SECTION G

SPECIFICATIONS

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PART 1– GENERAL

1.01 DESCRIPTION OF WORK

This section describes the furnishing and installation of textured surface high-density polyethylene (HDPE) geomembrane for the liner of the conveyance canal.

1.02 RELATED WORK SPECIFIED ELSEWHERE

The provisions and intent of the CT&C apply to this Work as if specified in this section. Work related to this section is described in the following sections:

A. Section 01300 – Submittals

B. Section 02315 – Excavation and Fill

1.03 REFERENCES

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

1. D 746. Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
2. D 792. Standard Test Methods for Specific Gravity and Density of Plastics by Displacement
3. D 1004. Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
4. D 1204. Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.
5. D 1238. Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
6. D 1505. Test Method for Density of Plastics by the Density-Gradient Technique.
7. D 1593. Specification for Nonrigid Vinyl Chloride Plastic Sheeting.
8. D 1603. Test Method for Carbon Black in Olefin Plastics.
9. D 3015. Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds.
10. D 3083. Standard Specification for Flexible Plastic Sheeting for Pond, Canal, and Reservoir Lining.
11. D 3895. Standard Test Method for Copper-Induced Oxidative Induction Time of Polyolefins by Thermal Analysis.

12. D 4437. Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

13. D 4833. Standard Test Method for Index Puncture of Geotextiles. Geomembranes, and Related Products.

14. D 5321. Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

15. D 5397. Notched Constant Tensile Load Test.

16. D 5994. Method for Measuring Core Thickness of Textured Geomembrane.

17. D 5596. Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.

18. D 6693. Standard Test Method for Tensile Properties of Plastics.

B. Federal Test Method Standards:

1. 101C. Puncture Resistance.

C. National Sanitation Foundation (NSF):

1. NSF 54. Flexible Membrane Liners.

D. Geosynthetic Research Institute Test Methods:

1. GM12. Measurement of the Aperity Height of Textured Geomembranes Using a Depth Gage.

2. GM13. Test Properties, Testing Frequency and Recommended Warranty for HDPE Smooth and Textured Geomembranes.

1.04 DEFINITIONS

A. Batch: A quantity of resin, usually the capacity of one railcar used in the fabrication of HDPE geomembrane sheet. The finished sheet will be identified by a roll number corresponding to the particular quantity of resin used.

B. Bridging: The condition when geomembrane becomes suspended over its subgrade due to contraction of the material or poor installation.

C. Construction Quality Assurance Consultant (CQAC): The party, independent from manufacturer or installer, who is responsible for observing and documenting activities related to the quality assurance of production and installation of the geosynthetic components of the lining system.

D. Construction Quality Assurance (CQA) Laboratory: The party, independent from the Engineer, manufacturer, fabricator, and installer, responsible for conducting tests on samples of geosynthetics obtained at the site.

E. Construction Quality Assurance (CQA) Monitor: The site representative of the CQAC.

F. Extrudate: The molten polymer which is emitted from an extruder during seaming using either extrusion fillet or extrusion flat methods. The polymer is initially in the form of a ribbon rod, bead, or pellets.

G. Fabricator: The party responsible for the fabrication of geomembrane panels constructed from rolls received from the manufacturer.

H. Geomembrane Manufacturer (Manufacturer): The party responsible for the production of the geomembrane rolls from resin and for the quality of the resin.

I. Geomembrane: An essentially impermeable membrane used as a solid or liquid barrier. Synonymous term for flexible membrane liner (FML).

J. Geomembrane Subsurface: The soil or geosynthetic surface on which the geomembrane lies.

K. Installer: The party responsible for field handling, transporting, storing, deploying, seaming, temporarily restraining (against wind), and installation of the geomembrane.

L. Panel: The unit area of geomembrane that will be seamed in the field. If the geomembrane is not fabricated into panels in a factory, a panel is identified as a roll or portion of a roll without any seams.

1.05 SUBMITTALS

A. Product Data: Submit the following to the Engineer 7 days prior to receiving material at site.

1. Resin Data (Manufacturer)

a) Statement of production date or dates.

b) Certification stating that the resin meets the product requirements (see Part 2.02).

c) Certification stating that all resin is from the same manufacturer.

d) Copy of quality control certificates issued by manufacturer.

e) Test reports from manufacturer.

2. Geomembrane Roll (Manufacturer)

a) Statement of production date or dates.

b) Laboratory test results and certification stating that the geomembrane meets the product requirements (see Part 2.03).

c) Certification stating that all geomembrane rolls are furnished by one supplier and that all rolls are manufactured from one resin type obtained from one resin supplier.

d) Copy of quality control certificates issued by manufacturer.

e) Test reports from the manufacturer.

f) Typical test results of complete notched constant tensile load test (ASTM D 5397) for specified resin and sheet thickness.

g) Statement certifying that no reclaimed polymer is added to the resin.

h) Statement listing percentages of processing aids, antioxidants, and other additives other than carbon black added to or in the resin.

i) Geomembrane delivery, storage, and handling instructions.

j) Geomembrane installation instructions.

k) Sample warranties for review.

B. Extrudate Beads and/or Rod (Manufacturer)

1. Statement of production date or dates.

2. Laboratory certification stating that the extrudate meets the product requirements (see Part 2.04).

3. Certification stating that all extrudate is manufactured by one manufacturer and resin is supplied from one supplier.

4. Copy of quality control certificates issued by manufacturer.

5. Test reports from the manufacturer.

6. Certification stating that the extrudate bead or rod resin is the same type, from the same manufacturer, and compatible with the resin used to manufacture the geomembrane supplied for this Project.

C. Schedules and Drawings (Installer)

1. Submit installation schedule one week prior to installation. Include hours worked per day, per week, and per shift. Indicate all weather delay built into schedule.

2. Installation Layout Drawings: Two weeks prior to installation of geomembrane, submit Drawings showing the panel layout indicating

both fabricated (if applicable) and field seams and details not conforming to the Drawings. Upon acceptance by Engineer, use these Drawings for installation of geomembrane.

D. Qualifications (Installer)

1. Submit, two weeks prior to installation, name of installer and resume of installation supervisor/field engineer to be assigned to the Project.

2. Submit, two weeks prior to installation, resume of master seamer.

3. Submit, two weeks prior to installation, resumes of installation seamers performing seaming operations.

E. Field Quality Control Documents (Installer)

1. Submit quality control documentation prepared during installation.

2. Submit daily prior to the start of installation, subgrade acceptance certificate signed by the installation supervisor for each area to be covered by the geomembrane.

F. Equipment and Personnel (Installer)

Submit the following two weeks prior to installation:

1. Equipment list stating quantity and types.

2. List of personnel to perform field seaming operations.

G. Final Certification (Installer)

Submit upon completion of the installation:

1. Certificate stating the liner has been installed in accordance with the Drawings and Specifications.

2. The warranty obtained from the manufacturer/fabricator and the installation warranty.

3. As-built drawings showing location of panels, seams, repairs, patches, and destructive samples, including measurements.

4. Copies of seam test results and statistical analysis of each welder’s performance.

1.06 QUALIFICATIONS

A. Installer: Must have successfully installed a minimum of 10,000,000 square feet of welded polyethylene geomembrane with documented references.

B. Master Welder Qualifications: Must have completed a minimum of 5,000,000 square feet of polyethylene geomembrane seaming work using the type of seaming apparatus proposed for use on this Project.

C. Other Seamers Qualifications: Must have seamed a minimum of 1,000,000 square feet of HDPE geomembrane.

1.07 QUALITY ASSURANCE

A. The Engineer will engage and pay for the services of 1) the CQAC, and 2) the CQA Laboratory for monitoring the quality and installation of geomembrane material being installed unless otherwise specified.

1.08 DELIVERY, STORAGE, AND HANDLING (MANUFACTURER)

A. General: Conform to the manufacturer's requirements.

B. Delivery

1. Deliver materials to the site only after the Engineer accepts required submittals. Materials delivered to the site prior to Engineer approval that do not meet the Specifications referenced herein will not be reimbursed.

2. Separate damaged rolls from undamaged rolls and store at locations designated by the Engineer until proper disposition of material is determined by Engineer.

3. Engineer will determine the extent of damage to geomembrane.

4. Deliver in rolls; do not fold.

C. Storage on Site (Installer)

1. Store geomembrane rolls in the space allocated by the Engineer.

2. Store geomembrane rolls on smooth, elevated, drained surface to protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, or other damage.

3. Store geomembrane rolls on prepared surface (not on wooden pallets).

4. Stack geomembrane no more than three rolls high.

D. Handling on Site (Installer)

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

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

3. Contractor is responsible for off-loading, storage, and transporting material from storage area to installation site.

1.09 WARRANTY (MANUFACTURER)

A. Provide manufacturer's warranty for geomembrane material in compliance with provisions of the conditions of the Contract. Provide a minimum 20-year pro rata warranty for the material against deterioration due to exposure to the elements, either exposed or buried. The warranty for material must cover costs of material replacement and installation.

B. Installation: Provide an installation warranty for geomembrane material in compliance with the conditions of the Contract. Provide a minimum of 2-year non-pro rata warranty for the installation against defects.

PART 2 – PRODUCTS (MANUFACTURER)

2.01 MANUFACTURERS

A. GSE Lining Technology Inc., 19103 Gundle Road, Houston, Texas.

B. CARPI USA Inc. 2706 Ogden Rd, Suite 3, Roanoke, VA 24018 USA

C. Huesker, Inc. 11107A So. Commerce Blvd. P. O. Box 411529,Charlotte, NC 28241

2.02 GEOMEMBRANE RESIN

A. High-density polyethylene. New, first quality, compounded, and manufactured specifically for producing HDPE geomembrane.

B. Do not mix resin types during manufacturing.

C. Do not use recycled materials or seconds in manufacturing.

D. Meeting the following requirements unless otherwise approved:

Test	Test Designation	Requirements
Specific Gravity	ASTM D 792 Method A or ASTM D 1505	0.935 to 0.942

2.03 TEXTURED SURFACE HIGH DENSITY POLYETHYLENE GEOMEMBRANE (TEXTURED ON BOTH SIDES)

A. Manufacturing

1. Do not exceed a combined maximum total of 1 percent by weight of additives other than carbon black or pigment. Identify percentage of processing aids, antioxidants, and other additives other than carbon black.

2. Do not exceed 3.5 percent by weight of finished geomembrane for total combined processing aids, antioxidants, carbon black, and other additives.

3. The Engineer accepts white geomembrane as an option if the following apply:

   a) Top surface off-white, maximum 6 mils thick.

   b) Remainder of thickness is black.

   c) White surface must be co-extruded with black to be integral to the geomembrane and cannot delaminate in any kind of physical testing.

   d) White material made from same resin and stabilized with a non-carbon black ultraviolet (UV) stabilizer to meet warranty conditions.

   e) There must be no gaps in white layer.

4. All additives for UV protection, thermal stability, color, or processing agents must not “bloom" to the surface over time or inhibit welding.

5. Provide finished product free from blemishes, holes, pin holes, bubbles, blisters, excessive gels, undispersed resins, and/or carbon black, contamination by foreign matter, and nicks or cuts on edges.

6. Roll manufactured panel for shipment.

7. Meeting the following Minimum Average Roll Value (MARV) requirements unless otherwise approved:

Properties for 60 mil Textured HDPE Geomembrane

Test	Test Designation	Requirements
Sheet Thickness	ASTM D 5994	60 mils minus 10% for any measurement and the average of all measurements for any roll not less than 60 mils (does not include textured surface)
Sheet Density	ASTM D 792 or D 1505	0.92-0.94 g/cm^3
Asperity	GM12	19 mils, each side

Oxidation Induction Time of Polyolefins	ASTM D 3895, 200°C, 1 atm	Min. 100 minutes
Tensile Strength Yield	ASTM D 6693	Min. 130 lb. per in. width
Elongation at Yield	ASTM D 6693	Min. 13%
Elongation at Break	ASTM D 6693	Min. 100% each sample
Tear Resistance	ASTM D 1004	Min. 42 lb.
Puncture Resistance	ASTM D 4833	Min. 90 lb.
Dimensional Stability (each direction)	ASTM D 1204, 212°F, 15 min.	2% max. change
Notched Constant Tensile Load Test	ASTM D 5397, Appendix	>350 hours @ 30% of yield stress
Low Temperature Brittleness	ASTM D 746, Procedure B	Minus 100ºF
Carbon Black Content	ASTM D 1603	2 to 3%
Carbon Black Dispersion	ASTM D 5596	Category 1 or 2

2.04 EXTRUDATE ROD OR BEAD

A. Meeting the geomembrane manufacturer requirements.

B. Made from same resin as the geomembrane.

C. Thoroughly disperse additives throughout rod or bead.

D. Containing 2 to 3 percent carbon black.

E. Free of contamination by moisture or foreign matter.

2.05 WELDING EQUIPMENT

A. Supply seam welding equipment and accessories meeting the following requirements:

1. Maintain sufficient operational seaming apparatus to continue Work without delay.

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

3. Provide protective lining and splash pad large enough to catch spilled fuel under electric generator, if located on liner.

4. Tensiometers capable of measuring seam strength, calibrated and accurate within 2 pounds.

5. Dies for cutting seam samples.

2.06 MANUFACTURER SOURCE QUALITY CONTROL

A. Perform the following quality control tests at the manufacturing plant on geomembrane products.

Test	Test Designation	Frequency (See Footnotes)
Sheet Thickness	ASTM D 5994	5 per roll
Sheet Density	ASTM D 792 or D 1505	(A)
Oxidation Induction Time of Polyolefins	ASTM D 3895, 200°C, 1 atm	(E)
Tensile Strength Yield	ASTM D 6693	(C)
Elongation at Yield	ASTM D 6693	(C)
Elongation at Break	ASTM D 6693	(C)
Tear Resistance	ASTM D 1004	(C)
Puncture Resistance	ASTM D 4833	(A)
Dimensional Stability (each direction)	ASTM D 1204, 212°F, 15 min.	(D)
Notched Constant Tensile Load Test	ASTM D 5397, Appendix	(F)
Low Temperature Brittleness	ASTM D 746, Procedure B	(D)
Carbon Black Content	ASTM D 1603	(C)
Carbon Black Dispersion	ASTM D 5596	(C)

Notes:

(A) One per 100,000 square feet of sheet produced or one per resin batch, whichever results in the greatest number of tests.

(B) One test per resin batch on typical sheet and seam. Perform a tensile test (ASTM D 6693) on a sample obtained from the same sheet and a test (ASTM D 4437) on seam.

(C) One per 50,000 sf or one per resin batch, whichever results in the greater number of tests.

(D) Certification only required.

(E) One test per resin batch.

(F) One test per resin batch at 30 percent of yield stress. Minimum time of failure of 200 hours. Each test performed with five samples; all must pass. Provide ultimate time to failure for each sample when data become available.

2.07 RELATION WITH OTHER MATERIALS

A. Prior to shipment, manufacturer must perform direct shear testing (ASTM D 5321) of interface friction between the HDPE geomembrane and the GCL for approval. The asperity specified in this section should be sufficient to provide an interface friction angle of 30 degrees peak and 28 degrees at 3-inch displacement with the normal stresses of 50, 200, and 400 pounds per square foot. Run test dry (as received moisture) at 0.04 inch/minute.

B. Testing should be performed on materials only produced from the same batch to be shipped for use on this Project.

C. Materials not meeting the above requirement shall be reported to the Engineer and direction shall be given to the Contractor. The Engineer may choose to accept the material as-is or may request an alternative product be manufactured.

D. No materials shall be shipped to the site without written approval by the Engineer.

PART 3 – EXECUTION (INSTALLER)

3.01 PREPARATION AND EXAMINATION OF GEOMEMBRANE SUBGRADE SURFACE

The subgrade surface upon which the HDPE geomembrane will be installed shall be continuously inspected, approved, and certified by the CQAC (or CQA Monitor) as it is prepared. Prior to installation of HDPE geomembrane, the prepared surface shall undergo a full inspection by the Engineer and CQAC, and no HDPE geomembrane installation may proceed until the surface has been approved by both. Furthermore, the surface shall be certified by the earthwork Contractor to be in accordance with the requirements of this Specification, as follows:

A. Site-specific compaction requirements shall be followed in accordance with the Drawings and Specifications.

B. The prepared surface shall be smooth and free of any debris, vegetation, roots, sticks, sharp rocks, or other deleterious materials larger than 1/2 inch; free of any voids, large cracks, ruts, ridges, or standing water or ice; and free of any other features which could be reasonably expected to puncture or damage the HDPE geomembrane.

C. Directly prior to deployment of the HDPE geomembrane, the surface shall be final-graded to fill remaining voids or desiccation cracks and proof-rolled to eliminate sharp irregularities or abrupt elevation changes. The surface shall be maintained in this smooth condition until the HDPE geomembrane is placed.

D. Subsequent to the CQAC’s approval, it shall be the installer's responsibility to indicate to the Engineer any change in the subgrade surface condition that could cause it to be out of compliance with any of the requirements of this section or the Specifications.

3.02 PREPARATION

A. Repair damage caused to subgrade during deployment.

B. Round edges of anchor trenches or cushion with geotextiles.

C. Perform trial seam welds as follows:

1. Perform trial welds on samples of geomembrane to verify the performance of welding equipment, seaming methods, and conditions.

2. No seaming equipment or welder will be allowed to perform production welds until equipment and welders have successfully completed trial weld.

3. Frequency of trial welds:

   a) Minimum of two trial welds per day with one prior to the start of work and one at mid-shift.

   b) When directed by the CQA Monitor.

   c) Every two hours when using a wedge weld to weld across seams.

   d) Minimum one trial weld per person per shift.

   e) When ambient temperature changes more than 10°F since previous trial weld.

4. Make trial welds in the same surroundings and environmental conditions as the production welds, i.e., in contact with subgrade.

5. Make trial weld sample at least 2 feet long, 3 feet long for double-wedge welding machines, and 12 inches wide with the seam centered lengthwise.

6. Cut two 1-inch-wide test strips from opposite ends of the trial weld.

7. Quantitatively test specimens; first for peel adhesion and then for bonded seam strength (shear) (ASTM D 413 and D 3083).

8. A specimen is considered passing when the following results are achieved. For double-wedge welding, both welds must pass in peel and shear.

   a) No peel penetration into the weld.

   b) The shear test results in a 200 percent elongation when the grips are set 1 inch from each side of the weld. The elongation is measured on only one side or the other of the weld. That is, one side must stretch to a 3-inch distance.

9. A trial weld sample is considered passing when both specimens pass peel and shear tests.

10. Repeat the trial weld in its entirety when any of the trial weld samples fail in either peel or shear.

11. When repeated trial weld fails, do not use welding apparatus and welder until deficiencies or conditions are corrected and two consecutive successful trial welds are achieved.

3.03 INSTALLATION

A. Deployment

1. Give careful consideration to the timing and temperature during deployment. The CQA Monitor will focus on verifying that (a) there are no bridging or stresses in the geomembrane; (b) there are no wrinkles in the geomembrane that will fold over when covering with soil material; and (c) strive to have deployment and welding occur within 10°F of their respective activities. Covering with soild should occur in a manner to minimize wrinkles which is generally during the cooler part of the day (nighttime and morning).

2. Panel Identification: Assign each panel an identifying code number or letter consistent with the Contractor's submitted panel layout drawing. The coding is subject to approval by the CQA Monitor.

3. Daily Panel Deployment: Deploy no more panels in one shift than can be welded or secured during that same day.

4. Do not deploy in the presence of excessive moisture, precipitation, ponded water, or high winds.

5. Do not damage geomembrane by handling, by trafficking, or leakage of hydrocarbons or any other means.

6. Do not wear damaging shoes or engage in activities that could damage the geomembrane.

7. Unroll geomembrane panels using methods that will not damage, stretch, or crimp geomembrane. Protect underlying surface from damage.

8. Use methods that minimize wrinkles and differential wrinkles between adjacent panels.

9. Place ballast on geomembrane that prevents uplift from wind.

10. Use ballast that will not damage geomembrane.

11. Protect geomembrane in area of heavy traffic by placing protective cover which is compatible with and will not damage geomembrane.

12. Repair damage to subgrade or other underlying materials prior to completing deployment of geomembrane.

13. Do not allow any vehicular traffic directly on geomembrane.

14. Remove wrinkled or folded material.

15. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for repair.

16. Use slip sheet when deploying textured geomembrane over GCL.

B. Seam Layout

1. Orient seams parallel to line of a maximum slope, i.e., orient down, not across, slope.

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

3. Keep horizontal seams (seams running approximately parallel to slope contours) at least 6 feet away from toe or crest of slope, unless approved by Engineer.

4. Use seam numbering system compatible with panel numbering system.

5. Shingle panels on all slopes and grades as directed by Engineer.

C. Seam Welding Personnel

1. Provide at least one welder (master welder) who has experience welding over 5 million square feet of geomembrane using the same type of welding apparatus in use at the site.

2. Qualify personnel performing welding operations by experience and by successful welding tests performed on site.

3. Master welder will provide direct supervision over other welders.

D. Seam Welding Equipment

1. Extrusion welder: Equipped with gauges showing temperatures in extruder apparatus and at nozzle. Temperature at nozzle may be measured by external temperature gauges.

2. Hot wedge welder: Automated variable speed vehicular-mounted devices equipped with devices adjusting and giving temperatures at wedge. Pressure controlled by spring, pneumatic, or other system that allows for variation in sheet thickness. Rigid-frame, fixed-position equipment is not acceptable.

3. Maintain adequate quality of welding apparatus in order to avoid delaying the Project.

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

E. General Welding Procedures

1. Do not commence welding with welding equipment until trial weld test sample, made by that equipment, passes test.

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

3. Overlap panels a minimum of 3 inches for extrusion and 4 inches for hot wedge welding.

4. Do not use solvents or adhesives.

5. Provide adequate material on weld to allow peel testing of both sides of double-wedge weld.

6. Extend welding to the outside edge of all panels.

7. If required, provide a firm substrata by using a flat board, a conveyor belt, or similar hard surface directly under the weld overlap to achieve firm support.

8. Provide adequate illumination if welding operations are carried out at night.

9. Cut fishmouths or wrinkles along the ridge of the wrinkle in order to achieve a flap overlap. Extrusion weld the cut fishmouths or wrinkles where the overlap is more than 3 inches. When there is less than 3 inches overlap, patch with an oval or round patch extending a minimum of 6 inches beyond the cut in all directions.

10. Log every two hours:

a) Temperature directly on the geomembrane surface being welded.

b) Extrudate temperatures in barrel and at nozzle (extrusion welder).

c) Operating temperature of hot wedge (hot wedge welder) and any pressure adjustments made.

d) Preheat temperature.

e) Speed of hot wedge welder in feet per minute.

11. Weld only when ambient temperature, measured 6 inches above the geomembrane, is between 40°F and l04°F.

12. If the installer wishes to use methods which may allow seaming at ambient temperatures below 40°F (5°C) or above 104°F (40°C), then the installer shall demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced at ambient temperatures above 40°F (5°C) and below 104°F (40°C) and that the overall quality of the geomembrane is not adversely affected. In addition, a Change Order to the Contract between the Engineer and the installer is required which specifically states that the seaming procedure does not cause any physical or chemical modification to the geomembrane that will generate any short- or long-term damage to the geomembrane.

F. Defects and Repairs

1. Examine all welds and non-weld areas of the geomembrane for defects, holes, blister, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of the examination.

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

G. Extrusion Type of Welding

1. Use procedures to tack bond adjacent panels together that do not damage geomembrane and allow CQA tests to be performed.

2. Purge welding apparatus of heat-degraded extrudate before welding.

3. Bevel top edges of geomembrane a minimum of 45° and full thickness of geomembrane before extrusion welding.

4. Clean seam welding surfaces of oxidation by disc grinder or equivalent not more than 30 minutes before extruding weld. Change grinding discs frequently. Do not use clogged discs.

5. Do not remove more than 4 mils of material when grinding.

6. Grind across, not parallel to, welds.

7. Cover entire width of grind area with extrudate.

8. When restarting welding, grind ends of all welds that are more than 5 minutes old.

H. Hot Wedge Welding

1. Place smooth, insulating plate or fabric beneath hot welding apparatus after use.

2. Protect against moisture build-up between panels.

3. If welding cross seams, conduct field test welds at least every 2 hours, otherwise once prior to the start of work and once at mid-day.

4. Bevel edges of top and bottom panels on cross seams.

5. Do not weld on geomembrane until equipment has passed trial weld test.

6. Extrusion-weld a repair patch over all seam intersections as described in Part 3.03G.

3.04 QUALITY CONTROL AND QUALITY ASSURANCE

A. General

1. Manufacturer, fabricator, and installer will participate in and conform with all terms and requirements of the Engineer's quality assurance program. The Contractor shall be responsible for assuring this participation. Quality control and quality assurance requirements are as written in this section.

B. Conformance Testing (Performed by CQA Laboratory)

1. Allow 3 days for conformance testing following the date sampled.

2. Perform conformance testing on geomembrane rolls.

3. Obtain samples as specified in Part 3.04.B.7. CQA Monitor will obtain samples.

4. Forward samples to CQA Laboratory.

5. Test samples for conformance with Specifications and guaranteed properties.

6. Perform, at a minimum, the following tests to determine geomembrane characteristics:

   a) Sheet Density: ASTM D 792, Method A or ASTM D 1505.

   b) Thickness: Measured with appropriate micrometer. Take five measurements across the roll width.

   c) Tensile Strength: ASTM D 6693.

   d) Carbon Black Content: ASTM D 1603.

   e) Carbon Black Dispersion: ASTM D 5596.

   f) Where optional procedures are noted in the test method, the requirements of the Specifications prevail.

g) Additional tests may be performed at the discretion of the CQAC.

7. Sampling Procedures

a) Sample across the entire width of the roll.

b) Cut sample 3 feet long by width of roll.

c) Mark machine direction on the samples with an arrow. CQA Monitor will be responsible for markings.

d) Sample at a rate of one per batch or one per 100,000 square feet of material supplied, whichever results in greatest number.

C. Field Testing (Performed by Installer)

1. General: Non-destructively test all field seams over their full length using a vacuum test unit, air pressure (for double fusion seams only), spark testing, or other approved methods. Perform testing as the seaming progresses and not at the completion of all the field seaming. Complete all required repairs in accordance with this Specification.

2. Vacuum Testing

a) Equipment, comprised of the following:

1) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, or valve assembly, and a vacuum gauge.

2) A vacuum pump assembly equipped with a pressure control.

3) A rubber pressure/vacuum hose with fittings and connections.

4) A soapy solution and an applicator.

b) Test Procedures:

1) Place the box over the wetted seam area (soapy solution).

2) Ensure that a leak-tight seal is created.

3) Energize the vacuum pump and reduce the vacuum box pressure to approximately 10 inches of mercury, i.e., 5 pounds per square inch (psi) gauge.

4) Examine the geomembrane through the viewing window for the presence of soap bubbles for a period of not less than 10 seconds.

5) All areas where soap bubbles appear shall be marked and repaired in accordance with repair procedures described in this Specification.

3. Air Pressure Testing (for seaming processes producing a double seam with an enclosed channel)

a) Equipment, comprised of the following:

1) An air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining a pressure over 40 psi and mounted on a cushion to protect the geomembrane.

2) A rubber hose with fittings and connections.

3) A sharp hollow needle or other approved pressure feed device.

4) A pressure gauge with an accuracy of plus or minus 1 psi.

b) Test Procedures:

1) Seal both ends of the welded seam to be tested.

2) Insert needle or other approved pressure feed device into the tunnel created by the weld.

3) Energize the air pump to a minimum pressure of 30 psi or 1/2 psi per mil of liner thickness, whichever is greater. Close valve and sustain pressure for at least 5 minutes.

4) If pressure loss exceeds 2 psi (10 mm mercury), or if pressure does not stabilize, locate faulty area and repair in accordance with repair procedures described in this Specification.

5) Puncture opposite end of seam to release air. If blockage is present, locate and test seam on both sides of blockage.

6) Remove needle or other approved pressure feed device and seal the penetration holes.

4. Spark Testing (for penetrations or other difficult areas not accessible for vacuum testing)

a) Equipment and Materials:

1) 24 gauge copper wire.

2) Low-amperage electric detector, 20,000 to 30,000 volt, with brush-type electrode, capable of causing visible arc up to 3/4 inch from copper wire.

b) Procedures:

1) Place copper wire within 1/4 inch of the edge of extrusion seam or clamp seal.

2) Pass electrode over seam or clamp area and observe for spark. If a spark is detected, perform a repair.

3) Make sure unit is properly grounded.

5. Destructive Testing (performed by CQAC and the installer)

a) Location and Frequency of Testing:

1) Perform one peel and one shear sample at beginning and/or end of each seam where there will be a patch anyway.

2) Determine additional test locations during welding. Locations may be prompted by suspicion or excess crystallinity, contamination, offset welds, or suspected defect. CQA Monitor will be responsible for choosing the locations. CQA Monitor will not notify installer in advance of selecting locations where weld samples will be taken.

3) The CQA Monitor may increase the test frequency based on marginal results.

b) Sampling Procedures:

1) Cut samples at locations designated by the CQA Monitor as the welding progresses. Verify that laboratory test results have been obtained before the geomembrane is covered by another material.

2) CQA Monitor will number each sample and mark sample number and location in compliance with the CQA program.

c) Immediately repair all holes in the geomembrane resulting from destructive test sampling. Repair in accordance with repair procedures described in this section. Test continuity of the repair in accordance with this section.

d) Size of Samples: Adequate to perform one peel and one shear.

e) Field Testing (performed by installer under observation of CQA Monitor):

1) Test the two 1-inch wide strips specified in Part (d) above by tensiometer for peel and shear, respectively.

2) Both test strips must meet peel and shear requirements for welded seams specified in Part 3.02.C.8.

3) If any field test sample fails, follow failed test procedures outlined in this section.

D. Failed Weld Procedures

1. Follow these procedures when there is a destructive test failure. Procedures apply when test failure is determined by the CQA Laboratory, the installer, or by field tensiometer. Follow one of the following two options.

a) First Option:

1) Reconstruct the seam between any two passing test locations. Cannot extrusion-weld flap.

b) Second Option:

1) Trace the weld at least 10 feet minimum in both directions from the location of the failed test or to the end of the weld.

2) Obtain a small sample at both locations for an additional field test.

3) If these additional test samples pass field tests, then take laboratory samples.

4) If the laboratory samples pass, then reconstruct the weld or cap between the two test sample locations that bracket the failed test location.

5) If any sample fails, then repeat the process to establish the zone in which the weld must be reconstructed.

E. Acceptable Welded Seams

1. Bracketed by two locations from which samples have passed destructive tests.

2. For reconstructed seams exceeding 50 feet, a sample taken from within the reconstructed weld passes destructive testing.

3. Whenever a sample fails, provide additional testing for seams that were welded by the same welder and welding apparatus or welded during the same time shift.

F. Seams That Cannot Be Non-Destructively Tested

Perform the following:

1. If the weld is accessible to testing equipment prior to final installation, non-destructively test the weld prior to final installation.

2. If the weld cannot be tested prior to final installation, cap-strip the weld. The welding and cap-stripping operations must be observed by the CQA Monitor and installer for uniformity and completeness.

3.05 REPAIR PROCEDURES

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

B. Repair, removal, and replacement shall be at Contractor's expense if the damage results from the Contractor's, installer's, or the Contractor's Subcontractor's activities.

C. Repair any portion of the geomembrane exhibiting a flaw or failing a destructive or non-destructive test. Agreement upon the appropriate repair method will be determined between the Engineer's Representative, the CQAC, and the installer. Do not commence welding on liner until trial weld test sample, made by that equipment and operator, passes trial test. Repair procedures available include:

1. Patching: Used to repair large holes (over 3/8-inch diameter), tears (over 2 inches long), undispersed raw materials, and contamination by foreign matter.

2. Abrading and rewelding: Used to repair small sections of seams.

3. Spot welding or seaming: Used to repair small tears (less than 2 inches long) and pin holes or other minor, localized flaws.

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

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

D. In addition, satisfy the following procedures:

1. Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one hour prior to the repair.

2. Clean and dry all surfaces at the time of repair.

3. The repair procedures, materials, and techniques must be accepted in advance of the specific repair by the Engineer's Representative, the CQAC, and the installer.

4. Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches.

5. Unless otherwise instructed by the Engineer, cut geomembrane below large caps to avoid water or gas collection between the sheets.

E. Verification of Repair

1. Number and log each patch repair.

2. Non-destructively test each repair using methods specified in Part 3.04 of this section.

3. Destructive tests may be required at the discretion of the Engineer's Representative or the CQAC.

4. Reconstruct repairs until tests indicate passing results.

3.06 GEOMEMBRANE ACCEPTANCE

A. Contractor retains all Engineership and responsibility for the geomembrane until acceptance by the Engineer.

B. Engineer will accept geomembrane installation when:

1. All required documentation from the manufacturer, fabricator, and installer has been received and accepted.

2. The installation is finished.

3. Test reports verifying completion of all field seams and repairs, including associated testing, are in accord with this section.

4. Written certification documents and Drawings have been received by the Engineer.

PART 4- MEASUREMENT AND PAYMENT

Measurement and Payment for HDPE Geomembrane shall be as specified in Section 01270 – Measurement and Payment.

END OF SECTION 02073

PART 1 – GENERAL

1.01 DESCRIPTION

This section describes requirements for preparation of the site for Work, including mobilization of equipment, preparation of roads and access routes, demolition, replacement of perimeter fencing, and creation of staging and stockpiling areas.

1.02 RELATED SECTIONS

A. Section 01010 – Summary of Work

B. Section 01300 - Submittals

C. Section 01500 – Construction facilities and Temporary Controls

D. Section 01530 – Protection of Existing Facilities

E. Section 01560 – Temporary Environmental Controls

F. Section 02230 – Site Clearing

G. Section 02315 – Excavation and Fill

PART 2 – MATERIALS

2.01 STOCKPILE UNDERLINER

Underliner for temporary stockpile areas shall be chemically resistant polyethylene geomembrane with a minimum thickness of 10 mils.

2.02 SECURITY FENCING

Materials shall meet the requirements for Type 1 fencing set forth in the WA State Department of Transportation (WSDOT), 2004 Standard Specifications for Road, Bridge, and Municipal Construction.

The fencing shall be removed upon completion of the project and the site restored to the original condition. Any additional fencing requests shall be submitted to the Engineer for approval.

PART 3 – EXECUTION

3.01 GENERAL

Before commencing with Work, the Contractor shall prepare the site for construction. Site preparation shall consist of equipment and field office, mobilization, preparing access roads and staging areas, establishing construction

layout controls, establishing erosion and sediment controls, establishing a decontamination area, and removing or temporarily relocating existing facilities, as detailed herein.

Areas where site preparation activities are to be implemented shall be located outside the limits of grading as indicated on the Drawings. Should the Contractor require additional area to establish facilities incidental to this Work, the Contractor shall notify the Engineer of their requirements, providing sketches or other details as needed. The Engineer will review the request and recommend changes, if needed.

Equipment required to perform clearing and grubbing and to construct staging and stockpiling areas (as needed) shall be mobilized first.

3.02 MOBILIZATION

Mobilization shall begin after a Notice to Proceed has been issued and within 7 days following receipt of the Contractor's Health and Safety Plan (HASP). The Contractor shall provide all of the necessary equipment, materials, labor, and incidentals to perform the Work outlined herein. These furnishings shall be staged at or within the locations indicated on the Drawings.

3.03 CONSTRUCTION ENTRANCES

The entrance to the job site for all equipment and materials is shown on the Drawings. The Contractor's vehicles and equipment will be allowed to use roads and parking areas as designated on the Drawings.

Stabilized construction entrances shall be established at all ingress/egress points connecting existing roads to construction sites, stockpiling areas, and staging areas. The Contractor shall maintain control of these entrances by restricting access to the public through such measures as signage and flagging.

3.04 PREPARATION OF ACCESS ROADS

The Contractor shall construct access roads at the locations shown on the Drawings, with additional roads as necessary to achieve the Work, subject to the Engineer's review and approval. The Contractor shall include a description of their proposed access roads in their Construction Work Plan (as specified in Section 01300).

Access road areas shall be cleared and grubbed, as necessary, in accordance with the requirements of Section 02230. After clearing and grubbing has been completed, a continuous 12-inch-thick layer of Base Course shall be placed to create the access road surface.

All constructed access roads shall remain in place at the end of the Work unless directed by the Engineer.

The Contractor shall prepare staging, stockpiling, and laydown areas at or within the locations shown on the Drawings. The identified Contractor laydown areas shall first be cleared and grubbed in accordance with the requirements of Section 02230.

END OF SECTION 02200

SECTION 02230

SITE CLEARING

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope: This Section covers clearing and grubbing the site. Clearing includes, but is not limited to, removing and disposing of all trees, stumps, brush, rubbish and debris in the work areas, except those objects shown on the Drawings or designated by the Engineer to remain. Grubbing includes, but is not limited to, removing and disposing of all buried items, stumps, roots, and vegetative matter in the work area.

1.02 RELATED SECTIONS

A. Excavation and Fill - Section 02315

B. Erosion and Sediment Control – Section 01570

PART 2 - PRODUCTS

Not applicable.

PART 3 - EXECUTION

3.01 CLEARING

A. The site shall be cleared to excavation, fill and structure limits shown on the Drawings. Brush and shrubs shall be removed to the ground surface within these limits. Clearing outside these limits will not be permitted.

B. The Contractor shall protect in place any utility structures, piping, vegetation or other materials within the clearing limits that are to remain in place, as shown on the Drawings.

3.02 GRUBBING

A. All sites shall be grubbed a minimum of 6" below final excavation lines and grades or until all organic matter is removed.

3.03 DISPOSAL

A. The Contractor shall be responsible for the legal disposal of waste material. Materials shall be disposed of as soon as practicable after clearing and grubbing.

B. Burning may be permitted only with the approval of the appropriate authorities.

END OF SECTION 02230

SECTION 02240

DEWATERING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Dewatering for construction of the pumping station, concrete channel, canal outlet structure, and river channel improvements.

1.02 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 01570 – Soil Erosion and Sediment Control

C. Section 03300 - Cast-in-Place Concrete

D. Section 05500 – Metal Fabrication and Castings (Fish Screens section will need to be added to section authored by CH2M Hill)

1.03 SUBMITTALS

A. The Contractor shall submit a dewatering plan and schedule prepared in accordance with the requirements of all in-stream work permits including the United States Army Corps of Engineers (USACE) Permit and the Washington State Department of Fish and Wildlife (WDFW) Hydraulic Project Approval (HPA).

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.01 GENERAL

A. Excavation for and construction of the pumping station, conveyance canal, canal outlet structure, and stream channel improvements may require dewatering. Design and construction of the dewatering system shall be the responsibility of the Contractor subject to the review and approval of the engineer.

B. The dewatering system shall be designed and operated to lower the water level to a minimum of one foot below the bottom of the lowest excavation. Dewatering shall be accomplished prior to the start of excavation, such that only minor quantities of water are allowed to enter the excavation.

C. Diversion water shall be screened to exclude fish from entering the pump station piping, conveyance canal, and outlet structure. The Contractor shall coordinate this work with the District.

D. The in-water work period assumed to be permitted within the HPA issued by the WDFW is July 15 through October 31. (Verify permit conditions)

END OF SECTION 02240

SECTION 02260

EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Requirements for excavation support and protection for trenches and open excavations greater than 4 feet in depth.

1.02 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 02315 - Excavation and Fill

1.03 QUALITY ASSURANCE

A. General: Publications listed below form a part of this Specification to the extent indicated by reference thereto:

B. Occupational Safety and Health Act (OSHA):

1. Construction Industry Standards

2. Occupational Safety and Health Standards

C. Washington Industrial Safety and Health Act (WISHA)

D. Chapter 296-155, Part N, WAC - Washington Safety Standards for Construction Work; Excavation, Trenching, and Shoring

1.04 SUBMITTALS

A. Excavation and shoring plan – Prior to excavation work requiring the use of sheeting, shoring, bracing, or other support and protection system, the Contractor shall develop an excavation and shoring plan for review by the District . The excavation and shoring plan shall remain onsite and be available for review by the Project Representative during all working hours. The excavation and shoring plan shall be signed and stamped by a licensed professional engineer, registered in the State of Washington.

B. Excavation support system design for each excavation requiring support and protection – The Contractor shall submit design calculations, and procedures for the installation and removal of each support system. The excavation support design shall be signed and stamped by a licensed professional engineer, registered in the State of Washington.

1.05 SUPPORT AND PROTECTION REQUIREMENTS

A. The Contractor shall be responsible for planning, designing, installing, maintaining, and removing support and protection for excavations and trenches in accordance with Chapter 296-155, Part N, WAC and applicable OSHA and WISHA requirements.

B. Excavation support systems shall be designed and installed to protect surrounding property including structures. Excavation support systems

shall also be designed so that installation and removal of the support systems does not disturb soil adjacent to or below the required excavation or trench section. Excavation and trenching shall be to the lines shown on the drawings and as specified in Section 02315.

C. Excavation support systems shall be designed to include dewatering requirements, as specified in Section 02240.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.01 GENERAL

A. Construct the excavation to the lines shown on the drawings and as specified in Section 02315. Install and remove support systems in such a manner as not to disturb the state of soil adjacent to the trench or below the trench or excavation.

B. Installation of horizontal strutting below the barrel of a pipe and use of the pipe as a support are not permitted

C. Unless otherwise indicated, remove all sheeting, shoring, and bracing after placement and compaction of backfill.

END OF SECTION

SECTION 02315

EXCAVATION AND FILL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Excavation for foundations, slabs, utilities, and channels

B. Structural filling, backfilling, and compacting

C. Miscellaneous filling, backfilling and compacting

D. In-river Rock

1.02 RELATED SECTIONS

A. Section 01570 – Soil Erosion and Sedimentation Control

B. Section 02073 – Geocomposite Liner for Canal

C. Section 02240 – Dewatering

D. Section 02260 – Excavation Support and Protection

E. Section 02273 – Rip Rap

F. Section 02320 – Trench Backfill

G. Section 02950 – Wood and Boulders

1.03 REFERENCES

A. General: Publications listed below form a part of this Specification to the extent indicated by reference thereto:

B. American Society for Testing and Materials (ASTM):

1. ASTM C33 – Specification for Concrete Aggregates

2. ASTM D422 – Standard Test Method for Particle-Size Analysis of Soils

3. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft^3)

4. ASTM D2922 – Standard Test Methods for Density of Soil and Soil Aggregate in Place by Nuclear Methods

C. Uniform Building Code (UBC)

D. Occupational Safety and Health Act (OSHA):

1. Construction Industry Standards

2. Occupational Safety and Health Standards

E. Washington Industrial Safety and Health Act (WISHA)

F. Chapter 296-155, Part N, WAC - Washington Safety Standards for Construction Work; Excavation, Trenching, and Shoring

1.04 QUALITY ASSURANCE

A. Imported Materials:

1. The Contractor shall ensure that imported materials are approved by the Engineer before hauling to the site. The Engineer maintains the right to reject any materials that, in the Engineer's opinion, are determined to be substandard for any reason. In the event material is hauled to the site without prior approval and is determined by the Engineer to be unacceptable, all materials shall be removed from the site at no additional cost to the owner.

B. Gradation Testing:

1. Prior to hauling to the site, the Contractor shall submit sieve analysis and suppliers certification of compliance for each imported material.

2. The Contractor shall also submit sieve analysis for on-site materials to be incorporated into the work when requested by the Engineer.

C. Compaction Testing:

1. The Contractor shall be responsible for testing to ensure compliance with the compaction requirements of the specifications. The Contractor shall obtain and pay for the services of an independent soils testing laboratory to perform the sieve analysis required above, determine the optimum moisture content for each material and conduct on-site density tests during material placement. The name and qualifications of the laboratory and its personnel shall be submitted to the Engineer for approval. Copies of all test results shall be forwarded to the Engineer (in addition to Contractor) directly by the laboratory.

2. The frequency of compaction testing shall be as determined by the Engineer, and shall generally be once at the beginning of placement of any given material to establish the required compaction for that material and at the mid and end points of placement of the material to document that the required compaction has been achieved. Additional testing, at the Contractor's expense, may be directed by the Engineer if the Engineer has reason to believe that the required compaction is not being achieved and the Contractor does not take corrective action.

D. Tolerances:

1. Lines: ±0.5 foot

2. Elevations: ±0.1 foot

1.05 PROTECTION

A. All excavations shall be in accordance with applicable OSHA and WISHA Construction Industry Standards and Chapter 296-155, Part N, WAC. The Contractor shall provide shoring, signs, barricades, etc., and shall maintain traffic where excavations cross roads or other traveled ways. Excavation slopes shown on the drawings are for illustrative purposes only. Actual slopes shall be determined by the Contractor, and are the sole responsibility of the Contractor. The maximum slope of an excavated surface shall be 1.5H:1V.

B. The Contractor shall protect structures, utilities, roadways, landscaped areas, and other facilities immediately adjacent to excavations, and shall restore such damaged facilities to the pre-construction condition.

C. The Contractor shall not store equipment within 5 feet of the upper edge of any excavation, or further as deemed necessary to ensure safety.

D. The Contractor shall be responsible for dewatering work areas in accordance with Section 02240, and no extra payment will be made for water encountered in any excavation or other work area. Water removed from the excavations and other work areas shall not be allowed to flow into the Chelan Tailrace or the Chelan River if it will increase the turbidity of the surface water in the Chelan Tailrace or the Chelan River.

E. The Contractor shall take all necessary precautions to prevent silt laden runoff from leaving the site and entering the Chelan Tailrace or the Chelan River. per Section 01570. No additional payment shall be made for erosion control measures. (Verify in Section 01570 authored by CH2M Hill as well as bid schedule)

1.06 SUBMITTALS

A. Documentation indicating the origin of imported materials.

B. Sieve analysis results and supplier's certification for structural fill, rock and other imported materials.

C. Name and qualifications of the testing laboratory.

D. Optimum moisture and maximum density lab test results.

E. On-site compaction test results.

PART 2 - PRODUCTS

2.01 STRUCTURAL FILL AND BACKFILL

A. Structural fill and backfill shall be clean, well graded sand and gravel; natural on-site sand and gravel; or on-site gravelly sand fill, free of refuse, organic material, and debris. Structural fill and backfill shall meet the material specification for grading and quality provided in Section 9-03.12(2) of the Standard Specifications.

B. Material shall be obtained from required excavations or other Contractor furnished sources and shall be approved by the Engineer prior to placement.

2.02 MISCELLANEOUS COMPACTED FILL AND BACKFILL

A. Miscellaneous compacted fill and backfill shall include granular material used for grading, site contouring, replacement of unsuitable material and other fill applications not classified as Pipe Bedding, Trench Backfill or Structural Fill and Backfill, as specified above.

B. Miscellaneous fill and backfill shall be clean, well graded sand and gravel, free of refuse and organic materials, with a maximum gravel size of 2 inches, and with less than 15 percent material passing the No. 200 sieve.

C. Material shall be obtained from required excavations or other Contractor furnished sources and shall be approved by the Engineer prior to placement.

2.03 IN-RIVER ROCK

A. Rock for in-river grade control structures shall consist of angular, hard, sound, durable rock, free from segregation, seams, cracks, and other defects. It shall be free of rock fines, solid, or other extraneous material. The source and a sample of the quality and size of rock to be provided shall be inspected and approved by the Engineer prior to any rock being loaded for hauling. Rock used for in-river grade control structures shall meet the following requirements for grading:

Coefficient	Minimum Size	Maximum Size
15%	24 inches	30 inches
25%	12 inches	24 inches
45%	6 inches	12 inches
20%	1 inch	6 inches
15%		1 inch

Note: 1 inch minus with fines shall be pit-run gravel naturally occurring granular material, free of wood waste or other extraneous materials. This material is to be worked into the rock mix and, after reaching final grade, spread into the voids using water. Silt laden water that is transported downstream shall be pumped out of the stream channel and allowed to infiltrate away from the river or into silt construction bags.

PART 3 - EXECUTION

3.01 GENERAL

A. The contractor shall excavate to the lines, grades, slopes and elevations shown on the Drawings.

B. The contractor shall dewater excavations as specified in Section 02240.

C. The Contractor shall stockpile materials on-site at locations designated by the owner. Material excavated from the site to be used as fill or backfill

shall be segregated into temporary stockpiles. The Contractor shall be responsible for managing temporary stockpiles for use in performing the work. Surface water shall be directed away from stockpiles to prevent erosion or deterioration of stockpiles.

D. Following completion of site grading and backfilling operations all disturbed areas shall be shaped and graded to pre-construction conditions, or to the lines and grades shown on the drawings. Finished areas shall be free of sudden dips or rises and depressions. All completed grading shall be to the satisfaction of the Engineer.

E. All disturbed areas shall be seeded and mulched, as specified in Section 02930, with silt fencing or other erosion control measures left in place until the seeding is firmly established and runoff is essentially silt-free.

3.02 TRENCH EXCAVATION

A. This section is applicable to excavations required for the placement of all underground pipes, conduits, and cables.

B. The trench shall be excavated to permit placement of the pipe, conduit, or cable to the alignment and grade shown on the drawings or specified. Excavation depth shall include an allowance for the required bedding. Trench bottom shall be cleaned of all loosened soil and rocks. Shape and dimension of the trench shall allow a minimum of 9-inches on each side of all pipes. If, without written authorization, the pipe trench is excavated below the required depth, it shall be backfilled at the Contractor's expense with pipe bedding.

C. Material obtained from pipeline excavation and meeting the trench backfill requirements may be used for pipeline backfill. Excess suitable material may be used in required fill. The Contractor shall dispose of material not meeting pipeline backfill requirements or fill requirements.

3.03 STRUCTURAL EXCAVATION

A. Structural excavations include excavations required for footings, retaining walls, grade beams, slabs, and concrete floors.

B. The bottom of excavation shall be within ± 0.10 feet of the elevations shown on the drawings. The bottom of all structural excavations shall be cleaned to remove all rocks over 3-inches in diameter and loosened soil.

C. Should the Contractor, through his own negligence or other fault, excavate below the designated elevations, he shall replace such excavation with approved materials and method at his own expense.

D. Excess cuts under slabs and floors on grade shall be filled with approved structural fill.

E. All excavations must be clean, dry and free from loose earth or other materials at time of placing concrete. Remove excess excavated materials from site.

3.04 MISCELLANEOUS EXCAVATION

A. Miscellaneous excavations may include excavations required for roadway cuts, paving and grading, site contouring, and other excavation not classified as Trench Excavation or Structural Excavation above.

B. The Contractor shall remove all material to the elevations shown on the drawings or as required for removal of unsuitable material as directed by the Engineer. Excavated material meeting the requirements of Part 2 of this Section may be used as fill material. The Contractor shall dispose of all other material.

3.05 WASTE MATERIAL DISPOSAL

A. Surplus excavated material may be reused on site or may be disposed of within the grounds of the Project site as directed and approved by the Engineer. At the completion of the project the disposal area shall be graded to drain without areas of standing water and seeded to prevent erosion. Prior to completion of the project the disposal area shall be surrounded with erosion control materials to prevent silt-laden runoff from entering surface waters tributary to the Columbia River.

B. Any material deemed by the Engineer not to be suitable for reuse or disposal on site shall be disposed of by the Contractor in an off-site disposal location. All costs for such disposal shall be considered to be incidental to the contract and no additional compensation will be made.

C. The Contractor shall provide the Engineer with the location of all disposal sites to be used, and also provide copies of the permits and approvals for such disposal sites.

3.06 STRUCTURAL FILL AND BACKFILL

A. Structural fill is defined as all fill and backfill, except sand fill, under all footings and concrete slabs on grade and all fill and backfill within a horizontal distance of 5-feet from concrete structures such as walls, footings, catch basins, manholes, etc.

B. Structural fill material shall conform to Section 2.03, and shall be placed and compacted in 8-inch maximum thickness layers, loose measure, to at least 95 percent of maximum dry density as determined by ASTM D1557.

C. Where backfill is to be placed against both sides of concrete walls, the backfill shall be brought up evenly on both sides of the wall.

D. Backfill shall not be placed against just one side of concrete walls (including grade beams) until the concrete has developed sufficient strength to resist the load imposed by the backfill. Any abutting concrete walls or beams shall also have attained sufficient strength. In any case, the backfill placement shall not begin prior to 72 hours after concrete placing and shall not exceed the following schedule:

Age of Concrete	Backfill Height
72 Hours	1/2 Wall Height
7 Days	2/3 Wall Height
28 Days	Full Wall Height

3.07 MISCELLANEOUS COMPACTED FILL

A. Compacted fill not classified as Pipeline Backfill or Structural Fill and Backfill shall conform to the requirements of Section 2.04. Miscellaneous compacted fill shall be placed in 8-inch maximum layers loose depth, and shall be compacted to at least 90 percent of maximum dry density as determined by ASTM D1557. The top 2-feet shall be placed in 6-inch maximum layers loose depth and shall be compacted to at least 95 percent of maximum dry density as determined by ASTM D1557.

B. Compacted fill shall be placed to the shapes and elevations shown on the drawings, sloped to drain, and without noticeable irregularities.

C. Fill material placed on existing slopes that are steeper than 4:1 (horizontal to vertical), including existing fill embankments, shall be properly keyed into the slope surface. This shall be accomplished by constructing the fill on a series of 4-foot to 8-foot wide horizontal benches cut into the slope.

3.08 COMPACTION

A. Compaction to the density as required by Sections 3.06, 3.07, or 3.08 above, shall be by means of an appropriately sized static, vibratory or impact type compactor suited to the soil and physical restrictions of the area to be compacted. Although the Contractor is responsible for the selection of the method of compaction, selection of an inappropriate method shall not relieve the Contractor of the responsibility to achieve the specified result.

B. Jetting, sluicing, or water settling will not be permitted.

3.09 IN-RIVER ROCK PLACEMENT

A. Channel banks along the alignment of the Chelan River and the Chelan Tailrace shall be graded as shown on the Drawings and as directed by the engineer.

B. Rock for in-river rock structures shall be machine placed to the orientation, thickness, slopes and grades shown on the Drawings. The top of the structures shall be of constant grade between the construction coordinates as shown on the Drawings, minimizing gaps and openings.

C. The exposed face of in-river rock structures shall be made as smooth as the size and shape of the rock will permit and be acceptable to the Engineer. No point on the surface of the in-river rock structures shall vary more than 12 inches from the plane surface defined by the line and grades shown on the Drawings.

END OF SECTION 02315

SECTION 02319

SUBGRADE PREPARATION

PART 1 - GENERAL

This section shall govern the preparation of natural or excavated areas prior to the placement of base material, concrete, foundations, or other structures.

PART 2 - MATERIAL

Subgrade material may be the existing site material. Organic material, solid obstructions, muck, debris, and other unsuitable materials shall be replaced with suitable material.

PART 3 - EXECUTION

3.01 DEPTH

Unless otherwise specified or shown on the plans, subgrade shall be prepared at least 6 inches below bottom of base course or bottom of concrete.

3.02 COMPACTION

Unless otherwise specified or shown on the plans, the density of the prepared subgrade shall be not less than 95%. If the material contains 35% or more material passing the No. 200 sieve, the compaction shall be not less than 90% as determined by ASTM D1557 or AASHTO T180.

3.03 TESTING

A. Subgrade density may be tested using the nuclear methods backscatter, direct transmission or airgap as described in AASHTO T238 or ASTM D2922.

B. The Contractor may request a density test using the sand cone method as described in AASHTO T191 or ASTM D1556 to verify the accuracy of the nuclear method. The Contractor may use the results of the sand cone method in lieu of other methods.

END OF SECTION 02319

PART 1 – GENERAL

1.01 DESCRIPTION

Provide planted trees and live stakes as shown on the Drawings and specified in this section. The Work includes:

A. Plants and planting

B. Mulch and fertilizer

C. Staking

D. Maintenance

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01010 – Summary of Work

B. Section 01300 – Submittals

C. Section 01560 – Temporary Environmental Controls

D. Section 02230 – Site Clearing and Grubbing

E. Section 02315 – Excavation and Fill

F. Section 02930 – Hydroseeding

1.03 QUALITY ASSURANCE

A. Comply with sizing and grading standards of the 2000 edition of "American Standard for Nursery Stock"

B. Nomenclature shall conform to Hortus Third compiled by the L. H. Bailey Arboretum, Cornell University, 1976

C. All plants shall be nursery grown or collected materials that have been held in a nursery for at least one year. Nursery climatic conditions must be similar to those in the locality of the Project. All plants shall be weed free at the time of planting

D. Stock furnished shall be at least the minimum size indicated. Larger stock is acceptable at no additional cost, provided that the larger plants will not be cut back to size indicated. Provide plants indicated by two measurements so that a maximum of 25 percent are of the minimum size indicated and 75 percent are of the maximum size indicated

1.04 **SUBMITTALS**

A. Submit the following material samples:

1. Mulch

2. Fertilizer

B. Submit the following material certifications:

1. Fertilizer

2. Plant material sources

1.05 SEQUENCING AND SCHEDULING

The surface to be planted shall be hydroseeded at least 30 days prior to planting and shall be fully covered with vigorous, healthy grass at least 6 inches high. Hydroseed application shall occur between March 15 and September 15. No seeding shall be done before or after these dates without the Engineer's written approval.

Planting of trees and live stakes will occur during the dormant season between October 30 and February 28. Work outside this time frame shall require the written approval of the Engineer. Coordinate installation of erosion control blankets with planting of trees to minimize disturbance of hydroseed and soil.

PART 2 – PRODUCTS

2.01 **GENERAL**

A. Plant materials shall meet or exceed the following reference standards for quality, size, and condition:

1. Washington State Department of Agriculture (WSDA) rules related to standards for Nursery Stock

2. American National Standards Institute (ANSI) Z60.1-1990: Nursery Stock

3. American Joint Committee for Horticultural Nomenclature: Standardized Plant Names

B. All plant materials shall be nursery grown, per the standards described above. Collected, wild plant materials are unacceptable

C. Refer to Section 02315 for topsoil specifications

2.02 LIVE STAKES

Live stakes shall be live wood 2 to 5 years old with smooth bark that is not deeply furrowed. Stakes with split ends or peeled bark are unacceptable. The stakes shall be consistently cut so that the top end is square and the bottom end (planted end) is angled. The cuts shall be clean; branches of stakes shall be trimmed as closely as possible. The top 1 to 2 inches of each stake shall be dipped into a 50/50 mix of light-colored latex paint and water. Live stakes shall be a minimum of 2 feet tall and a maximum of 3 feet tall. Live stake cuttings shall be kept soaked in water at all times between harvest and installation. Live stake cuttings will be installed within 5 days of harvest.

2.03 TREES

Trees shall be of the size shown on the Drawings and shall meet the reference standards for nursery stock stated above.

2.04 FERTILIZER

Fertilizer shall conform to reference FS O-F-24D, Commercial Fertilizers and WSDA laws. Fertilizer for all tree plantings shall be "BioPaks-16-6-8 plus minors and biostimulants" available from Reforestation Technologies International (RTI), 1-800-784-4769.

The Contractor will demonstrate compliance by showing invoices to prove purchase of product in sufficient quantity to cover the Project at the rates recommended by the manufacturer. Include product name, date of purchase of product, and name of contact. BioPak®, or approved equivalent, shall consist of:

Rhizosphere Bacteria	45 billion colony forming units (cfu)/lb
7.5 billion cfu/lb (8.3 million cfu/cc) *Bacillus licheniformis*	
7.5 billion cfu/lb (8.3 million cfu/cc) *Bacillus megaterium*	
7.5 billion cfu/lb (8.3 million cfu/cc) *Bacillus polymyxa*	
7.5 billion cfu/lb (8.3 million cfu/cc) *Bacillus subtilis*	
7.5 billion cfu/lb (8.3 million cfu/cc) *Bacillus thuringiensis*	
7.5 billion cfu/lb (8.3 million cfu/cc) *Paenibacillus azotofixans*	
Humic acids	31 percent
Sea kelp extract	35 percent
Sugar (dextrose)	13.5 percent
Yeast extract	5.5 percent

2.05 MULCH

Mulch shall be derived from fir, pine, or hemlock species. It shall be ground so that a minimum of 95 percent of the material will pass through a 1-1/2 inch sieve and no more than 55 percent, by loose volume, will pass through a U.S. No. 4 sieve. The mulch shall not contain resin, tannin, or other compounds in quantities that would be detrimental to plant life. Mulch can include chipped on-site tree

clearing debris, provided it is approved by the Engineer and does not contain any Himalayan blackberry, Scotch broom, or other weedy species.

PART 3 – EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

All plants shall be furnished in unopened manufacturer's standard containers bearing original labels showing quantity, analysis, and name of manufacturer. The plants shall be protected from sun, weather, or other conditions that would damage or impair their effectiveness. All plant material shall be delivered with tags or labels identifying species and variety (as applicable). Incorrect species shall be removed from the site immediately. Deliveries of live stakes shall be scheduled so that the plants are installed no more than two days after they are delivered to the site. Deliveries of trees shall be scheduled so that the plants are installed no more than 7 days after they are delivered to the site. Balled and burlapped trees shall be held in moist sawdust and watered daily while on site and unplanted. Live stakes shall be kept saturated in water until installation and will be installed within 5 days of harvest. Trees and live stakes shall be protected from excessive heat (over 50°F), excessive cold (under 32°F), and high winds (over 15 miles per hour [mph]) prior to installation. All other plants should be held on site before planting for an absolute minimum time period. Water plants daily prior to installation. Installation shall not occur if temperature is below 32°F or if winds are above 20 mph.

3.02 SURFACE PREPARATION

All debris and unneeded materials shall be removed prior to planting. Planting, backfilling, mulching, and initial irrigation will be done for each plant before moving on to the next plant. All Work will be done from the bottom of the slope upward to minimize the impact to areas once they are planted.

The Contractor shall perform the necessary survey/layout Work to establish the proper spacing for each of the plant species. Wood stakes shall be used to establish tree locations or lines of tree planting. The Contractor shall use the lesser value when comparing actual measured field spacing of trees and proposed spacing of trees. Live stakes may be staked out by boundary rather than by individual plants. Planting shall not begin until satisfactory conditions are attained.

3.03 LIVE STAKE PLANTING

After erosion control measures, including hydroseed, have been installed and approved by the Engineer, the Contractor shall install live stakes. Openings within the erosion control blanket shall be made by cross-cutting a 3-inch diameter "X" with a knife. An iron bar or rod with a diameter equal to the live

stake shall be used to create a pilot hole of sufficient depth in the center of the opening. The hole shall be perpendicular to the slope. The live stakes shall be driven into the hole with a rubber mallet, with the angled bottom end in the ground and at least two to five emerging buds exposed at the top end. At least 80 percent of the live stake shall be installed beneath the ground surface. Care shall be taken to protect the live stakes from damage such as splitting, bark peeling, and bud breakage during installation. After live stake installation, the soil shall be tamped to create contact between live stake and soil. Installation is shown in detail on the Drawings.

3.04 TREE PLANTING

After erosion control measures, including hydroseed, have been installed and approved by the Engineer, the Contractor shall install trees. All tree planting shall be done on the seams between adjacent erosion control blankets, where such blankets are used. Erosion control blankets shall not be cut or damaged in order to plant trees. Trees shall be planted in the areas and at the spacing shown on the Drawings. In order to plant trees, staples may be temporarily removed as necessary and adjacent blankets may be pulled away from the seams. A trowel or small narrow shovel shall be used to dig a hole of sufficient depth and width to accommodate the roots of the tree or to the dimensions shown on the Drawings, whichever is greater. The tree shall be placed in the pit so that root crown is at finished grade and so that the tree is vertical. After balled and burlapped trees are set, water the soil mixture around bases of balls, and fill all voids. Remove all burlap or plastic wrapping materials, twine, wires, and wire baskets from root balls. The pit shall be backfilled with 50 percent native soil and 50 percent organic compost material, thoroughly mixed. Remaining unused native soil will be used to make a terrace and berm to collect runoff. After tree installation, the Contractor shall tamp the soil to create contact between the roots and soil. The mulch ring, fertilizer and other amendments shall be placed prior to placing the erosion control blankets. The erosion control blankets shall be installed with their positions overlapping and all staples replaced, except at tree locations. Trees shall be watered immediately after planting and adjusted to proper grade if settling occurs. Installation is shown in detail on the Drawings.

3.05 MULCH RING

A ring of mulch 2 inches deep and 24 inches in diameter shall be placed around each tree and compacted by hand. All hydroseed grasses shall be removed from the area of the mulch ring before planting or placement of the mulch. Installation is shown in detail on the Drawings.

3.06 FERTILIZER FOR TREES

Prior to completing the backfill of the tree roots, the Contractor shall place BioPaks® equidistant around the root ball of the tree. The number of BioPaks®

shall be as specified by the manufacturer's installation guidelines. The BioPaks® shall be installed not less than 1 inch and not more than 4 inches below the finished grade and approximately 2 inches from root tips. The Engineer will be present when BioPaks® are installed.

3.07 MAINTENANCE OF REVEGETATED AREAS

Depending upon the time of planting, the Contractor may have to water plants to maintain growth. The use of DriWater® or an approved equivalent will be permitted to improve plant survival. DriWater® is a time-release gel used to water plants for up to 90 days. It can be ordered at http://www.driwater.com.

3.08 ACCEPTANCE AND MAINTENANCE

A. Within the 1-year warranty period, as specified herein, the Contractor shall reseed or replant in accordance with these Specifications any areas where, in the opinion of the Owner, satisfactory growth has not been obtained.

B. Acceptance of sample plants does not constitute acceptance of all plants. Final acceptance of plants shall occur at Owner acceptance of the completed Project. Maintenance standards for revegetated areas are as follows:

1. Plant materials: 60 percent of live stakes installed and 80 percent of trees installed shall be warranted to be healthy and thriving based on the number of plants installed at final acceptance.

2. Any area of 500 or more contiguous square feet must meet the following plant warranty conditions: 60 percent of live stakes installed and 70 percent of balled and burlapped trees installed shall be warranted to be healthy and thriving based on the number of plants installed at final acceptance.

3. The Contractor shall be held responsible for failure due to damage or predation by rodents or mammals. Installation of exclosures shall be permitted with product submittal and the written approval of the Engineer.

4. The Contractor shall remove and replace immediately during the guarantee period any dead, diseased, dying, broken, or missing plant materials (except as noted below). The Contractor shall use specified plants and plant as specified, and shall guarantee until acceptable, active, healthy growth is evident.

5. Contractor's Responsibility: During the guarantee period, the Contractor shall not be held responsible for replacing plants destroyed or damaged by vandalism, accidents caused by vehicles

(other than that of the Contractor), or acts of God, provided that the Contractor has exercised due care to protect the Work.

6. When the time of a required replacement falls during a non-planting season, the Contractor may request Owner's permission to defer planting until the proper season. If granted, the Contractor shall immediately remove dead plants, including roots, from site, backfill pits properly with topsoil mix, finish grade, and leave in acceptable condition until proper planting season occurs. The Contractor shall replace with plants of same species and size as those originally planted, and plant as originally specified.

END OF SECTION 02900

DIVISION 2 – SITE WORK
Section 02930 – Hydroseeding

PART 1 – GENERAL

1.01 DESCRIPTION

Furnish all materials, equipment, and labor necessary for preparation, seeding, fertilizing, mulching, and protection of hydroseeded areas.

1.02 RELATED WORK SPECIFIED ELSEWHERE

The provisions and intent of the CT&C apply to this Work as if specified in this section. Work related to this section is described in the following sections:

A. Section 01100 – Summary of Work

B. Section 01300 – Submittals

C. Section 01560 – Temporary Environmental Controls

D. Section 02230 – Site Clearing and Grubbing

E. Section 02315 – Excavation and Fill

F. Section 02900 – Planting

1.03 SUBMITTALS

Submit product data for fertilizers and hydromulch components. Submit seed Vendor's certification for required grass seed mixture, indicating percentage by weight and percentages of purity, rumination, and weed seed for each grass species.

1.04 QUALITY ASSURANCE

Seed shall be furnished in containers that show the following information: seed name, lot number, net weight, percentage of purity, germination, weed seed, and inert material. Seed that has become wet, moldy, or otherwise damaged will not be accepted. Seed shall conform to the requirements of the Washington State Seed Law and, when applicable, the Federal Seed Act and shall be "certified" grade or better.

1.05 FIELD QUALITY CONTROL

A. Grading Inspection

1. Rough grading shall be inspected and approved by the Engineer prior to placement of planting soil.

2. Finish grading shall be inspected and approved by the Engineer prior to seed application.

B. Inspections

1. The Contractor shall request a provisional inspection upon completion of the Work. Upon completion of the punchlist, the Engineer will make provisional acceptance in writing.

2. Final acceptance will be at the end of the 1-year warranty period and after all required repairs have been made.

1.06 WARRANTY AND REPLACEMENT

Hydroseeding is warranted as specified in the Specifications. Seeded areas must have a relatively uniform stand of grass with no bare spots over 6 feet square at the time of provisional acceptance. The Contractor shall reseed at the original rate and fertilize with 15-22-15 at the rate of 1 lb. of nitrogen per 1,000 square feet. All areas failing to vigorously establish for any reason whatsoever within 90 days after germination or a growing season, whichever is longest, shall be reseeded.

PART 2 – PRODUCTS

2.01 GENERAL

The materials used in performing this Work shall conform to the material specifications listed in this section.

2.02 FERTILIZER

A. Finely ground dolomitic lime shall be retained by Taylor Standard Sieves as follows:

1. Number 20 sieve – retains 0.0 percent

2. Number 100 sieve – retains 25 percent

B. Lawn installation fertilizer 15-22-15 shall be as manufactured by Lilly Miller (or approved equivalent).

1. Guaranteed Fertilizer Analysis:

Total Nitrogen (N)	15 percent
Ammoniacal Nitrogen	4.6 percent
Urea Nitrogen	3.2 percent
Coated Slow Release Urea Nitrogen	3.3 percent

Slowly Available Water Soluble Nitrogen*	2.3 percent
Water Insoluble Nitrogen	1.6 percent
Available Phosphoric Acid (P205)	22 percent
Soluble Potash (K20)	15 percent
Sulfur (S)	4 percent
Boron (B)	0.06 percent
Copper (Cu)	0.06 percent
Iron (Fe)	1 percent
Manganese (Mn)	0.15 percent
Zinc (Zn)	0.14 percent

Note: Derived from Urea, Sulfur-Coated Urea, Methylene Ureas, Ammonium Phosphate, Sulfate of Potash, Muriate of Potash, Iron Sulfate, Calcium and Sodium Borate, Copper Oxide and Sulfate, Iron Oxide Sulfate and Frit, Manganese Oxide and Sulfate, and Zinc Oxide and Sulfate.

* Slowly Available Water Soluble Nitrogen from Methylene Ureas

2.03 HYDROMULCH TYPE A

Mulching material to be used in hydroseeding all disturbed areas shall meet the requirements of Section 9-14.4(2) of the WSDOT Standard Specifications 2004. The Mechanically-Bonded Fiber Matrix™ (M-BFM) shall be Conwed Fibers 3000 M-BFM, as manufactured by PROFILE Products (or an approved equivalent). The M-BFM shall require no cure time and be comprised of wood fiber, cross-linking hydrocolloid tackifier, co-polymer gel, and crimped interlocking fibers. The M-BFM shall be manufactured using thermal-mechanical defibration to create wood fibers that, when combined with tackifier and synthetic fibers, shall have a minimum water holding capacity of 1,500 percent.

2.04 HYDROMULCH TYPE B

Mulch shall be wood cellulose fiber from alder, containing no growth- or germination-inhibiting substances. A soil-binding agent (tackifier) is required. Mulch shall be dyed a suitable color to facilitate placement.

2.05 SOIL-BINDING AGENT (TACKIFIER)

Soil-binding agent shall consist of non-toxic, biodegradable materials that are environmentally safe, such as ESI – TAK or approved equivalent. Tackifier shall

be applied, at a minimum, in quantities sufficient to equal the retention properties of guar when applied at a rate of 60 gallons per ton of mulch.

2.06 SEED MIX A

A. Seed to be used in hydraulic application (hydroseeding) shall meet the requirements of Section 9-14.2 of the WSDOT Standard Specifications 2004.

Upon request, the Contractor shall furnish to the Engineer duplicate copies of a statement signed by the Vendor certifying that each lot of seed has been tested by a recognized seed-testing laboratory. Seed which has become wet, moldy, or otherwise damaged in transit or storage will not be accepted.

B. Hydroseed Mix A: Composed of the following species and applied at a rate of 250 pounds per acre:

Name	Pure Live Seed per Acre
Creeping Red Fescue (*Festuca rubra*)	100.0 lbs
Perennial Ryegrass (*Lolium perenne*)	100.0 lbs
Highland Colonial Bentgrass (*Agrostis tenuis*)	25.0 lbs
White Clover (*Trifoium repens*)	25.0 lbs
TOTAL	**250.0 lbs per acre**

2.07 SEED MIX B

A. Seed to be used in hydroseeding shall meet the requirements of Section 9-14.2 of the WSDOT Standard Specifications 2004. Seed shall be packed in clean, sound containers of uniform weight.

Upon request, the Contractor shall furnish to the Engineer duplicate copies of a statement signed by the Vendor certifying that each lot of seed has been tested by a recognized seed-testing laboratory. Seed which has become wet, moldy, or otherwise damaged in transit or storage will not be accepted.

B. Hydroseed Mix B: Composed of the following species and applied at a rate of 250 pounds per acre:

Name	Pure Live Seed per Acre
Perennial Ryegrass (*Lolium perenne*)	125.0 lbs
Chewings Fescue (*Festuca rubra ssp. commutata*)	75.0 lbs
Hard Fescue (*Festuca ovina duriuscula*)	50.0 lbs
TOTAL	**250.0 lbs per acre**

1. Approved Varieties

a) Turf-Type Perennial Rye Grass Blend: Blend must consist of at least three varieties listed below and be mixed in equal portions, by weight:

Brightstar	Palmer II	Nighthawk	Prelude II
SR 4200	Prizm	Affinity	Assure
Dimension	APM	Charger	Sherwood
Blazer II	Stallion Sel	Tara	Commander
Saturn	SR 4100	Fiesta II	Birdie II

b) Creeping Red Fescue: A single variety must be selected from the following list:

Cindy	Ensylva	Flyer	Salem	Jasper

c) Chewings Fescue: A single variety must be selected from the following list:

Longfellow	Promoter	Victory	Weekend
Shadow w/Endo	Southport	Tamara	Bridgeport
Waldorf	Enjoy	Bargreen	

PART 3 – EXECUTION

3.01 SITE PREPARATION

The Contractor shall notify the Engineer no less than 48 hours in advance of any seeding operation and shall not begin the Work until areas prepared for seeding have been approved. Following the Engineer's approval, seeding of the approved areas shall begin immediately. All soil preparation operations, compaction, and cleanup of debris shall be done prior to seeding and shall be approved by the Engineer.

3.02 SEEDING SCHEDULE

The time period for seeding shall be March 15 to September 15. No seeding shall be done before or after these dates without Engineer's written approval. No seeding shall take place on weekends or legal holidays.

3.03 WATERING

Any temporary irrigation system must be installed prior to hydroseed application and shall not be removed until the Contractor's warrantee expires.

3.04 SEEDING

Hydroseeding:

A. Fertilizer, seed, and mulch shall be applied in one operation with approved hydraulic equipment. The Contractor shall apply materials at the following rates:

1. Mulch – 50 lbs. per 1,000 square feet

2. Seed – 8 lbs. per 1,000 square feet

3. Lawn Installation Fertilizer – 15-22-15, 10 lbs. per 1,000 square feet

4. Soil-Binding Agent – 1 lb. per 1,000 square feet

B. Seeding shall not be done during windy weather or when the ground is frozen.

C. The Engineer shall approve the Contractor's proposed watering methods prior to seeding.

D. The Contractor shall give the Engineer 48 hours notice prior to seeding operation. Equipment shall utilize water as carrying agent, utilizing continuous built-in agitation system.

E. Equipment with a gear pump is not acceptable.

F. The Contractor shall pump a continuous, non-fluctuating supply of homogenous slurry to provide a uniform distribution of material over designated areas.

3.05 PHYSICAL COMPLETION

A. Inspection to determine physical completion of seeded areas will be made by the Engineer upon Contractor's notification of completion. The Contractor may request a specific inspection date provided that the request is made at least 5 working days before requested inspection date.

1. Seeded areas will be accepted, provided all requirements, including maintenance, have been complied with and grass is well established and exhibits a vigorous growing condition.

2. Areas failing to show a uniform stand of grass shall be reseeded at the Contractor's expense. A uniform stand of grass is defined as vigorous grass growth with no bare spots greater than 10 square feet.

3.06 CLEANING

The Contractor shall perform cleaning during installation of the Work and upon completion of the Work. The Contractor shall remove from the site all excess materials, soil, debris, and equipment and shall repair the damage resulting from seeding operations.

END OF SECTION 02930

SECTION 02950

LARGE WOODY DEBRIS INSTALLATION

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

Provide and install boulder, constructed riffles and pools and anchored large woody debris structures as shown and specified on the Plans.

1.02 PROJECT CONDITIONS

A. Work notification: Notify Engineer at least seven working days prior to installation of woody debris.

B. Protect existing utilities and previously placed rock from damage during installation of large woody debris.

C. Confine work to designated areas. Do not disturb existing vegetation outside Project limits and protect all trees, shrubs and ground covers within Project limits not designated to be removed.

PART 2 – PRODUCTS

2.01 LARGE WOODY DEBRIS

A. Logs shall consist of salvaged natural wood that has not been preservative treated. Preservative treated logs are not acceptable. All anchored logs shall have root wads attached. The Contractor shall obtain logs with root wads from approved offsite sources. Use of decay resistant species, such as Madrone, Black Locust, Cedar, and Douglas Fir, are preferred. Logs shall be a minimum of 12 inches in diameter, 4 feet from the base, and shall be a minimum length as shown on the Contract Drawings. Trim woody debris as directed by Engineer. Logs shall be washed of soil and debris prior to installation.

B. No split logs or individual root wads without trunks will be accepted.

C. Some logs are available from the Owner and shall be used prior to any other logs being purchased and delivered to the site. The Engineer will provide an inventory of the size and quantity of the available logs.

2.02 CONSTRUCTED POOL AND RIFFLE MIX

A. Constructed riffle mix shall consist of hard rock that is durable and angular in size and shape. It shall be free from segregation, seams, cracks, and other defects tending to destroy its resistance to weather. It shall be free from overburden, spoil, shale, and any organic material.

B. Rock source and a sample of the quality and size to be provided shall be inspected and approved by the Engineer prior to any rock being loaded for hauling

Size:

Percent by Volume	Diameter
15%	24 to 30 inches
25%	12 to 24 inches
45%	6 to 12 inches
20%	1 to 6 inch
15%	1 inch minus with fines

Note: 1 inch minus with fines shall be pit-run gravel naturally occurring granular material, free of wood waste or other extraneous materials. This material is to be worked into the rock mix and, after reaching final grade, spread into the voids using water. Silt laden water that is transported downstream shall be pumped out of the stream channel and allowed to infiltrate away from the river or into silt construction bags.

2.03 BOULDERS

Boulders shall consist of naturally occurring rounded or sub-rounded rock, free from organic material. The rock shall be free from segregation, seams, cracks, and other defects tending to destroy its resistance to weather.

Boulders shall consist of rounded or sub-rounded rock weighing an average of 750 pounds, with a minimum weight of 500 pounds. No stone shall be used that is less than 18 inches in its least dimension.

2.04 LOG VANE STRUCTURES

Logs as specified for log vane structures shall be sound, Western Red Cedar or Douglas-fir logs with their root wads near to fully intact, and shall be a minimum of 10 feet long and 12 inches in diameter at the mid-point in log length. Logs shall be straight, unless otherwise allowed on an individual basis by the Engineer. Logs may also be shortened to a minimum of 5 feet in length on an individual basis at the direction of the Engineer. Logs may be supplied with limbs attached, but limbs are to be trimmed at the direction of the Engineer.

2.05 LOG TOE BANK PROTECTION STRUCTURES

Logs as specified for log toe bank protection structures shall be sound, Western Red Cedar or Douglas-fir logs with their root wads near to fully intact, and shall be a minimum of 5 feet long and 12 inches in diameter at the mid-point in log length. Logs used as the top log and the toe log shall be sound, Western Red Cedar or Douglas-fir logs without root wads. Top and toe logs shall be a minimum of 10 feet long and 12 inches in diameter at the mid-point in log length. Logs shall be straight, unless otherwise allowed on an individual basis by the Engineer. Logs may be supplied with limbs attached, but are to be trimmed at the direction of the Engineer.

2.06 CONCRETE ANCHORS

Concrete Anchors shall be rectangular blocks of concrete measuring 2 feet x 2 feet x 6 feet (commonly termed “Ecology Blocks”) with a steel eye for chain connection. The Contractor shall obtain Concrete Anchors from approved off-site sources.

2.07 CHAINS

Chains shall be 1/2-inch galvanized lashing chains with one screw shackle per log. The Contractor shall obtain chains from approved off-site sources.

PART 3 – EXECUTION

3.01 INSPECTION

Finish grading and woody debris placement shall be inspected and approved by the Engineer.

3.02 PREPARATION

Contractor shall locate large woody debris by staking with stakes and flags as indicated on the Drawings or as approved in the field. If obstructions are encountered that are not shown on the Drawings, do not proceed until the Engineer has selected alternate locations.

3.03 INSTALLATION OF ANCHORED LARGE WOODY DEBRIS AND WOODY DEBRIS BARRIER

Construct anchored large woody debris as shown on the Drawings. Concrete anchors shall be placed during excavation and/or grading operations and before cap or backfill placement. The Contractor may use colored stakes or other Engineer-approved means to identify locations of concrete anchor underneath the cap or backfill.

The Contractor shall alert the Engineer at least 48 hours before placement and selection of woody debris. The Engineer shall be present during placement and selection of woody debris.

Contractor shall not prepare placement or place more than one large woody structure at a time, unless directed otherwise by Engineer. Contractor shall identify location of concrete anchor and expose the anchor’s steel eye before placement. The Contractor shall minimize cap or backfill disturbance during installation and exposure of the concrete anchor steel eye. The Contractor shall install large woody debris structures as presented in the Contract Drawings and securely fasten logs to steel chain and concrete anchors to prevent movement by high water. Once the large woody structure is installed and approved by Engineer, the Contractor shall carefully re-place cap or backfill material on top of steel eye to conceal concrete anchor from view.

3.04 CONSTRUCTED POOL AND RIFFLE STRUCTURES

Constructed pool and riffle structures shall be installed in locations and to the depths and grades shown on the Plans. The Contractor shall remove all vegetation along the riverbank that is located in the footprint of the constructed pool or riffle. Placement of the material shall be done with a track mounted excavator, or similar, working in the stream. Placement shall occur in lifts not to exceed 12 inches before compaction. The excavator shall carefully drive over the final grade of the gravel/cobble mix using the weight of the equipment to embed materials and ensure compaction before elevations are checked.

END OF SECTION 02950

SECTION 03360
SHOTCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the requirements for materials, proportioning, and application of shotcrete using either dry-mix or wet-mix process.

1.2 DEFINITION

Shotcrete: Mortar or concrete pneumatically projected at high velocity onto a surface; also known as air-blown mortar; also pneumatically applied mortar or concrete, sprayed mortar and gunned concrete.

1.3 RELATED WORK

A. Materials testing and inspection during construction: Section 01810, EQUIPMENT TESTING AND FACILITY START UP.

B. Formwork and reinforcement: Section 03300, CAST-IN-PLACE CONCRETE.

1.4 SUBMITTALS

A. Submit in accordance with Section 01300, SUBMITTALS.

B. Certified shotcrete mix design including, but not limited to:

1. Brand and type of Portland cement.
2. Source gradation, and quality of all aggregates, if used.
3. Proportions of mix by weight and water-cement ratio.
4. Proposed admixtures, manufacturer, dosage, technical literature (where allowed).
5. Compressive strength test results for the proposed shotcrete mix design, manufacturer records completed within 6 months of the start of shotcreting may be submitted for initial verification of the required compressive strengths at the start of production work.

C. Shop Drawings: Reinforcing Steel.

D. Two 300 mm x 300 mm x 25 mm (12 inch by 12 inch by 1 inch) sample panels showing required finish. Submit panels within 30 days after receipt of notice to proceed.

E. Aggregate gradation.

F. Written documentation of project references, including project name, owner’s name, and phone numbers from at least 3 comparable projects in the last 2 years.

G. Written documentation of the nozzleman's qualifications including proof of ACI certification (if applicable).

H. Written documentation of the shotcrete supervisors experience, including direct shotcrete application experience on comparable projects.

I. Written documentation of the certification of the testing laboratory. Include documentation that the strength testing laboratory complies with ASTM C 1077 and has the experience to perform the tests specified in this Section. The testing laboratory shall be AASHTO accredited for ASTM C 1077 or demonstrate the ability to perform the requisite tests.

J. Proposed methods of shotcrete placement and of controlling shotcrete thickness and maintaining facing alignment and location.

K. Description of the proposed equipment for mixing and applying shotcrete. Include the manufacturer instructions, recommendations, literature, performance, and test data.

1.5 QUALITY CONTROL

A. Contractor Qualifications.

1. The work defined in this section is specialty construction requiring a specialty contractor who is highly knowledgeable and experienced in the fabrication and installation of shotcrete. The Contractor performing the work in this Section shall submit proof of three (3) projects within the last five (5) years on which the Contractor has successfully installed shotcrete of similar applications as required for this project. A brief description of each project with the owner’s name and phone number shall be included.

2. Workers, including foreman, nozzleman, and delivery equipment operators, shall be fully qualified to perform the work. All nozzlemen on this project shall have at least one year of experience in the past three years in similar shotcrete application work and shall demonstrate ability to satisfactorily place the material.

3. Initial qualification of the nozzlemen shall be based either on ACI certification or satisfactory completion of preconstruction test panels. The requirement for nozzlemen to shoot preconstruction test panels will be waived for nozzlemen who can submit documented proof that they have been certified in accordance with the ACI 506.3R, and that their certification is current. The Certification shall have been done by an ACI recognized shotcrete testing laboratory, or recognized shotcreting consultant, and shall

have covered the type of shotcrete used for the project. Nozzlemen who are not required to shoot preconstruction test panels on the basis of ACI Certification shall still be required to shoot production test panels periodically during the course of the Work at the frequency specified herein.

4. The Contractor shall notify the Engineer not less than 5 days prior to the shooting of preproduction test panels by non-certified nozzlemen. Preproduction test panels shall be prepared using the same shotcrete mix and equipment as those to be used in the production work.
5. The Contractor shall notify the Engineer of any problem that may influence the quality of the shotcrete.

B. Tolerances:
   1. Cover of reinforcement: ACI 506.2, Paragraph 3.6.2.
   2. Alignment and thickness of shotcrete shall be controlled by installing ground wires. Alignment and thickness control shall conform to ACI 506R Section 5.6.

1.6 PRECONSTRUCTION TESTING

A. Conform to the requirements of ACI 506R, Paragraph 6.4.

B. Testing laboratory approved by the Engineer and reimbursed by Contractor shall design dry or wet mix, as applicable, to produce compressive strengths indicated on drawings.

C. Each nozzleman without previous ACI certification shall make 2 test panels for each mix design, 600 mm (24 inches) square and 90 mm (3 1/2 inches) minimum thickness. Take 5 cores or cubes from each 75 mm (3 inch) panel for compressive strength testing in accordance with ACI 506.2.

D. Qualification of the nozzlemen shall also be based on a visual inspection of the shotcrete density and void structure and on achieving the specified 3-day and 28-day compressive strength requirements determined for test specimens extracted from the preconstruction test panels. Preconstruction and production test panels, core extraction and compressive strength shall be conducted in accordance with ACI 506.2 and AASHTO T24/ASTM C42, unless otherwise specified herein.

E. Nozzlemen who are qualified on the basis of preproduction testing may begin production shooting on the basis of acceptable preconstruction test panels and on test specimens passing the 3-day strength requirements. Continued qualification will be subject to test

specimens passing the 28-day strength tests and maintaining satisfactory shooting performance during production test panels.

F. Using the proposed mix design make at least two job-site sample panels approximately 2400 mm (8 feet) high and 1800 mm (6 feet) wide with thicknesses shown. The job-site panels shall contain reinforcing typical of the work to be installed and other details to simulate actual job conditions. Finish sample panels as required for work to be installed. Sample panels must be approved by the Engineer before any work can begin.

1.7 CONSTRUCTION TESTING

Make one test panel 450 mm (18 inches) square and 75 mm (3 inches) thick for each day's work or portion thereof. Provide test panels to a testing laboratory approved by Engineer and reimbursed by the contractor. Five compressive strength specimens will be obtained from each panel and tested for compressive strength in accordance with ASTM C42. Two (2) samples are to be tested at 7 days and 28 days after application. The fifth sample should be retained for 56 days should additional testing be required. Strength test results are to be reported to the Engineer 24 hours after completion of test.

1.8 DELIVERY, HANDLING, AND STORAGE

A. Properly deliver and handle materials to prevent contamination, segregation, corrosion or damage to materials.

B. Store cement in weathertight enclosures to protect against dampness and contamination.

C. Prevent segregation and contamination of aggregates by proper arrangement and use of stockpiles.

D. Store admixtures properly to prevent contamination, evaporation, freezing, or other damage.

1.9 APPLICABLE PUBLICATIONS

A. Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by basic designation only.

B. American Concrete Institute (ACI):

304R-00.....Guide for Measuring, Mixing, Transporting, and Placing Concrete

506R-05.....Guide to Shotcrete

506.2-95 .....Specification for Shotcrete

506.3R-91.....Guide to Certification of Shotcrete Nozzlemen

506.4R-94(2004).....Guide for the Evaluation of Shotcrete

C. American Society for Testing and Materials (ASTM):

C33-03.....Standard Specification for Concrete Aggregates

C42/C42M-04 .....Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C94/C94M-05 .....Standard Specification for Ready-Mixed Concrete

C150-05.....Standard Specification for Portland Cement

C260-01.....Standard Specification for Air-Entraining Admixtures for Concrete

C494/C494M-05a .....Standard Specification for Chemical Admixtures for Concrete

C1077-06.....Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

C1116-06.....Standard Specification for Fiber-Reinforced Concrete

D. US Army Corps of Engineers (UACE):

EM 1110-2-2005(1993) .....Standard Practice for Shotcrete

E. American Association of State Highway and Transportation Officials (AASHTO):

T24-05.....Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement: ASTM C150, Type I or II.

B. Reinforcement: Synthetic Fiber: Fibrillated polypropylene fibers engineered and designed for use in shotcrete, complying with ASTM C 1116, Type 111, not less than ¾-inch (19mm) long

C. Aggregate: ASTM C33, and UACE EM 1110-2 (Gradation Table 3-1), as defined in Table 2.

TABLE 2 -- GRADATION LIMIT FOR AGGREGATES

Sieve Size, U.S. standard square mesh	Percent by Weight Passing Individual Sieves		
	Gradation No. 1	Gradation No. 2	Gradation No. 3
20 mm 3/4 inch	---	---	100
13 mm 1/2 inch	---	100	80-95
10 mm 3/8 inch	100	90-100	70-90
No. 4	95-100	70-85	50-70
No. 8	80-100	50-70	35-55
No. 16	50-85	35-55	20-40
No. 30	25-60	20-35	10-30
No. 50	10-30	8-20	5-17
No. 100	2-10	2-10	2-10

D. Chemical Admixtures: ASTM C494.

E. Air-entraining Admixture: ASTM C260.

F. Water: Fresh, Clean, and Potable

2.1 MIXES

A. Shotcrete: The shotcrete used shall consist of a mixture of Portland cement, sand, aggregate, and water so proportioned and mixed to be pumped. Mixture shall be proportioned to provide a minimum compressive strength of ___Mpa (___psi) at 28 days.

B. Mix Design: Testing Laboratory, retained by Contractor, shall design a mix to produce concrete as specified and perform tests as required. Certified test reports (duplicate) shall be submitted. Reports shall include proportions of design mix.

C. Maintain water-cement ratio between 0.35 to 0.50 by weight.

D. Concrete-mix design adjustments may be considered if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant. Resubmit and obtain approval from the Engineer of proposed changes to concrete-mix design.

E. Improper Mix: Immediately notify the Concrete Testing Laboratory and the Engineer if at any time during construction the accepted mix design proves to be unsatisfactory for any reason. The Contractor's Concrete Mix Designer shall modify the design, subject to the review of the Engineer, until a satisfactory mix is obtained.

PART 3 - EXECUTION

3.1 PROPORTIONING, DELIVERY AND MIXING

A. Proportioning: Mix shall be designed by Contractor-retained testing laboratory; see "PRECONSTRUCTION TESTING" hereinbefore.

B. Mixing Processes:

1. Mixing, General: Strength of mix is specified on the drawings. At Contractor's option, use either the dry or wet mix process. Discharge entire batch before recharging. Clean mixer at least once every 8-hour shift or portion thereof. Reject material mixed and standing for 45 minutes; remixing or tempering not permitted.
2. Dry Mix Process: Conform to ACI 506R, Paragraph 1.5.1.
3. Wet Mix Process: Conform to ACI 506R, Paragraph 1.5.2.

3.2 EQUIPMENT, DRY MIX PROCESS

A. Batching and Mixing Equipment: Batch by weighing, use rotating mixer or adequate capacity for dry-mixing aggregate and cement for continuous supply of material to gun, all conforming to ACI 506R, Paragraph 3.5.

B. Delivery equipment:

1. Gun and Nozzle: Premixing type conforming to the requirements of ACI 506R, Paragraphs 3.2 and 3.7 designed for material delivery and water injection.
2. Air Compressor and Hoses: Standard type, of capacity to provide without interruption, pressures and volume of air necessary for longest hose delivery; conform to ACI 506R, Table 3.1. Make allowances for air consumed by separate blow pipe in blowing away rebound, cleaning reinforcing and incidental uses.

3.3 EQUIPMENT, WET MIX PROCESS

A. Batching and Mixing Equipment: ACI 506R, Paragraph 3.5. Batch by weighing; use rotating mixing equipment and mix in accordance with ACI 304R, and ASTM C94 for ready-mixed concrete.
B. Delivery Equipment: Use pneumatic feed or positive displacement type of design and size capable of delivering premixed materials accurately, uniformly and continuously through the hose, all in accordance with ACI 506R, Paragraphs 3.3 and 3.7.
C. Air Supply: ACI 506R, Paragraph 3.4.2.
D. Water Supply: Conform to ACI 506R, Paragraph 3.8.1 with adequate capacity to maintain water pressure approximately 65 N (15 pounds) higher than highest air pressure required, both air and water pressure uniformly steady, non-pulsating.

3.4 ALIGNMENT CONTROL

A. General: To establish thickness and surface planes or shotcrete build-up provide ground wires, taut, secure, true to line and plane, conforming to ACI 506R, Paragraph 5.6.
B. The Contractor shall ensure that the thickness of shotcrete satisfies the minimum requirements shown on the Contract Drawings.
C. The Contractor shall ensure that the front face of the shotcrete remains less than 25 mm (1 inch) outside of its required limits shown on the Contract Drawings.
D. The Contractor shall ensure that the excavated face be flat and free from irregularity prior to shotcrete placement. Additional shotcrete used to fill gaps, voids and irregularities on the excavation face is the responsibility of the Contractor.
E. The cost of additional material used to fill void space between the actual shotcrete face and the proposed limits of the shotcrete face is the responsibility of the Contractor.
F. Reinforcing Positioning: Check that reinforcing is positioned and sized in accordance with the Contract Documents and ACI 506R, Paragraph 5.4.

3.5 EXHAUST SYSTEM

A. Construct a sealed air barrier around immediate area of work as approved by Engineer. Construct a sealed air barrier prior to any application within confines of the Medical Center.
B. Continuously exhaust work area to outside creating a negative pressure within area. Do not locate air exhaust near any air intakes.

3.6 SHOOTING

A. General: ACI 506R, Paragraph 8.5.7. Shoot and fill corners first, with continuous uniform material flow from nozzle held approximately 600 to 1500 mm (2 to 5 feet) from the work, at angle normal to the surface.
    1. Shoot around reinforcing with nozzle close to encase reinforcement as illustrated in ACI 506R, Figure 8.4, left column.
    2. If flow is not uniform and slugs, sand spots or wet sloughs result, turn nozzle away until faulty work is cut out and repaired.
    3. Do no shotcrete work if temperature is below 4 degrees Celsius (40 degrees Fahrenheit) without providing continuous heat and adequate protection from freezing.
B. Preparation of Surfaces to Receive Shotcrete: ACI 506R, Paragraph 5.2, as applicable to the work, as approved.
C. Rebound: ACI 506R, Paragraph 8.5.11. Do not work rebound into construction nor salvage rebound for subsequent batching.
D. Suspend application if:
    1. High wind prevents nozzlemen from proper application of material.
    2. Weather approaches freezing and shotcrete cannot be protected.
    3. Rain, other than a very light sprinkle, occurs which would wash cement out of freshly placed material.
    4. Ground water or surface water flow is persistent enough to wash cement out of freshly placed material.
E. Time Between Coats:
    1. In sloping, vertical or overhanging work, allow interval of time sufficient for initial, but not final, set to develop.
    2. At development of initial set, lightly broom surface to remove any laitance to provide better bond with succeeding applications.
F. Construction Joints:
    1. ACI 506R, Paragraph 5.7.2, tapering over a width of 300 mm (1 foot) to a 25 mm (1 inch) edge from board laid flat.
    2. Before proceeding with additional shotcrete work, thoroughly clean joint and adjacent shotcrete, then wet and scour surfaces with air jet.

G. Warm Weather Application: Prevent dryout resulting in cracking and separation by keeping surfaces continuously moist and/or covered with continuously moistened burlap for 7 days after shotcreting.

H. Surface Finish: Bring final surfaces of shotcrete to an even plane, well formed corners either square or to radius shown, working up to ground wires using somewhat lower placing velocity than normal.

1. Remove ground wires to 20 mm (3/4 inch) back from surface and fill holes with shotcrete to adjacent surface elevations.
2. Wood float surfaces to provide a smooth true finish.

3.7 CURING

ACI 506.2, Paragraph 3.8.

3.8 HOT WEATHER SHOTCRETING

ACI 506R, Paragraph 8.9.

3.9 COLD WEATHER SHOTCRETING

ACI 506R, Paragraph 8.10.

3.10 PROTECTION AND CLEAN-UP

A. Protection: Protect adjacent walls, windows, doors, other building surfaces, grounds and/or shrubs and property of others from damage by shotcreting, rebound and dust.

1. Construct a sealed dust partition to confine rebound and dust to immediate work area. Dust partition shall be integral with exhaust system. A negative air pressure shall be maintained within partitioned area during shotcrete applications to prevent dust leakage beyond area.
2. Immediately clean all shotcrete materials and remove all rebound from site.

B. Clean-up: Continuously remove rebound material to ensure that base, intermediate, and finish surfaces are clean and ready for bonding layers.

3.11 DEFECTIVE WORK

General work will be evaluated be the Engineer or designated agent in accordance with ACI 506.4. If the evaluation reveals unbonded work or cores fail to meet specified strengths, or finishes are unsatisfactory, repair such defective work, as approved, without additional cost to the District.

END SECTION 03360