D-2487, Classification of Soils for Engineering Purposes, and ASTM D-2488, Standard Practice for Description and Identification of Soils (Visual Manual Procedure).

PART 2 PRODUCTS

2.01 GRADATION

- A. The following table lists some general properties of materials suitable for bedding. Gradation is unique for each soil in the USCS. The bedding requirements are site specific and shall be shown on the drawings using an identification symbol of the USCS.

Material	USCS	S.G. (Min.)	Size (Max.)
Soil	SW,SP,SM,SC,ML,CL	1.75	#10 Sieve
Fine Gravel	SW,SP,SM,SC	2.00	3/4-inch
Coarse Gravel	GW,GP,GM,GC	2.40	3-inch
	SW,SP,SM,SC		

PART 3 EXECUTION – NOT USED

PART 4 MEASUREMENT AND PAYMENT – NOT USED

END OF SECTION

MS-213

STEEL REINFORCEMENT

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

This specification governs the quality of steel reinforcement for reinforced concrete.

1.02 QUALITY

- A. Reinforcing steel shall be free from rust, oil grease, paint or other deleterious matter.
- B. Steel bars for concrete reinforcement requiring bends shall be deformed billet-steel bars conforming to ASTM Specification A-615, Grade 40 or Grade 60.
- C. Straight steel bars shall be deformed bars conforming to one of the following specifications:
 - 1. Deformed Billet-Steel Bars for Concrete Reinforcement (Grade 40 or Grade 60) - ASTM Designation A-615.
 - 2. Rail-Steel Deformed Bars for Concrete Reinforcement (Grade 50 or Grade 60) - ASTM Designation A-616.
 - 3. Axle-Steel Deformed Bars for Concrete Reinforcement (Grade 40 or Grade 60) - ASTM Designation A-617.
- D. Fabricated steel bar mats shall conform to the requirements of ASTM Specification A-184.
- E. Welded steel wire fabric reinforcement shall conform to the requirements of ASTM Specification A-185.
- F. Welded deformed steel wire fabric for concrete reinforcement shall conform to the requirements of ASTM Specification A0497.
- G. Cold-drawn steel wire reinforcement shall conform to the requirements of ASTM Specification A-82.
- H. Deformed steel wire for concrete reinforcement shall conform to the requirements of ASTM Specification A-496.

PART 2 PRODUCTS

2.01 DIMENSIONS OF WELDED WIRE FABRIC

- A. Gauges, spacing and arrangement of wires in welded steel wire fabric shall be as defined in ACI Standard 315 of the American Concrete Institute for the specified style designations.

2.02 STORAGE

- A. Steel reinforcement stored at the site of the work shall be stored above the ground surface on platforms, skids, or other supports and shall be protected from mechanical injury and corrosion.

PART 3 EXECUTION – NOT USED

PART 4 MEASUREMMENT AND PAYMENT – NOT USED

END OF SECTION

MS-222

HDPE and LLDPE FLEXIBLE MEMBRANE LINER

PART 1 GENERAL

1.01 SCOPE

A. DESCRIPTION

This specification covers the quality of High Density Polyethylene (HDPE) and Low Linear Density Polyethylene (LLDPE) flexible liner, seams, gaskets, metal battens, embed channels, clamps, and sealant.

PART 2 PRODUCTS

2.01 MATERIAL

A. Liner

The HDPE or LLDPE liner shall have a nominal thickness of 30 mils, 40 mils, or 60 mils as specified. The liner shall be manufactured to be suitable for use in either exposed or buried conditions. It shall conform to the requirements of this specification as shown in tables 222-1 through 222-4. It shall also meet the requirements shown on the drawings and as specified in additional sections of this specification.

B. Gaskets, Metal Battens, Clamps, Embed Channels, and Sealant

Gasket material shall be neoprene, closed cell medium, 0.25 inch thick, with adhesive on one side, or other gasket material as approved by the liner manufacturer. Metal battens shall be 0.25 inch thick by 2 inches wide stainless steel. Clamps shall be 0.5-inch-wide stainless steel. Embed channel shall have the same properties as the liner. Sealant shall be General Electric Silicone, RTV 103, or equivalent.

2.02 HDPE and LLDPE LINER PROPERTIES

- A. The HDPE or LLDPE liner shall be manufactured from virgin polymer material and shall meet the property values specified under tables 222-1 through 222-4 as applicable.

Table 222-1 Requirements for smooth HPDE liner

Property	Test methods	Requirements*		
		----- nominal thickness -----		
		30 mil	40 mil	60 mil
Density, g/cc	ASTM D 1505	0.940	0.940	0.940
Tensile properties	ASTM D 638 (type IV at 2 in/min)			
yield stress, lb/in		63	84	126
break stress, lb/in		114	152	228
yield elongation, %		12	12	12
break elongation, %		560	560	560
Tear resistance, lb	ASTM D 1004	21	28	42
Puncture resistance, lb	ASTM D 4833	54	72	108
Carbon black content, %	ASTM D 1603	2-3	2-3	2-3
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2	Cat 1-2
Seam properties	ASTM D 4437 (1 in wide at 2 in/min)			
shear strength, lb/in		60	80	120
peel strength, lb/in**		39/FTB	52/FTB	78/FTB

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 222-2 Requirements for textured HPDE liner

Property	Test methods	Requirements*		
		----- nominal thickness -----		
		30 mil	40 mil	60 mil
Density, g/cc	ASTM D 1505	0.940	0.940	0.940
Tensile Properties	ASTM D 638 (type IV at 2 in/min)			
yield stress, lb/in		63	84	126
break stress, lb/in		45	60	90
yield elongation, %		12	12	12
break elongation, %		100	100	100
Tear resistance, lb	ASTM D 1004	21	28	42
Puncture resistance, lb	ASTM D 4833	45	60	90
Carbon black content, %	ASTM D 1603	2 - 3	2 - 3	2 - 3
Carbon black dispersion	ASTM D 5596	Cat 1-2	Cat 1-2	Cat 1-2
Seam properties	ASTM D 4437 (1 in wide at 2 in/min)			
shear strength, lb/in		60	80	120
peel strength, lb/in**		39/FTB	52/FTB	78/FTB

* All values, unless specified otherwise, are minimum average roll values as reported by the specified test methods.

** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

PART 3 EXECUTION – NOT USED

PART 4 MEAUREMENT AND PAYMENT – NOT USED

END OF SECTION

DIVISION 6 – SUPPLEMENTARY SPECIFICATIONS

SECTION 02100 SUBGRADE PREPARATION

PART 1 - GENERAL

1.01 SUMMARY

A. DESCRIPTION

1. This specification covers the requirements for preparing subgrade.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
2. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
3. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
4. ASTM D6913 – Standard Test Methods for Particle – Size Distribution (Gradation) of Soils Using Sieve Analysis
5. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
6. ASTM D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.03 DENSITY CONTROL TESTING

A. Field Density Testing

1. Contractor shall meet the quality control assurance testing requirements in CS-70, Contractor Quality Control.
2. In-place field densities tests for quality assurance are at Owner's expense and shall meet the requirements of ASTM D1556 or ASTM D6938. Quality assurance field density testing frequency is at the discretion of the Engineer.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Ensure subgrade is free of all organic material. Any organic material encountered shall be excavated and relocated to an on-site location approved by the Owner.

2.02 EQUIPMENT

- A. **Compaction Equipment**
 - 1. Contractor shall furnish the necessary equipment to apply sufficient compactive effort to meet the project specifications.
 - 2. Contractor shall ensure that compaction equipment has the ability to traverse slopes of 2:1 (horizontal to vertical).

2.03 WATERING

- A. Use uncontaminated water free of organics.

PART 3 - EXECUTION

3.01 PLACEMENT AND SPREADING

- A. Place material in maximum 6-inch thick loose layers to the lines and grades shown in the project plan sheets. Deposit and spread layers continuously and without breaks.
- B. Spread using equipment that will distribute the material in a uniform layer without causing segregation.
- C. For multiple layers, mix each layer as specified above. Blade smooth and compact each layer before placing the succeeding layer.
- D. Add water uniformly, when required, on site and place in amounts required to compact the material as necessary to aid in densification and to limit segregation. Maintain an adequate water supply during the work. Assure the equipment used for watering is of the capacity and design to provide uniform water application.
- E. Apply water during the work to control dust and to maintain the subgrade in a damp condition.
- F. Compact the material using appropriate tamping equipment or power rollers. Correct all irregularities or depressions that develop under rolling by scarifying the material and adding or removing material, as required, until the surface meets specifications.
- G. Blade and compact alternately as required to produce the specified surface until final inspection.

3.02 FIELD DENSITY REQUIREMENTS

- A. Furnish watering and compactive effort to obtain a minimum field density of 90 percent of the maximum dry density. No separate compensation is allowed for rolling and watering the subgrade other than the s bid item or items listed on the Contract documents.

3.03 ELEVATION TOLERANCES

- A. Finish the subgrade to within elevation deviations of no more than 0.25 feet at any point along slopes and 0.1 feet at any point along the bottom of the excavation.

PART 4 - MEASUREMENT AND PAYMENT

- A. Payment for subgrade preparation is measured by and paid for per contract unit price per in-place (bank) cubic yard.
- B. Measurement for total quantity of subgrade preparation will be made by topographic survey prior to and following completion of the subgrade preparation.

END OF SECTION

**SECTION 02200
BASE COURSE**

PART 1 - GENERAL

1.01 SUMMARY

A. DESCRIPTION

1. This specification covers the requirements for preparing base material for geotextile and geomembrane liners meeting the gradation and other quality criteria specified herein.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
2. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
3. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
4. ASTM D6913 – Standard Test Methods for Particle – Size Distribution (Gradation) of Soils Using Sieve Analysis
5. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
6. ASTM D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.03 DENSITY CONTROL TESTING

A. Field Density Testing

1. Contractor shall meet the quality control assurance testing requirements in CS-70, Contractor Quality Control.
2. In-place field densities tests for quality assurance are at Owner's expense and shall meet the requirements of ASTM D1556 or ASTM D6938. Quality assurance field density testing frequency is at the discretion of the Engineer.

B. Laboratory Maximum Density and Optimum Moisture

1. Submit to the Engineer gradations, moisture density curves, and other test results for sources to be used for base materials prior to delivery to the site for approval by the Engineer. If on-site materials are proposed, test data must be submitted to the

Engineer to assure consistency with the design requirements

PART 2 - PRODUCTS

2.01 GENERAL

- A. Furnish base material meeting the applicable gradation and other quality requirements.

2.02 GRADATION

- A. Furnish material meeting the requirements of the grading in the Gradation Table below:

GRADATION TABLE

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVE

STANDARD SIEVE SIZE	PERCENT PASSING
3/8 in	95 - 100
No. 4	50 - 95
No. 10	25 - 75
No. 40	10 - 50
No. 70	5 - 10
No. 200	0 - 5

- B. Up to 5% “oversized” material is permitted provided that the “oversized” material passes the screen size immediately larger than the top size specified. The produced material between the maximum screen opening and the No. 4 sieve shall be reasonable well graded.
- C. Suitability of the base material is based on samples obtained during placement in the project within limits allowed in the table for the particular grading specified.
- D. The liquid limit for the portion of the fine material passing a No. 40 sieve cannot exceed 25, nor the plasticity index exceed 6, as determined by ASTM D4318.

2.03 WATERING

- A. Use uncontaminated water free of organics.

PART 3 - EXECUTION

3.01 GENERAL

- A. Before placing base material, smooth and shape the surface of the underlying subgrade to the cross section lines and grades shown on the plans.
- B. Do not place base material on a wet or muddy subgrade. Complete at least one area of finished and accepted subgrade underlying the base material before placing any of the base material.

3.02 PLACEMENT AND SPREADING

- A. Place material in minimum 3-inch thick compacted layer to the lines and grades shown in the project plan sheets. Deposit and spread layers continuously and without breaks.
- B. Deposit and spread the material in a uniform layer, without segregation, to a loose depth so that when compacted, the layer has the specified thickness.
- C. Spread material using dump boards, spreader boxes, or vehicles equipped to distribute the material in a uniform layer. The material may be deposited in windrows mixed and spread as described below.
- D. Construct each layer meeting these requirements. Blade smooth and thoroughly compact each layer as specified before placing the succeeding layer.
- E. If segregation or moisture problems exist, or if the material was placed on the subgrade in windrows, thoroughly blade-mix the material of the affected layer by alternately blading to the center and back to the edges of the layer.
- F. Uniformly add water, when required, on site and place in amounts required to compact the material as necessary to aid in densification and to limit segregation. Maintain an adequate water supply during the work. Assure the equipment used for watering is of the capacity and design to provide uniform water application.
- G. Apply water during the work to control dust and to maintain the base material in a condition that is as close to the optimum moisture as practicable.
- H. Water required for compacting base material may be obtained from on-site if approved by the owner, or from other sources.

3.03 FIELD DENSITY REQUIREMENTS

- A. Compact placed material the full width by rolling with suitable tamping equipment or power rollers. Correct all irregularities or depressions that develop during rolling by loosening the material in these places and adding or removing material, as required.

- B. Perform blading and compacting alternately as required or directed, to maintain a smooth, even, uniformly compacted surface until the final inspection. Along curbs, headers, manholes, and similar structures, and at all places not accessible to the roller, compact the base course material with suitable mechanical tampers or hand tampers to reach the compaction requirements.
- C. Provide the watering and rolling required to obtain a minimum field density of 95 percent of maximum dry density as determined by ASTM D6938. No separate compensation is made for rolling and watering the base course other than the base course bid item or items listed on the contract documents.

3.04 ELEVATION TOLERANCES

- A. Finish the subgrade to within elevation deviations of no more than 0.25 feet at any point along slopes and 0.1 feet at any point along the bottom of the excavation. Additionally, the sum of the deviations from two points not more than 30 feet apart cannot exceed 0.05 feet.

PART 4 - MEASUREMENT AND PAYMENT

- A. Payment for base course is measured by and paid for per contract unit price per in-place (bank) cubic yard. Price and payment is full compensation for furnishing, crushing, loading, hauling, spreading, shaping, watering, and compaction the base course material, and for all tools, labor, and incidentals necessary to complete this item.
- B. Measurement for total quantity of base course will be made by topographic survey prior to and following completion of the base course installation.

END OF SECTION

SECTION 02300 COURSE AGGREGATE

PART 1 - GENERAL

1.01 SUMMARY

A. DESCRIPTION

1. This specification covers the requirements for preparing course aggregate for use in leachate detection sumps meeting the gradation and other quality criteria specified herein.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
2. ASTM D6913 – Standard Test Methods for Particle – Size Distribution (Gradation) of Soils Using Sieve Analysis

1.03 SUBMITTALS

A. Laboratory Maximum Density and Optimum Moisture

1. Submit to the Engineer gradations, and other test results for sources to be used for course aggregate prior to delivery to the site for approval by the Engineer. If on-site materials are proposed, test data must be submitted to the Engineer to assure consistency with the design requirements.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Furnish course aggregate meeting the applicable gradation and other quality requirements.
- B. Furnish course aggregate that has been washed to reduce sand and fine content to the maximum allowable gradations.

2.02 GRADATION

- A. Furnish course aggregate meeting the requirements of the grading in the Gradation Table below:

GRADATION TABLE – COURSE AGGREGATE
PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVE

STANDARD SIEVE SIZE	PERCENT PASSING
2 in	95 - 100
1 ½ in	5 - 10
¾ in	0 - 10
No. 4	0 - 5
No. 200	0 - 2

- B. Up to 5% “oversized” material is permitted provided that the “oversized” material passes the screen size immediately larger than the top size specified.
- C. Suitability of the course aggregate is based on samples obtained during placement in the project within limits allowed in the table for the particular grading specified.
- D. The liquid limit for the portion of the fine material passing a No. 40 sieve may not exceed 25, nor the plasticity index exceed a value of 6, as determined by ASTM D4318.

PART 3 - EXECUTION

3.01 GENERAL

- A. Before placing geotextile and course aggregate, smooth and shape the surface of the underlying subgrade to the cross section lines and grades shown on the plans.

3.02 GEOTEXTILE

- A. Ensure 10 oz. geotextile conforming to Section 03100 is installed prior to placement of course aggregate. At no time will course aggregate be allowed to be in direct contact with the geomembrane.
- B. Place geotextile directly on geomembrane. Ensure sufficient square footage to provide a minimum of 18” of overlap after placement and spreading of course aggregate.

3.03 PLACEMENT AND SPREADING

- A. Place course aggregated in maximum 6-inch thick loose layers to the lines and grades shown in the project plan sheets. Deposit and spread layers continuously and without breaks.

- B. Deposit and spread the material in a uniform layer, without segregation, to the loose layer depth specified.
- C. Use of wheeled or tracked equipment directly on the geomembrane will not be allowed. Contractor will be responsible for ensuring that course aggregate is transported and installed in a manner as to not damage the underlying geomembrane.

3.04 COMPACTION REQUIREMENTS

- A. Compact course aggregate by means of vibratory plate or other suitable vibratory equipment. Impact equipment such as rammer plate (jumping jack) compactors will not be allowed for use in consolidating course aggregate.
- B. Perform blading and compacting alternately as required or directed, to maintain a smooth, even, uniformly compacted surface until the final inspection.
- C. Field density requirements will not be applicable to course aggregate installation.

3.05 ELEVATION TOLERANCES

- A. Finish the aggregate course to within elevation deviations of no more than 0.20 feet at any point within the course aggregate installation area.

PART 4 - MEASUREMENT AND PAYMENT

- A. No separate payment for course aggregate will be made.
- B. Payment will be made under "Sump Installation" on a lump sum basis. Price and payment is full compensation for furnishing, crushing, loading, hauling, spreading, shaping, and compaction of the course aggregate material, and for all tools, labor, and incidentals necessary to complete this item.

END OF SECTION

**SECTION 03100
NONWOVEN GEOTEXTILE**

PART 1 - GENERAL

1.01 SUMMARY

A. DESCRIPTION

1. This specification covers the technical requirements for the Manufacturing and Installation of the nonwoven geotextile. All materials must meet or exceed the requirements of this specification, and all work will be performed in accordance with the procedures recommended by the manufacturer and provided in these project specifications.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D 5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles
2. ASTM D 4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
3. ASTM D 4533 - Standard Test Method for Index Trapezoidal Tearing Strength of Geotextiles
4. ASTM D 4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
5. ASTM D 4491 - Standard Test Method for Water Permeability of Geotextiles by Permittivity
6. ASTM D 4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile
7. ASTM D 4354 - Standard Practice for Sampling of Geosynthetics for Testing
8. ASTM D 4759 - Standard Practice for Determining the Specifications Conformance of Geosynthetics

1.03 DEFINITIONS

- A. Construction Quality Assurance Consultant (**CQA CONSULTANT**) - Party, independent from MANUFACTURER and INSTALLER that is responsible for observing and documenting activities related to quality assurance during the liner system construction.

- B. **ENGINEER** - The individual or firm responsible for the design and preparation of the project's Contract Drawings and Specifications.
- C. Geotextile Manufacturer (**MANUFACTURER**) - The party responsible for manufacturing the geocomposite rolls.
- D. Geosynthetic Quality Assurance Laboratory (**TESTING LABORATORY**) - The party, independent from the MANUFACTURER and INSTALLER, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the OWNER.
- E. **INSTALLER**- Party responsible for field handling, transporting, storing and deploying the geotextile.
- F. **Lot**- A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geotextile rolls. The finished rolls will be identified by a roll number traceable to the resin lot.

1.04 SUBMITTALS

- A. Prior to material delivery to project site, the CONTRACTOR shall provide the ENGINEER with a written certification or MANUFACTURER's quality control data which displays that the geotextile meets or exceeds minimum average roll values (MARV) specified herein.
- B. The CONTRACTOR shall submit, if required by the ENGINEER, MANUFACTURER's quality control manual for the geotextile to be delivered to the site.

1.05 WARRANTY

- A. Material shall be warranted, on a pro-rata basis against defects for a period of 1-year from the date of the geotextile installation.
- B. Installation shall be warranted against defects in workmanship for a period of 1-year from the date of geotextile completion.

PART 2 – PRODUCT

2.01 GEOTEXTILE

- A. The nonwoven needle-punched geotextile specified herein shall be made from staple fiber.
- B. The geotextile shall be manufactured from prime quality virgin polymer.

- C. The geotextile shall be able to withstand direct exposure to ultraviolet radiation from the sun for up to 30 days without any noticeable effect on index or performance properties.
- D. Geotextile shall meet or exceed all material properties listed in Table 1.

Property	Test Method	Frequency	Min. Average Roll Value	
			NW8	NW10
Mass per Unit Area, oz./yd ²	ASTM D5261	1/90,000 ft ²	8	10
Grab Tensile Strength, lb.	ASTM D4632	1/90,000 ft ²	220	260
Grab Elongation, %	ASTM D4632	1/90,000 ft ²	50	50
CBR Puncture Strength, lb.	ASTM D6241	1/540,000 ft ²	575	725
Trapezoidal Tear Strength, lb.	ASTM D4533	1/90,000 ft ²	90	100
AOS, US sieve (mm)	ASTM D4751	1/540,000 ft ²	80 (0.180)	100 (0.150)
Permittivity, sec ⁻¹	ASTM D4491	1/540,000 ft ²	1.3	1.00
Water Flow Rate, gpm/ft ²	ASTM D4491	1/540,000 ft ²	95	75
UV Resistance, % retained	ASTM D4355 (after 500 hours)	per formulation	70	70
TYPICAL ROLL DIMENSIONS				
Roll Length, ft.			600	500
Roll Width, ft.			15	15
Roll Area, ft ²			9,000	7,500

2.02 MANUFACTURE

- A. All rolls of the geotextile shall be identified with permanent marking on the roll or packaging, with the MANUFACTURE’s name, product identification, roll number and roll dimensions.

2.03 TRANSPORT

- A. Transportation of the geotextile shall be the responsibility of the CONTRACTOR.
- B. During shipment, the geotextile shall be protected from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, or other damaging or deleterious conditions.
- C. Upon delivery at the job site, the CONTRACTOR shall ensure that the geotextile rolls are handled and stored in accordance with the MANUFACTURER’s instructions as to prevent damage.

PART 3 – EXECUTION

3.01 QUALITY ASSURANCE

- A. The ENGINEER shall examine the geotextile rolls upon delivery to the site and report any deviations from project specifications to the CONTRACTOR.
- B. The ENGINEER may decide to arrange conformance testing of the rolls delivered to the job site. For this purpose, the ENGINEER shall take a sample three feet (along roll length) by roll width according to ASTM Practice D 4354. The sample shall be properly marked, wrapped and sent to an independent laboratory for conformance testing.
- C. The pass or fail of the conformance test results shall be determined according to ASTM Practice D 4759.

3.02 INSTALLATION

- A. The geotextile shall be handled in such a manner as to ensure that it is not damaged in any way. Should the CONTRACTOR damage the geotextile to the extent that it is no longer usable as determined by these specifications or by the ENGINEER, the CONTRACTOR shall replace the geotextile at his own cost.
- B. The geotextile shall be installed to the lines and grades as shown on the project drawings and as described herein.
- C. The geotextile shall be rolled down the slope in such a manner as to continuously keep the geotextile in tension by self-weight. The geotextile shall be securely anchored in an anchor trench where applicable, or by other approved or specified methods.
- D. In the presence of wind, all geotextiles shall be weighted by sandbags or approved equivalent. Such anchors shall be installed during placement and shall remain in place until replaced with cover material.
- E. The CONTRACTOR shall take necessary precautions to prevent damage to adjacent or underlying materials during placement of the geotextile. If damage to such material occurs due to the fault of the CONTRACTOR, the latter shall repair the damaged materials at his own cost and to the satisfaction of the ENGINEER.
- F. During placement of the geotextile, care shall be taken not to entrap soil, stones or excessive moisture that could hamper subsequent seaming of the geotextile as judged by the ENGINEER.
- G. The geotextile shall not be exposed to precipitation prior to being installed and shall not be exposed to direct sunlight for more than 15 days after installation.

- H. The geotextile shall be seamed using heat seaming or stitching methods as recommended by the MANUFACTURER and approved by the ENGINEER. Sewn seams shall be made using polymeric thread with chemical resistance equal to or exceeding that of the geotextile. All sewn seams shall be continuous. Seams shall be oriented down slopes perpendicular to grading contours unless otherwise specified. For heat seaming, fusion welding techniques recommended by the MANUFACTURE shall be used.
- I. The CONTRACTOR shall not use heavy equipment to traffic above the geotextile without approved protection.
- J. The geotextile shall be covered as soon as possible after installation and approval. Installed geotextile shall not be left exposed for more than 15 days.
- K. Material overlying the geotextile shall be carefully placed to avoid wrinkling or damage to the geotextile.

PART 4 - MEASUREMENT AND PAYMENT

- A. Payment for geotextile installation will be as per contract unit price per square foot, as measured parallel to liner surface, including designed anchor trench material and is based upon net lined area.
- B. Net lined area is defined to be the true area of all surfaces, as measured by topographic survey, to be lined plus designed burial in all anchor trenches, rub sheets, and sacrificial layers.
- C. Prices shall include full compensation for furnishing all labor, material, tools, equipment, and incidentals.
- D. Prices also include doing all the work involved in performing geotextile installation completely as shown on the drawings, as specified herein, and as directed by the ENGINEER.

END OF SECTION

SECTION 03200 GEOCOMPOSITES

PART 1 - GENERAL

1.01 SUMMARY

A. DESCRIPTION

1. This specification covers the technical requirements for the manufacturing and installation of the geocomposite drainage layer and strip drains. All materials shall meet or exceed the requirements of this specification, and all work will be performed in accordance with the procedures provided in these project specifications.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D 1238 Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.
2. ASTM D 1505-98 Standard Test Method for Density of Plastics by the Density-Gradient Technique
3. ASTM D 4218, Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle Furnace Technique D 1603-94 Standard Test Method for Carbon Black in Olefin Plastics
4. ASTM D 4355-02 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
5. ASTM D 4491-99 Standard Test Method for Water Permeability of Geotextiles by Permittivity
6. ASTM D4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles
7. ASTM D 4716-00 Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
8. ASTM D 4751-99 Standard Test Method for Determining Apparent Opening Size of a Geotextile
9. ASTM D 6241 Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile- Related Products Using a 50-mm Probe D 4833-88 (1996) Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
10. ASTM D 5261-92 (1996) Standard Test Method for Measuring the Mass Per Unit Area of Geotextiles

11. ASTM D7005-03 Determining The Bond Strength (Ply-Adhesion) of Geocomposites
 12. ASTM D 7179 Standard Test Method for Determining Geonet Breaking Force
- B. Relevant publications from the Environmental Protection Agency (EPA)
1. Daniel, D.E. and R.M. Koerner, (1993), Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182.

1.03 DEFINITIONS

- A. Construction Quality Assurance Consultant (**CONSULTANT**) - Party, independent from MANUFACTURER and INSTALLER that is responsible for observing and documenting activities related to quality assurance during the lining system construction.
- B. **ENGINEER** - The individual or firm responsible for the design and preparation of the project's Contract Drawings and Specifications.
- C. Geocomposite Manufacturer (**MANUFACTURER**) - The party responsible for manufacturing the geocomposite rolls.
- D. Geosynthetic Quality Assurance Laboratory (**TESTING LABORATORY**) - The party, independent from the MANUFACTURER and INSTALLER, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the OWNER.
- E. **INSTALLER**- Party responsible for field handling, transporting, storing and deploying the geocomposite.
- F. **Lot**- A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geocomposite rolls. The finished rolls will be identified by a roll number traceable to the resin lot.
- G. **Strip Drain**- Bi-planar geocomposite strips installed to discharge subgrade gases to the gas venting system.

1.04 QUALIFICATIONS

- A. MANUFACTURER
1. MANUFACTURER shall have manufactured a minimum of **10,000,000** square feet of polyethylene geocomposite material during the last year.

B. INSTALLER

1. INSTALLER shall have installed a minimum of **50,000** square feet of geocomposite in the last **5** years.
2. INSTALLER shall have worked in a similar capacity on at least **3** projects similar in complexity to the project described in the contract documents, and within at least **50,000** square feet of geonet and/or geocomposite installation on each project.
3. The Installation Supervisor shall have worked in a similar capacity on projects similar in size and complexity to the project described in the Contract Documents.

1.05 MATERIAL LABELING, DELIVERY, STORAGE AND HANDLING

A. Labeling - Each roll delivered to the site shall be wrapped and labeled by the MANUFACTURER. The label will identify:

1. manufacturer's name
2. product identification
3. length
4. width
5. roll number

B. Delivery - Rolls will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

C. Storage- The on-site storage location provided by the CONTRACTOR to protect the geonet from abrasions, excessive dirt and moisture shall have the following characteristics:

1. level (no wooden pallets)
2. smooth
3. dry
4. protected from theft and vandalism
5. adjacent to the area being lined

D. Handling

1. The CONTRACTOR and INSTALLER shall handle all rolls in such a manner to ensure they are not damaged in any way.
2. The INSTALLER shall take any necessary precautions to prevent damage to underlying layers during placement of the drainage material.

1.06 WARRANTY

- A.** Material shall be warranted, on a pro-rata basis against defects for a period of 1-year from the date of the geocomposite installation.

- B. Installation shall be warranted against defects in workmanship for a period of 1-year from the date of geocomposite completion.

PART 2 - PRODUCTS

2.01 GEOCOMPOSITE PROPERTIES

- A. A geocomposite shall be manufactured by extruding two crossing strands to form a bi-planar drainage net structure with a nonwoven geotextile bonded to both sides.
- B. The geocomposite specified shall have properties that meet or exceed the values listed in the Tables 1-1 and 1-2 below.

Table 1-1: Geocomposite Properties

Property	Test Method	Frequency	Value
Geocomposite			
Transmissivity, gal/min/ft (m ² /sec)	ASTM D4716	1/540,000 ft ²	2.4 (5x10 ⁻⁴)
Ply Adhesion, lb/in	ASTM D7005	1/50,000 ft ²	1.0
Geonet			
Geonet Core Thickness, mil	ASTM D5199	1/50,000 ft ²	250
Transmissivity, gal/min/ft (m ² /sec)	ASTM D4716	N/A	14.5 (3x10 ⁻³)
Density, g/cm ³	ASTM D1505	1/50,000 ft ²	0.94
Tensile Strength (MD), lb/in	ASTM D7179	1/50,000 ft ²	55
Carbon Black Content, %	ASTM D4218	1/50,000 ft ²	2.0
Geotextile			
Mass per Unit Area, oz/yd ²	ASTM D5261	1/90,000 ft ²	8
Grab Tensile Strength, lb.	ASTM D4632	1/90,000 ft ²	220
Grab Elongation, %	ASTM D4632	1/90,000 ft ²	50
CBR Puncture Strength, lb.	ASTM D6241	1/540,000 ft ²	575
Trapezoidal Tear Strength, lb.	ASTM D4533	1/90,000 ft ²	90
AOS, US sieve (mm)	ASTM D4751	1/540,000 ft ²	80 (0.180)
Permittivity, sec ⁻¹	ASTM D4491	1/540,000 ft ²	1.3
Water Flow Rate, gpm/ft ²	ASTM D4491	1/540,000 ft ²	95
UV Resistance, % retained	ASTM D4355 (after 500 hours)	per formulation	70

C. Resin

1. Resin shall be new first quality, compounded polyethylene resin.
2. Natural resin (without carbon black) shall meet the following additional minimum requirements:

Table 1-2: Raw Material Properties

Property	Test Method	Value
Density (g/cm ³)	ASTM D1505	≥ 0.94
Melt Flow Index (g/10 min)	ASTM D1238	≤ 1.0

2.02 MAUFACTURING QUALITY CONTROL

- A. The geocomposite shall be manufactured in accordance with the Manufacturer's Quality Control Plan, and shall be submitted to and approved by the ENGINEER prior to project execution.
- B. The geocomposite shall be tested according to the test methods and frequencies listed on Table 1-1 which has been prepared based on product data sheets.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

A. **Inspection**

1. Prior to implementing any of the work in the Section to be lined, the INSTALLER shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the Section may properly commence without adverse impact.
2. If the INSTALLER has any concerns regarding the installed work of other Sections, he shall notify the ENGINEER.

3.02 MATERIAL PLACEMENT

- A. The geocomposite roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the ENGINEER.

- B. If the project contains long, steep slopes, special care should be taken so that only full length rolls are used at the top of the slope.
- C. In the presence of wind, all geocomposites shall be weighted down with sandbags or the equivalent. Such sandbags shall be used during placement and remain until replaced with cover material.
- D. If the project includes an anchor trench at the top of the slopes, the geocomposite shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geocomposite.
- E. In applying fill material, no equipment can drive directly across the geocomposite. The specified fill material shall be placed and spread utilizing vehicles with a low ground pressure.
- F. The cover soil shall be placed on the geocomposite in a manner that prevents damage to the geocomposite. Placement of the cover soil shall proceed immediately following the placement and inspection of the geocomposite.

3.03 SEAMS AND OVERLAPS

- A. Each component of the geocomposite will be secured or seamed to the like component at overlaps.
- B. Geonet Components
 - 1. Adjacent edges of the geonet along the length of the geocomposite roll shall be placed with the edges of each geonet butted against each other.
 - 2. The overlaps shall be joined by tying the geonet structure with cable ties. These ties shall be spaced every 5 feet along the roll length.
 - 3. Adjoining geocomposite rolls (end to end) across the roll width should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geocomposite a minimum of 12 inches across the roll width.
 - 4. The geonet portion should be tied every 6 inches in the anchor trench or as specified by the ENGINEER.

3.04 REPAIR

- A. Prior to covering the deployed geocomposite, each roll shall be inspected for damage resulting from construction.
- B. Any rips, tears or damaged areas on the deployed geocomposite shall be removed and patched. The patch shall be secured to the original geonet by tying every 6 inches

with the approved tying devices. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out and the two portions of the geonet shall be cut out and the two portions of the geonet shall be joined in accordance with Subsection 3.03.

PART 4 - MEASUREMENT AND PAYMENT

- A. Payment for geocomposite drainage layer installation will be as per contract unit price per square foot, as measured parallel to liner surface, including designed anchor trench material and is based upon net lined area.
- B. Net lined area is defined to be the true area of all surfaces, as measured by topographic survey, to be lined plus designed burial in all anchor trenches, rub sheets, and sacrificial layers.
- C. Payment for strip drain installation will be as per contract unit price per linear foot, as measured parallel to liner surface, including designed anchor trench material.
- D. Prices shall include full compensation for furnishing all labor, material, tools, equipment, and incidentals.
- E. Prices also include doing all the work involved in performing geocomposite drainage layer and strip drain installation completely as shown on the drawings, as specified herein, and as directed by the ENGINEER.

END OF SECTION

**SECTION 03300
HDPE GEOMEMBRANES**

PART 1 - GENERAL

1.01 SUMMARY

A. DESCRIPTION

1. This specification covers the technical requirements for the Manufacturing and Installation of the geomembrane. All materials meet or exceed the requirements of this specification, and all work will be performed in accordance with the procedures provided in these project specifications.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D 1004 - Test Method for Initial Tear Resistance of Plastic Film and Sheeting
2. ASTM D 1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
3. ASTM D 1505 - Test Method for Density of Plastics by the Density-Gradient Technique
4. ASTM D 1603 - Test Method for Carbon Black in Olefin Plastics
5. ASTM D 3895 - Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
6. ASTM D 4218 - Standard Test Method for Determination of Carbon Black in Polyethylene Compounds
7. ASTM D 4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
8. ASTM D 5199 - Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
9. ASTM D 5397 - Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
10. ASTM D 5596 - Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
11. ASTM D 5994 - Standard Test Method for Measuring Core Thickness of Textured Geomembranes
12. ASTM D 7179 - Standard Test Method for Determining Geonet Breaking Force
13. ASTM D 6693 - Standard Test Method for Determining Tensile Properties of Non-reinforced Polyethylene and Non-reinforced Flexible Polypropylene Geomembranes

14. ASTM D 7240 - Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)

B. Relevant Geosynthetic Research Institute (GRI)

1. GRI GM 13 Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

1.03 DEFINITIONS

A. Construction Quality Assurance Consultant (**CONSULTANT**) - Party, independent from MANUFACTURER and INSTALLER that is responsible for observing and documenting activities related to quality assurance during the lining system construction.

B. **ENGINEER** - The individual or firm responsible for the design and preparation of the project's Contract Drawings and Specifications.

C. Geomembrane Manufacturer (**MANUFACTURER**) - The party responsible for manufacturing the geomembrane rolls.

D. Geosynthetic Quality Assurance Laboratory (**TESTING LABORATORY**) - The party, independent from the MANUFACTURER and INSTALLER, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the OWNER.

E. **INSTALLER**- Party responsible for field handling, transporting, storing and deploying the geocomposite.

F. **Lot**- A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geocomposite rolls. The finished rolls will be identified by a roll number traceable to the resin lot.

G. **Panel** - Unit area of a geomembrane that will be seamed in the field that is larger than 100 ft².

H. **Patch** - Unit area of a geomembrane that will be seamed in the field that is smaller than 100 ft².

I. **Subgrade Surface** - Soil layer surface which immediately underlies the geosynthetic material(s).

1.04 SUBMITTALS (POST-AWARD)

- A. Furnish the following product data, in writing, to ENGINEER prior to installation of the geomembrane material:
 - 1. Resin Data shall include the following:
 - a. Certification stating that the resin meets the specification requirements.
 - 2. Geomembrane Roll
 - a. Statement certifying no recycled polymer and no more than 10% rework of the same type of material is added to the resin (product run may be recycled).

- B. The INSTALLER shall furnish the following information to the ENGINEER and OWNER prior to installation:
 - 1. Installation layout drawings
 - a. Must show proposed panel layout including field seams and details.
 - b. Must be approved prior to installing the geomembrane.
 - 2. Approved drawings will be for concept only and actual panel placement will be determined by site conditions.
 - 3. Installer's Geosynthetic Field Installation Quality Assurance Plan.

- C. The INSTALLER will submit the following to the ENGINEER upon completion of installation:
 - 1. Certificate stating the geomembrane has been installed in accordance with the Contract Documents.
 - 2. Material and installation warranties.
 - 3. As-built drawings showing actual geomembrane placement and seams, including typical anchor trench detail.

1.05 QUALITY ASSURANCE

- A. The OWNER will engage and pay for the services of a Geosynthetic Quality Assurance Consultant and Laboratory to monitor geomembrane installation.

1.06 QUALIFICATIONS

- A. MANUFACTURER
 - 1. MANUFACTURER shall have manufactured a minimum of **10,000,000** square feet of polyethylene geocomposite material during the last year.

- B. INSTALLER

1. INSTALLER must be certified by the MANUFACTURER.
2. INSTALLER shall have installed a minimum of **50,000** square feet of geocomposite in the last **5** years.
3. INSTALLER shall have worked in a similar capacity on at least **3** projects similar in complexity to the project described in the contract documents, and within at least **50,000** square feet of geonet installation on each project.
4. The Installation Supervisor shall have worked in a similar capacity on projects similar in size and complexity to the project described in the Contract Documents.
5. The INSTALLER shall provide a minimum of one Master Seamer for work on the project.
 - a. Master Seamer must have completed a minimum of **1,000,000** square feet of geomembrane seaming work using the type of seaming apparatus required for the welds proposed for the use on this Project.

1.07 MATERIAL LABELING, DELIVERY, STORAGE AND HANDLING

- A. **Labeling** - Each roll delivered to the site shall be wrapped and labeled by the MANUFACTURER. The label will identify:
 1. manufacturer's name
 2. product identification
 3. length
 4. width
 5. roll number
- B. **Delivery** - Rolls will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.
- C. **Storage**- The on-site storage location provided by the CONTRACTOR to protect the geomembrane from abrasions, excessive dirt, and moisture shall have the following characteristics:
 1. level (no wooden pallets)
 2. smooth
 3. dry
 4. protected from theft and vandalism
 5. adjacent to the area being lined
- D. **Handling**
 1. The CONTRACTOR and INSTALLER shall handle all rolls in such a manner as to ensure they are not damaged in any way and conform to MANFUCATURER .

2. The INSTALLER shall take any necessary precautions to prevent damage to underlying layers during placement of the drainage material.

1.08 WARRANTY

- A. Material shall be warranted, on a pro-rata basis, against defects for a period of 5 years from the date of the geomembrane installation.
- B. Installation shall be warranted against defects in workmanship for a period of 1 year from the date of geomembrane completion.

PART 2 - PRODUCTS

2.01 GEOMEMBRANE PROPERTIES

- A. Material shall be smooth polyethylene geomembrane as shown on the project drawings and as stated as follows:
 1. **Primary Liner**
The primary liner shall be a **white** HDPE geomembrane capable of leak location by means of spark testing (ASTM D7240).
 2. **Secondary Liner**
The secondary liner shall be a **black** HDPE geomembrane capable of leak location by means of spark testing (ASTM D7240).
- B. Resin
 1. Resin shall be new first quality, compounded polyethylene resin.
 2. Natural resin (without carbon black) shall meet the following additional minimum requirements:

Table 1-3: Raw Material Properties

Property	Test Method	Value
Density (g/cm ³)	ASTM D1505	≥ 0.94
Melt Flow Index (g/10 min)	ASTM D1238	≤ 1.0
OIT (minutes)	ASTM D3895	≥ 100

- C. Geomembrane Rolls
 1. Do not exceed a combined maximum total of 1 percent by weight of additives other than carbon black.
 2. Geomembrane shall be free of holes, pinholes as verified by on-line electrical detection, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.

3. Geomembrane material is to be supplied in roll form. Each roll is to be identified with labels indicating roll number, thickness, length, width and MANUFACTURER.
4. All liner sheets produced at the factory shall be inspected prior to shipment for compliance with the physical property requirements listed in this specification and be tested by an acceptable method of inspecting for pinholes. If pinholes are located, identified and indicated during manufacturing, these pinholes may be corrected during installation.

D. Smooth surfaced geomembrane shall meet the requirements shown in the following data sheet:

Tested Property	Test Method	Frequency	Minimum Average Values				
			30 mil	40 mil	60 mil	80 mil	100 mil
Thickness, mil Lowest individual reading	ASTM D 5199	every roll	30 27	40 36	60 54	80 72	100 90
Density, g/cm ³ , (min.)	ASTM D 1505	200,000 lbs.	0.940	0.940	0.940	0.940	0.940
Tensile Properties (each direction) Strength at Break, lb/in-width Strength at Yield, lb/in-width Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 2 ipm G.L. 2.0 in G.L. 1.3 in	20,000 lbs	114 63 700 12	152 84 700 12	228 126 700 12	304 168 700 12	380 210 700 12
Tear Resistance, lb.	ASTM D 1004	45,000 lbs.	21	28	42	56	70
Puncture Resistance, lb.	ASTM D 4833	45,000 lbs	54	72	108	144	180
Carbon Black Content, % (Range)	ASTM D 1603*/4218	20,000 lbs	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lbs	Note ⁽¹⁾	Note ⁽¹⁾	Note ⁽¹⁾	Note ⁽¹⁾	Note ⁽¹⁾
Notch Constant Tensile Load, hr.	ASTM D 5397, Appendix	200,000 lbs	300	300	300	300	300
Oxidative Induction Time, min	ASTM D 3895, 200°C; O ₂ , 1 atm	200,000 lbs	>100	>100	>100	>100	>100
Typical Roll Dimensions							
Roll Length ⁽²⁾ , ft.			1,120	870	560	430	340
Roll Width ⁽²⁾ , ft.			22.5	22.5	22.5	22.5	22.5
Roll Area, ft ²			25,200	19,575	12,600	9,675	7,650

NOTES:

- ⁽¹⁾Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- ⁽²⁾Roll lengths and widths have a tolerance of ± 1%.
- GSE HD Smooth is available in rolls weighing approximately 4,000 lb.
- All GSE geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTb of <-77° C when tested according to ASTM D 746.
- *Modified.

E. Extrudate Rod or Bead

1. Extrudate material shall be made from same type resin as the geomembrane.
2. Additives shall be thoroughly dispersed.
3. Materials shall be free of contamination by moisture or foreign matter.

2.02 EQUIPMENT

- A. Welding equipment and accessories shall meet the following requirements:
 - 1. Gauges showing temperatures in apparatus such as extrusion welder or fusion welder shall be present.
 - 2. An adequate number of welding apparatus shall be available to avoid delaying work.
 - 3. Power source must be capable of providing constant voltage under combined line load.

PART 3 - EXECUTION

3.01 DEPLOYMENT

- A. Assign each panel a simple and logical identifying code. The coding system shall be subject to approval and shall be determined at the job site.
- B. Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas.
- C. Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:
 - 1. Geomembranes shall be installed according to site-specific specifications, and the MAUNFACTURER
 - 2. Unroll geomembrane using methods that will not damage geomembrane and will protect underlying surface from damage (spreader bar, protected equipment bucket).
 - 3. Place ballast (commonly sandbags) on geomembrane which will not damage geomembrane to prevent wind uplift.
 - 4. Personnel walking on geomembrane shall not engage in activities or wear shoes that could damage it. Smoking will not be permitted on the geomembrane.
 - 5. Do not allow heavy vehicular traffic directly on geomembrane. Rubber-tired ATV's and trucks are acceptable if wheel contact is less than 8 psi (1150 psf).
 - 6. Protect geomembrane in areas of heavy traffic by placing protective cover over the geomembrane.

3.02 MATERIAL PLACEMENT

- A. The geocomposite roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the ENGINEER.
- B. If the project contains long, steep slopes, special care should be taken so that only full length rolls are used at the top of the slope.

- C. In the presence of wind, all geocomposites shall be weighted down with sandbags or the equivalent. Such sandbags shall be used during placement and remain until replaced with cover material.
- D. If the project includes an anchor trench at the top of the slopes, the geocomposite shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geocomposite.
- E. In applying fill material, no equipment can drive directly across the geocomposite. The specified fill material shall be placed and spread utilizing vehicles with a low ground pressure.
- F. The cover soil shall be placed in the geocomposite in a manner that prevents damage to the geocomposite. Placement of the cover soil shall proceed immediately following the placement and inspection of the geocomposite.

3.03 FIELD SEAMING

- A. Seams shall meet the following requirements:
 - 1. To the maximum extent possible, orient seams parallel to line of slope, i.e., down and not across slope.
 - 2. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.
 - 3. Slope seams (panels) shall extend a minimum of five-feet beyond the grade break into the flat area.
 - 4. Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the CONSULTANT and INSTALLER.
 - 5. Align seam overlaps consistent with the requirements of the welding equipment being used. A 6-inch overlap is commonly suggested.
- B. Welding Operations
 - 1. Provide at least one Master Seamer who shall provide direct supervision over other welders as necessary.
- C. Extrusion Welding
 - 1. Hot-air tack adjacent pieces together using procedures that do not damage the geomembrane.
 - 2. Clean geomembrane surfaces by disc grinder or equivalent.
 - 3. Purge welding apparatus of heat-degraded extrudate before welding.
- D. Hot Wedge Welding
 - 1. Welding apparatus shall be a self-propelled device equipped with an electronic controller which displays applicable temperatures.

2. Clean seam area of dust, mud, moisture and debris immediately ahead of hot wedge welder.
3. Protect against moisture build-up between sheets.

E. Trial Welds

1. Perform trial welds on geomembrane samples to verify welding equipment is operating properly.
2. Make trial welds under the same surface and environmental conditions as the production welds, i.e., in contact with subgrade and similar ambient temperature.
3. Minimum of two trial welds per day, per welding apparatus, one made prior to the start of work and one completed at mid shift.
4. Cut four, one-inch wide by six-inch long test strips from the trial weld.
5. Quantitatively test specimens for peel adhesion, and then for shear strength.
6. Trial weld specimens shall pass when the results shown in the following tables for HDPE and LLDPE are achieved in both peel and shear test.

Table 1.12.6A: Minimum Weld Values for HDPE Geomembranes (English)

Property	Test Method	30	40	60	80	100	120
Peel Strength (fusion), ppi	ASTM D 6392	49	65	98	130	162	196
Peel Strength (extrusion), ppi	ASTM D 6392	39	52	78	104	130	157
Shear Strength (fusion & ext.), ppi	ASTM D 6392	61	81	121	162	203	242

- a. The break, when peel testing, occurs in the liner material itself, not through peel separation (FTB).
 - b. The break is ductile.
7. Repeat the trial weld, in its entirety, when any of the trial weld samples fail in either peel or shear.
 8. No welding equipment or welder shall be allowed to perform production welds until equipment and welders have successfully completed trial weld.

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

G. Defects and Repairs

1. Examine all seams and non-seam areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

2. Repair and non-destructively test each suspect location in both seam and non-seam areas. Do not cover geomembrane at locations that have been repaired until test results with passing values are available.

3.04 FIELD QUALITY ASSURANCE

- A. MANUFACTURER and INSTALLER shall participate in and conform to all terms and requirements of the Owner's quality assurance program. CONTRACTOR shall be responsible for assuring this participation.
- B. Quality assurance requirements are as specified in this Section and in the Field Installation Quality Assurance Manual if it is included in the contract.
- C. Field Testing
 1. Non-destructive testing may be carried out as the seaming progresses or at completion of all field seaming.
 - a. Spark Testing
Spark testing shall be performed accordance with ASTM D 7240 - Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test).
 2. Destructive Testing (performed by CONSULTANT with assistance from INSTALLER)
 - a. Location and Frequency of Testing
 - 1) Collect destructive test samples at a frequency of one per every 500 lineal feet of seam length or.
 - 2) Test locations will be determined after seaming.
 - 3) Exercise Method of Attributes as described by GRI GM-14 (Geosynthetic Research Institute, <http://www.geosynthetic-institute.org>) to minimize test samples taken.
 - b. Sampling Procedures are performed as follows:
 - 1) INSTALLER shall cut samples at locations designated by the CONSULTANT as the seaming progresses in order to obtain field laboratory test results before the geomembrane is covered.
 - 2) CONSULTANT will number each sample, and the location will be noted on the installation as-built.

- 3) Samples shall be twelve (12) inches wide by minimal length with the seam centered lengthwise.
- 4) Cut a 2-inch wide strip from each end of the sample for field-testing.
- 5) Cut the remaining sample into two parts for distribution as follows:
 - a) One portion for INSTALLER, 12-inches by 12 inches
 - b) One portion for the Third Party laboratory, 12-inches by 18-inches
 - c) Additional samples may be archived if required.
- 6) Destructive testing shall be performed in accordance with ASTM D 6392 - Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
- 7) INSTALLER shall repair all holes in the geomembrane resulting from destructive sampling.
- 8) Repair and test the continuity of the repair in accordance with these Specifications.

3.05 REPAIR PROCEDURES

- A. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.
- B. Repair any portion of unsatisfactory geomembrane or seam area failing a destructive or non-destructive test.
- C. INSTALLER shall be responsible for repair of defective areas.
- D. Agreement upon the appropriate repair method shall be decided between CONSULTANT and INSTALLER by using one of the following repair methods:
 1. Patching- Used to repair large holes, tears, undispersed raw materials and contamination by foreign matter.
 2. Abrading and Re-welding- Used to repair short section of a seam.
 3. Spot Welding- Used to repair pinholes or other minor, localized flaws or where geomembrane thickness has been reduced.
 4. Capping- Used to repair long lengths of failed seams.

5. Flap Welding- Used to extrusion weld the flap (excess outer portion) of a fusion weld in lieu of a full cap.
 6. Remove the unacceptable seam and replace with new material.
- E. The following procedures shall be observed when a repair method is used:
1. All geomembrane surfaces shall be clean and dry at the time of repair.
 2. Surfaces of the polyethylene which are to be repaired by extrusion welds shall be lightly abraded to assure cleanliness.
 3. Extend patches or caps at least 6 inches for extrusion welds and 4 inches for wedge welds beyond the edge of the defect, and around all corners of patch material.
- F. Repair Verification
1. Number and log each patch repair (performed by CONSULTANT).
 2. Non-destructively test each repair using methods specified in this Specification.

PART 4 - MEASUREMENT AND PAYMENT

- A. Payment for geomembrane installation will be as per contract unit price per square foot, as measured parallel to liner surface, including designed anchor trench material and is based upon net lined area.
- B. Net lined area is defined to be the true area of all surfaces as measured by survey to be lined plus designed burial in all anchor trenches, rub sheets, and sacrificial layers.
- C. Prices shall include full compensation for furnishing all labor, material, tools, equipment, and incidentals.
- D. Prices also include doing all the work involved in performing geomembrane installation completely as shown on the drawings, as specified herein, and as directed by the ENGINEER.

END OF SECTION

SECTION 03500
HIGH DENSITY POLYETHYLENE (HDPE) PIPE

PART 1 - GENERAL

1.01 SUMMARY

A. DESCRIPTION

The work in this section consists of providing High Density Polyethylene (HDPE) pipe and fittings.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D3350 – Standard Specification for Polyethylene Plastics Pipe and Fitting Materials
2. ASTM F714 – Standard Specification for Polyethylene (PE) Pipe (SDR-PR) Based on Outside Diameter
3. ASTM D3035 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
4. ASTM D2774 – Standard Practice for Underground Installation of Thermoplastic Pressure Piping
5. ASTM F1668 – Standard Guide for Construction Practices for Buried Plastic Pipe
6. ASTM F2620 – Standard Practice for Heat Fusion of Polyethylene Pipe and Fittings
7. ASTM D3261 – Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
8. ASTM F2206 – Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE) Plastic Pipe, Fittings, Sheet Stock, Plate Stock or Block Stock

B. Handbook of Polyethylene Pipe

C. AWWA M55, PE Pipe – Design and Installation

1.03 SUBMITTALS

- A. Material list naming each product to be used identified by manufacturer and type number.

1.04 PRODUCT HANDLING

- A. Handle pipe and fittings to insure delivery in a sound, undamaged condition.

PART 2 - PRODUCTS

2.01 PIPE

- A. Pipe shall be manufactured from a PE 3608 resin listed with the Plastic Pipe Institute (PPI) as TR-4. The resin material will meet the specifications of ASTM D 3350 with a cell classification of 345464C. Pipe shall have a manufacturing standard of ASTM F 714. Pipe shall be DR 17 (100psi WPR) unless otherwise specified on the plans. The pipe shall contain no recycled compounds except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.

2.02 FITTINGS

A. Butt Fusion Fittings

- 1. Fittings shall be PE3608 HDPE, minimum cell classification of 345464C as determined by ASTM D 3350. Molded butt fusion fittings shall have a manufacturing standard of ASTM D 3261. Molded fittings shall have the same pressure rating as the pipe unless otherwise specified on the plans. Fabricated fittings are to be manufactured using a Data Logger. Temperature, fusion pressure and a graphic representation of the fusion cycle shall be part of the quality control records.

B. Electrofusion Fittings

- 1. Fittings shall be PE3608 HDPE, minimum cell classification of 345464C as determined by ASTM D 3350. Electrofusion Fittings shall have a manufacturing standard of ASTM F 1055. Fittings shall have the same pressure rating as the pipe unless otherwise specified on the plans.

C. Flanged and Mechanical Joint Adapters

- 1. Flanged and Mechanical Joint Adapters shall be PE 3608 HDPE, minimum cell classification of 345464C as determined by ASTM D 3350. Flanged and Mechanical Joint Adapters shall have a manufacturing standard of ASTM D 3261. Fittings shall have the same pressure rating as the pipe unless otherwise specified on the plans.

PART 3 - EXECUTION

3.01 GENERAL

- A. Pipe and Fittings: Size as indicated on the plans. Install as shown in accordance with manufacturer's recommendations.

3.02 HAULING, UNLOADING and DISTRIBUTING PIPE:

- A. During loading, transportation and unloading, every precaution shall be taken to prevent injury to the pipe. No pipe shall be dropped from cars or trucks, or allowed to roll down slides without proper retaining ropes. During transportation each pipe shall rest on suitable pads, strips, skids or blocks securely wedged or tied in place. Any pipe damaged shall be replaced.

3.03 FUSION

- A. Sections of polyethylene pipe should be joined into continuous lengths on the jobsite above ground. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations. The butt fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements of 400-450 degrees Fahrenheit, alignment, and an interfacial fusion pressure of 75 PSI. The butt fusion joining will produce a joint with weld strength equal to or greater than the tensile strength of the pipe itself. All field welds shall be made with fusion equipment equipped with a Data Logger. Temperature, fusion pressure and a graphic representation of the fusion cycle shall be part of the Quality Control records.
- B. Sidewall fusions for connections to outlet piping shall be performed in accordance with HDPE pipe and fitting manufacturer's specifications. The heating irons used for sidewall fusion shall have an inside diameter equal to the outside diameter of the HDPE pipe being fused. The size of the heating iron shall be ¼ inch larger than the size of the outlet branch being fused.
- C. Mechanical joining will be used where the butt fusion method cannot be used. Mechanical joining will be accomplished by either using a HDPE flange adapter with a ductile iron back-up ring or HDPE Mechanical Joint adapter with a ductile iron back-up ring.
- D. Socket fusion, hot gas fusion, threading, solvents, and epoxies will not be used to join HDPE pipe.

3.04 INSPECTION

- A. Inspect the pipe for defects before installation and fusion. Defective, damaged or unsound pipe will be rejected.

3.05 TESTING

- A. Hydrostatic testing will not be required.

PART 4 - MEASUREMENT AND PAYMENT

- A. No separate payment will be made for “HDPE Pipe”.
- B. Payment will be made under “Pump and Controller Installation” on a lump sum basis.

END OF SECTION

SECTION 04100 LEACHATE EXTRACTION PUMPS

PART 1 - GENERAL

1.01 SUMMARY

A. DESCRIPTION

1. The leachate extraction pumping system(s) outlined in this section shall perform to the design operating requirements within the conditions and dimensions as described and shall be complete and at a minimum consist of the following:
 - a. A pump and motor assembly with power cable;
 - b. Control panel and level sensor and cable with gages and meters as required;
 - c. Deployment and retrieval assembly to include pump carriage;
 - d. Discharge pipe assembly;
 - e. Appropriate exit fitting for gas-tight transition through the sump or riser wall, and;
 - f. All appropriate fasteners, fittings and accessories necessary for “Turn-Key” operation.
2. The system shall be designed for primary, secondary and or leakage detection service. Multiple systems shall ideally be identical and interchangeable and if not identical, will share as many identical, similar and interchangeable components and characteristics as possible.

1.02 QUALITY ASSURANCE

- A. Hydraulic Institute Compliance: design, manufacture, and install pumps in accordance with “Hydraulic Institute Standards.”
- B. National Electrical Code Compliance: Components shall comply with NFPA 70 “National Electrical Code.”
- C. Underwriter’s Laboratories (UL) Compliance: pumps shall be listed and labeled by UL and comply UL Standard 778 “Motor Operated Water Pumps.”
- D. SSPMA Compliance: Test and rate sump and sewage pumps in accordance with the Sump and Sewage Pump Manufacturers Association (SSPMA) Standards.
- E. Single-Source Responsibility: Obtain pumps of the same type from a single manufacturer.

- F. Pumping manufacturer shall have a MINIMUM of five (5) years of experience with their proposed type of pumping system in a leachate application.
- G. Design Criteria: The Drawings indicate sizes, profiles, connections, and dimensional requirements of pumps and are based on the specific manufacturer types and models indicated. Pumps having equal performance characteristics by other manufacturers may be considered, provided that deviations in dimensions and profiles do not change the design concept or intended performance as judged by the Engineer. The burden of proof for equality of pumps is on the proposer.

1.03 DELIVERY, STORAGE, AND HANDLING

- A. Store pumps in a dry location.
- B. Retain shipping flange protective covers and protective coatings during storage.
- C. Protect equipment and couplings against damage from sand, grit, and other foreign matter.
- D. Comply with manufacturer's rigging instructions for handling.

1.04 MANUFACTURER'S WARRANTY

- A. The pump manufacturer shall warrant all equipment to be of quality construction, free of defects in material and workmanship. A written warranty shall include specific details described below.
 - 1. All equipment, apparatus, and parts furnished shall be warranted for one (1) year, excepting only those items that are normally consumed in service, such as light bulbs, oils, grease, packing, gaskets, a-rings, etc. The pump manufacturer shall be solely responsible for warranty of all pump components.
- B. Components failing to perform as specified by the Engineer, or as represented by the manufacturer, or as proven defective in service during warranty period, shall be replaced, repaired, or satisfactorily modified by the manufacturer.
- C. It is not intended that the manufacturer assume liability for consequential damages or contingent liabilities arising from failure of any vendor supplied product or part which fails to properly operate, however caused. Consequential damages resulting from defects in design or delays in delivery are also beyond the manufacturer's scope of liability.
- D. The warranty shall become effective upon acceptance by the purchaser or the purchaser's authorized agent, or sixty (60) days after installation, or ninety (90) days after shipment, whichever occurs first.

1.05 SUBMITTALS

- A. Contractor shall submit pump technical specifications including but not limited to; pump performance curves, shop drawings, electrical diagrams, and any other pertinent information to the Engineer prior to project execution.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. The contractor shall furnish and install a complete leachate pumping system as manufactured by:
1. Environmental Pump Solutions, Inc. (EPS)
PO Box 3726
Ann Arbor, MI 48106-3726
1-888-512-1110
 2. Any system manufacturer or supplier not specifically named as an approved manufacturer must provide a complete submittal package to the Engineer prior to the bid date for pre-approval as an equal system provider. To simplify comparison, the manufacturer seeking approval will provide references and documentation of experience and a thorough technical brief addressing each specifying paragraph as either "no exception taken" (acceptance of both the fact and spirit of the designer's intent) or "exception taken" with arguments for equality to the specification.
- B. Available Products: Subject to compliance with requirements, products that may be incorporated in the work include the following (or approved equal):
1. Leachate Riser Pumps (Collection and Detection):
 - a. EPS Model No. **50290**, Reference Number **10SRP05-6** rated for **15** GPM @ **30** feet of Total Dynamic Head.
 - b. Motor Horsepower: Motor horsepower shall be a minimum of ½ horsepower, and shall operate on 230 Volt, 3-phase, 60 hertz supply power.

2.02 LEACHATE RISER PUMPS

- A. Pump Construction
1. The materials of pump construction shall be as follows:
 - a. Impeller – 304 Stainless Steel
 - b. Impelled Seal Ring – Teflon®
 - c. Motor Adaptor – 304 Stainless Steel

- d. Inlet Screen – 304 Stainless Steel
- e. Pump Shaft: 431 Stainless Steel
- f. Coupling: 316 Stainless Steel
- g. Check Valve Housing: 304 Stainless Steel
- h. Check Valve: 304 Stainless Steel
- i. Check Valve Seat: 304 Stainless Steel
- j. Diffuser Chamber: 304 Stainless Steel
- k. Fasteners: 304 Stainless Steel
- l. Bearings: Teflon®
- m. Suspension Cables: 3/16”- 7x19 Braided 304 Stainless Steel

B. Submersible Motors

- 1. Motors shall be 4-inch, corrosion-resistant motors having the following characteristics:
 - a. Temperature and Time Rating:
Continuous duty with 0.25 ft/sec. flow past motor. Temperature 30°C ambient.
 - b. Enclosure:
Hermetically sealed windings (no arc producing devices), corrosion-resistant materials. Stainless steel, splined shaft.
 - c. Bearings:
 - 1) Thrust Bearing: (Stationary) Carbon
 - 2) Radial Bearing: (Complete) Ceramic
 - 3) Thrust Bearing: (Rotating) Ceramic
 - d. Lubrication:
Water Bases

C. Carriage System

- 1. Pump shall be mounted in a High Density Polyethylene (HDPE) carriage designed for side slope riser leachate applications. Wheels will NOT be of an acceptable construction due to wear, failure and/or immobility caused by lack of contact with the inside diameter of the riser pipe.

D. Check Valve

- 1. Check valve shall be pre-drilled with a 1/8” diameter hole, to prevent freezing in discharge line.

E. Spare Parts

1. Provide one complete spare pump (packaged and labeled for storage) with stainless steel cable, power and control cable of proper length.
- F. Submersible Transducer
1. A submersible transducer shall be provided with an adequate size cable for each pump (including spare). The transducer shall be constructed from 316 stainless steel. The unit shall provide a 4-20mA signal output to the control unit. Static accuracy rating shall be no less than $\pm 0.1\%$ of full scale. Cable shall be the same length as the pump power cable.

2.03 EXAMINATION

- A. Examine areas, equipment foundations, and conditions with Installer present, for compliance with requirements for installation and other conditions affecting performance of pumps. Do NOT proceed with installation until unsatisfactory conditions have been corrected.
- B. Examine rough-in for piping systems to verify actual locations of piping connections prior to installation.

2.04 INSTALLATION

- A. Comply with the manufacturer's written installation and alignment instructions.
- B. Install pumps in indicated locations.

2.05 CONNECTIONS

- A. Install discharge pipe sizes equal to the diameter of the pump discharge.
- B. Discharge pipe shall be High Density Polyethylene (HDPE) hard piped directly to the discharge exit connection.
- C. Discharge exit connection shall be minimum 304 stainless steel "Pitless" style quick disconnect fitting.

2.06 COMMISSIONING

- A. After installation of pumps and related piping and controls, manufacturer's representative to perform system start-up and test to ensure proper functioning of pumping systems.

PART 3 - EXECUTION – NOT USED

PART 4 - MEASUREMENT AND PAYMENT

- A. No separate payment for "Leachate Extraction Pump".

- B. Payment will be made under “Pump and Controller Installation” on a lump sum basis.

END OF SECTION

SECTION 04200 CONTROL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

- A. Furnish one control system to operate ½ HP pump motor and auxiliary equipment in manual or automatic mode.
- B. The control panel enclosure shall be NEMA type 4X.
- C. The enclosure shall be equipped with a window in the outer door, an inner door, and a drip shield. The NEMA 4X enclosure can be either stainless steel (Standard) or non-metallic.
- D. The control system will operate from a 230 Volt, 60 Hertz, 3-phase, power supply. Pump control components shall be sized to operate a pump motor of specified horsepower.
- E. Multiple systems shall ideally be identical and interchangeable and if not identical, will share as many identical, similar and interchangeable components and characteristics as possible.

1.02 MANUFACTURER'S WARRANTY

- A. The control system manufacturer shall warrant all equipment to be of quality construction, free of defects in material and workmanship. A written warranty shall include specific details described below.
 - 1. All equipment, apparatus, and parts furnished shall be warranted for one (1) year, excepting only those items that are normally consumed in service, such as light bulbs, oils, grease, packing, gaskets, a-rings, etc. The control system manufacturer shall be solely responsible for warranty of all control system components.
- B. Components failing to perform as specified by the Engineer, or as represented by the manufacturer, or as proven defective in service during warranty period, shall be replaced, repaired, or satisfactorily modified by the manufacturer.
- C. It is not intended that the manufacturer assume liability for consequential damages or contingent liabilities arising from failure of any vendor supplied product or part which fails to properly operate, however caused. Consequential damages resulting from defects in design or delays in delivery are also beyond the manufacturer's scope of liability.

- D. The warranty shall become effective upon acceptance by the purchaser or the purchaser's authorized agent, or sixty (60) days after installation, or ninety (90) days after shipment, whichever occurs first.

1.03 SUBMITTALS

- A. Contractor shall submit to Engineer full technical specifications of the control system prior to project execution.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. The Contractor shall furnish and install a complete control system as manufactured by:
1. Environmental Pump Solutions, Inc. (EPS)
PO Box 3726
Ann Arbor, MI 48106-3726
1-888-512-1110
 2. Any system manufacturer or supplier not specifically named as an approved manufacturer must provide a complete submittal package to the Engineer prior to the bid date for pre-approval as an equal system provider. To simplify comparison, the manufacturer seeking approval will provide references and documentation of experience and a thorough technical brief addressing each specifying paragraph as either "no exception taken" (acceptance of both the fact and spirit of the designer's intent) or "exception taken" with arguments for equality to the specification.
- B. Available Products: Subject to compliance with requirements, products that may be incorporated in the work include the following (or approved equal):
1. Control System
 - a. EPS Model No. **50892**, Simplex 100S PLC Commander Controller.
 - b. Control system will operate from a 230 Volt, 60 Hertz, 3-phase power supply. Pump control components shall be sized to operate a pump motor of the specified horsepower.

2.02 CONTROL PANEL

- A. **Control Panel Construction Standards**
1. The control panel shall be constructed in accordance with Underwriter's Laboratories (UL) Standard 508 "Industrial Control Equipment" and UL standard 698A Industrial Control Panels Relating to Hazardous (Classified Locations). The panel shall be shop inspected by UL, or constructed in a UL recognized

facility. The panel shall bear a serialized UL label indicating acceptance under Standards 508 and 698A.

B. Pump Controller

1. The level controller shall be mounted on the inner door and viewable by the enclosure outer door window. The controller shall have a 4-digit, 13.8mm, 14-segment readout, scrolling help text and the capability to monitor and maintain liquid levels as well as output a high level indication. Level controller shall be accurate to within 0.1 inch.

C. Level Transducer

1. A submersible level transducer shall be provided in the sump. The transducer shall be of a suspended type and shall be constructed from 316 stainless steel. A 4-20 mA signal shall be output to the controller for display and control of sump level.
2. The pressure transmitter level sensor shall have a range of 0 to 5 PSI with a 4-20 mA output signal proportional to the required sump level.

D. Flow Meter

1. A paddle wheel type or magnetic flow meter shall be provided in the discharge line. The flow sensor shall be constructed of PVC, and shall be of insertion type. A square wave signal shall be output to the controller for display of flow and total flow.

E. Main Disconnect Switch

1. The main disconnect switch shall be UL 98 rated and will prevent opening of the control panel inner door while the power is on, and includes 230 Volt, 2.5 Amp dual element fuses.

F. Control Circuit Breaker

1. A UL 489 type current limiting circuit breaker shall be provided on the control circuit.

G. Hand-Off-Auto Selector Switch

1. Allows manual or automatic operation of the pump motor. The selector switch shall be a heavy duty, oil tight, NEMA 4 rated switch mounted on the inner door and shall be viewable by the enclosure outer door window.

H. Motor Starter

1. Provide full voltage non-reversing, circuit breaker combination type with adjustable electronic overload relay.

I. Wire Markers

1. Brady type printed wire markers shall be provided on both ends of all conductors to correlate with manufactures drawings.

J. Terminal Blocks

1. Provide terminal blocks sized for the wire used for all field terminations. Clearly mark all terminal blocks with a typewritten marking system. Terminal blocks shall be DIN rail mounted, screw clamp, feed through type with 600 volt minimum rating.

K. Control Relays

1. Control relays shall be general purpose type, contacts rated 10 amps at 120 VAC, coil voltage as required, and include indicator lamp.

L. Control Transformer

1. A transformer with UL 489 type current limiting circuit breakers on the primary and secondary circuits shall be provided where required. If fuses are used provide 10 of each type used as spare parts.

M. Run Light

1. A pump running indicator lamp shall be provided. It shall be heavy duty, LED, oil tight, NEMA 4 rated. The light shall be connected to the motor starter auxiliary contacts and shall be mounted on the inner door and will be green in color and viewable by the enclosure outer door window.

N. Run Time Meter

1. A pump run time meter shall be provided and incorporated into the controller. The runtime meter shall be connected to the motor starter auxiliary contacts and shall be mounted on the inner door and viewable by the enclosure outer door window.

O. Alarm Light

1. A red 25 watt high intensity alarm beacon shall be provided on top of the enclosure to provide high alarm indication. The lamp shall be replaceable from the inside of the enclosure so not to disrupt water tightness of the light fixture.

P. Intrinsically Safe Barrier

1. The level sensor circuit shall be protected by an intrinsically safe barrier.

Q. Heater with Adjustable Thermostat

1. A heater with adjustable thermostat shall be provided; it shall maintain the minimum temperature required for the operation of the level controller.

R. Lightning Arrestor

1. Eaton CHSA type or equal shall be provided.

S. Pass Along Circuit

1. A pass along circuit shall be provided to enable a shutdown of the pump in the event of a high level alarm at a storage facility.

T. Breakout Junction Box

1. An EPSBOB junction box with terminals shall be provided for connections of field devices to the control panel, 1 EPSBOB shall be provided for the pump power connection, and 1 shall be provided for the level transducer and flow meter. A poured seal off shall be installed between the EPSBOB and the control panel to prevent migration of landfill gasses into the control panel.

2.03 INSTALLATION

- A. Comply with the manufacturer's written installation instructions.
- B. Install control systems in indicated locations.

PART 3 - EXECUTION – NOT USED

PART 4 - MEASUREMENT AND PAYMENT

- A. No separate payment for "Control Systems".
- B. Payment will be made under "Pump and Controller Installation" on a lump sum basis.

END OF SECTION

SECTION 04300 ELECTROMAGNETIC FLOW METER

PART 1 - GENERAL

1.01 SUMMARY

- A. Electromagnetic flow meter is intended for fluid metering in industries including water, wastewater, food and beverage, pharmaceutical and chemical. Measures fluid flow of water or fluids which are highly corrosive, very viscous, contain a moderate amount of solids, or require special handling. No moving parts are in the flow stream. Amplifier can be integrally mounted to the detector or can be remote-mounted. Unit is ideally suited for measuring dynamic, non-continuous flow. In applications where a minimum and/or maximum flow rate must be tracked and monitored, the unit provides pulse signals that can be fed to dedicated batch controllers, PLCs and other more specialized instrumentation.

1.02 SCOPE

- A. This section describes the requirements for a flow sensor.
- B. This section describes the requirements for a flow sensor.

1.03 MANUFACTURER'S WARRANTY

- A. Terms
 - 1. The manufacturer of the above specified equipment warrants the Product to be free from defects in materials and workmanship appearing within the earlier of either: One (1) year after installation; or one (1) year and six (6) months after shipment from manufacturer.

1.04 QUALITY ASSURANCE

- A. Referenced Standards and Guidelines - Complies with applicable portions of ANSI/AWWA Standards and NSF/ANSI Standard 61, Annex G. There are currently no AWWA standards that specifically address electromagnetic metering.
 - 1. Flow measurement function to comply with the following Industry Standards:
 - a. ANSI B16.5 Class 150 RF
 - b. AWWA Class B
 - c. NEMA 4x/6P (IP66/IP67)
 - d. CSA

1.05 SUBMITTALS

- A. The following information shall be included in the submittal for this section:
1. Outline dimensions, conduit entry locations and weight.
 2. Customer connection and power wiring diagrams.
 3. Data sheets and catalog literature for microprocessor-based transmitter and transducer.
 4. Interconnection drawings.
 5. Installation and operations manual.
 6. List of spare parts.
 7. Complete technical product description including a complete list of options provided.
 8. Any portions of this specification not met must be clearly indicated or the supplier and contractor shall be liable to provide all additional components required to meet this specification.

1.06 DEFINITIONS

- A. Amplifier – Device used for increasing the power of a signal. It does this by taking energy from a power supply and controlling the output to match the input signal shape but with larger amplitude.
- B. ANSI – (American National Standards Institute) A private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States. The organization also coordinates U.S. standards with international standards so that American products can be used worldwide.
- C. AWWA – (American Water Works Association) An international non-profit professional organization founded to improve water quality and supply.
- D. Detector Coils – Also called an “induction loop”, an electromagnetic communication or detection system which uses a moving magnet to induce an electrical current in a nearby wire.

- E. Electrode – An electrical conductor used to make contact with a nonmetallic part of a circuit (e.g. a semiconductor, an electrolyte or a vacuum).
- F. Modbus RTU – a serial communications protocol published by Modicon (now Schneider Electric) in 1979 for use with its programmable logic controllers (PLCs). This is used in serial communication & makes use of a compact, binary representation of the data for protocol communication.
- G. NEMA – (National Electrical Manufacturers Association) Is the 'Association of Electrical Equipment and Medical Imaging Manufacturers' in the United States. Its approximately 450 member companies manufacture products used in the generation, transmission, distribution, control, and end use of electricity. These products are used in utility, industrial, commercial, institutional, and residential applications.
- H. NSF – (National Science Foundation) A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering.
- I. PLCs – (Programmable Logic Controller) A digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many industries and machines.
- J. PTFE – (Polytetrafluoroethylene) A synthetic fluoropolymer of tetrafluoroethylene that finds numerous applications. The best known brand name of PTFE is Teflon by DuPont Co.
- K. Serial Communications – In telecommunication and computer science, serial communication is the process of sending data one bit at a time, sequentially, over a communication channel or computer bus. This is in contrast to parallel communication, where several bits are sent as a whole, on a link with several parallel channels.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. The Contractor shall furnish and install a complete control system as manufactured by:
Basis-of-Design Product: Subject to compliance with these specifications, provide flow measurement equipment by one of the following:
 - 1. Badger Meter
 - 2. Approved Equivalent

2.02 OPERATING CONDITIONS

A. System Components

1. Metering Tube (Detector)
 - a. Consists of stainless steel tube lined with a non-conductive material. Energized detector coils around tube create a magnetic field across the diameter of the pipe. As a conductive fluid flows through the magnetic field, a voltage is induced across two electrodes; this voltage is proportional to the average flow velocity of the fluid.
2. Signal Amplifier
 - a. Consists of unit which receives, amplifies, and processes the detector's analog signal. Signal is converted to both analog and digital signals that are used to display rate of flow and totalization. Processor controls zero-flow stability, analog and frequency outputs, serial communications and a variety of other parameters. Integrated LCD display indicates rate of flow, forward and reverse totalizers and diagnostic messages. Display guides user through programmable routines.

B. Operational Requirements

1. Electromagnetic Flow Meter
 - a. The flow meter system shall operate with a pulsed DC excitation frequency, and shall produce a signal output that is directly proportional and linear with the volumetric flow rate of the liquid flowing through the metering tube. The metering system shall include a metering sensor tube (detector), a signal amplifier, and the necessary connecting wiring. The metering system shall have the ability to incorporate a meter mounted or remote mounted amplifier.
 - b. Engineering Units:
 - 1) The signal amplifier shall be program selectable to display the following units of measure: U.S. gallons, imperial gallons, million gallons (U.S.), cubic feet, cubic meters, liters, hector-liters, oil barrels, pounds, ounces or acre feet.
 - c. Operating Principle: Electromagnetic Induction
 - d. Metering Tube (Detector)
 - 1) The metering tube (detector) shall be constructed of 316 stainless steel, and rated for a maximum allowable non-shock pressure and temperature for steel pipe flanges, according to ANSI B16.5.

- 2) The metering tube (detector) shall be available in line size from ¼" [6 mm] to 54" [1400 mm].
 - 3) The metering tube (detector) end connections shall be carbon steel or 316 stainless steel flanged, according to ANSI B16, Class 150 and AWWA Class B standards.
 - 4) The insulating liner material of the metering tube (detector) shall be made of a hard rubber elastomer and NSF-listed for meter sizes 4" and above, in conformance with manufacturer's recommendation for the intended service or an NSF-listed meter option with PTFE liner.
 - 5) The metering tube (detector) shall include two self-cleaning measuring electrodes. The electrode material shall be corrosion resistant and available in Alloy C or 316 stainless steel.
 - 6) The metering tube (detector) shall include a third "empty pipe detection" electrode located in the upper portion of the inside diameter of the flow tube in order to detect an empty pipe condition when the flow tube is running partially empty. Empty pipe detection that is not activated until the pipe is 50% empty is not acceptable.
 - 7) The metering tube (detector) housing shall be constructed of carbon steel, welded at all joints, and rated to meet NEMA 4X/6P (IP66/IP67) ratings.
 - 8) For remote amplifier applications, the metering tube (detector) junction box enclosure shall be constructed of cast aluminum (powder-coated paint) and shall meet NEMA 4X/6P (IP66/IP67) ratings.
 - 9) When installed in non-metallic or internally lined piping, the metering tube (detector) shall be provided with a pair of corrosion resistant grounding rings. The grounding ring material shall be 316 stainless steel.
 - 10) Fluid Temperature Range
 - a) For remote amplifier applications, the fluid temperature range shall be 32°F to 178°F [0°C to 80°C] at a maximum ambient temperature of 122°F [50°C] for the hard rubber liner material.
- e. Signal Amplifier
- 1) The signal amplifier shall be microprocessor based, and shall energize the detector coils with a digitally controlled pulsed DC. The excitation frequency shall be program selectable for the following: 1Hz, 3.75Hz, 7.5Hz, or 15Hz. (factory optimized to pipe size and application)

- 2) The signal amplifier electrical power requirement shall be 85-265VAC, 45-65Hz. The power consumption shall not exceed 15W.
- 3) The signal amplifier shall have an ambient temperature rating of -4°F to 140°F [-20°C to 60°C].
- 4) The signal amplifier shall include non-volatile memory capable of storing all programmable data and accumulated totalizer values in the event of a power interruption.
- 5) Automatic zero stability, low flow cut-off, empty pipe detection and bi-directional flow measurement shall be inherent capabilities of the signal amplifier.
- 6) All signal amplifier outputs shall be galvanically isolated to 250 volts.
- 7) The signal amplifier and remote junction enclosures shall be constructed of cast aluminum (powder-coated paint) and shall meet NEMA 4X/6P (IP66/IP67) ratings.
- 8) Outputs

The signal amplifier shall provide a total of four digital outputs, one analog output and one digital output.

- a) Up to four open collector digital outputs, program selectable from the following: Forward pulse, reverse pulse, AMR pulse, flow set point, empty pipe alarm, flow direction, reset output, error alarm and 24V supply.
- b) Up to two active digital (24 Volt) outputs, program selectable from the following: Forward pulse, reverse pulse, AMR pulse, flow set point, empty pipe alarm, flow direction, preset output, error alarm and 24V supply.
- c) Up to two AC solid-state relay outputs, program selectable from the following: Frequency output, flow set point, empty pipe alarm, flow direction, preset amount and error alarm.
- d) One digital input, program selectable from the following: Remote reset, batch reset and positive return to zero.
- e) Advanced protocol support using Modbus/RTU.
- f) One analog output programmable and scalable from 4-20mA. Voltage sourced and isolated. Max. loop resistance = 800 ohms.

f. Control and Programming

- 1) The signal amplifier shall be programmed via three function buttons. The programming functions shall be available in a user-friendly, menu driven software through the four-line LCD interface. The signal amplifier shall accommodate the following languages: English, German, Czech, French or Spanish.
- 2) Programmable parameters of the amplifier include, but are not limited to: calibration factors, totalizer resets, unit of measure, analog and pulse output scaling, flow-alarm functions, language selection, low-flow cutoff, noise dampening factor and excitation frequency selection.
- 3) The signal amplifier shall have a programming option allowing entry of a selected numeric password value for tamper protection.

g. System Performance

- 1) The metering system shall operate over a flow range of 0.10 to 39.4 ft/s [0.03 to 12.0 m/s].
- 2) The metering system shall perform to an accuracy ± 0.25 percent of rate for velocities greater than 1.64 ft/s [0.50 m/s], ± 0.004 ft/s [± 1 mm/s] for velocities less than 1.64 ft/s [0.50 m/s].
- 3) The metering system shall be capable of measuring the volumetric flow rate of liquids having an electrical conductivity as low as 5.0 micromhos per centimeter.
- 4) The system measuring repeatability shall be $<0.10\%$ of full scale.

h. Indication

- 1) The signal amplifier shall include a four-line, 20-character, backlit LCD interface to display the following values:
 - a) Flow rate in selectable rate units
 - b) Forward totalizer in selectable volume units
 - c) Reverse totalizer in selectable volume units
 - d) Net totalizer in selectable volume units
 - e) Error or alarm messages
 - f) Software revision level

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Follow manufacturer's recommendation for installation. Installation will conform to the guidelines provided by the Installation & Operation Manual.
- B. Straight pipe requirement shall be an equivalent of three diameters on the inlet (upstream) side, and two diameters on the outlet (downstream) side.
- C. For best performance, place meter vertically, with liquid flowing upward and meter electrodes in a closed, full pipe.

3.02 CALIBRATION

- A. Each meter shall be hydraulically calibrated in an ISO 9000-certified testing facility, which utilizes a computerized gravimetric testing method with a measuring uncertainty of 0.1%.
- B. Each meter shall be provided with a calibration certificate indicating the measured error (percent deviation) at three different flows, respectively equivalent to 25%, 50% and 75% of the nominal flow rate for each size.

PART 4 - MEASUREMENT AND PAYMENT

- A. No separate payment will be made for "Electromagnetic Flow Meter".
- B. Payment will be made under "Pump and Controller Installation" on a lump sum basis.

END OF SECTION