ELY COPPER MINE OU1 FINAL TECHNICAL SPECIFICATIONS

List of Technical Specifications

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SECTION 31 10 00 - SITE CLEARING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Specifies requirements for removing and disposing of surface debris, trees, shrubs, and stumps from within the Work Area.

B. Remove existing above- and below-grade improvements as indicated on the Drawings or as designated by the ENGINEER necessary to facilitate new construction.

1.2 WORK INCLUDES

A. Remove all surface debris, trees, shrubs, and stumps from within the Work Area and other areas as approved or designated by the ENGINEER.

B. Dispose of cleared shrubs, trees, stumps, cobbles, boulders, and debris as shown on the Drawings in areas designated by the ENGINEER (Part 3.6).

C. Remove old equipment and building debris, if found, from within the Work Area and dispose of as designated by the ENGINEER (Part 3.6).

1.3 DEFINITIONS

A. Site Clearing – the removal, hauling, and disposal of surface debris, trees, boulders, and shrubs from within clearing limits shown on the Drawings.

B. Grubbing – the removal, hauling, and disposal of rocks, boulders, stumps, roots and other vegetation below ground, debris, and obstructions from within the clearing limits shown on the Drawings.

C. Stripping – the removal and disposal or re-use of organic soils (topsoil) from within the limits shown on the Drawings.

1.4 RELATED SECTIONS

A. Section 31 20 00 Earth Moving

B. Section 31 23 19 Dewatering and Surface Water Control

C. Section 31 25 00 Erosion and Sedimentation Control

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.1 PREPARATION

A. The project site is located within a known bat roosting habitat. All clearing and grubbing activities are prohibited between April 15th and October 31st. All clearing and grubbing activities shall be undertaken between November 1st and April 14th.

B. Limit the area of clearing and grubbing to the minimum area possible that allows for the proper construction of the Work as shown on the Drawings.

C. Install temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust in accordance with the Project Drawings and as directed by the ENGINEER.

D. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

E. Inspect, maintain, and repair erosion and sedimentation control measures during construction until permanent vegetation has been established.

3.2 PROTECTION

A. Protect benchmarks and survey monuments from damage or displacement. Any benchmarks or survey monuments damaged during clearing and grubbing shall be repaired or replaced immediately.

B. Locate, identify, and protect utilities and existing historic structures from damage.

C. Protect existing trees and other vegetation along the perimeter of the limits of clearing against unnecessary cutting, breaking or skinning of roots, skinning or bruising of bark, smothering of trees by stockpiling within the drip line, excess foot or vehicular traffic, or parking vehicles or equipment within the drip line.

D. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified prior to the start of clearing activities.

E. Protect existing mine buildings, building relics, and mine infrastructure from damage to the maximum extent practical. Historical features and mine infrastructure should be protected in accordance with the contract drawings and as required by the ENGINEER and/or Project Historian.

3.3 CLEARING

A. Clear areas required for access to Site and the execution of Work.

B. Remove all trees, shrubs, deadwood, boulders, and other surface debris within the clearing limits. Set aside large trees for the property OWNER's use with consideration for Site access as directed by the ENGINEER.

C. Chip and stockpile trees as directed by the ENGINEER.

3.4 GRUBBING

A. Remove all rocks and boulders, stumps, roots and other vegetation below ground, all debris, and obstructions within the clearing limits.

B. Remove the roots from trees, tree stumps, bushes and shrubs to a minimum depth of one foot below the existing or finished grade, whichever is lower.

C. Remove stumps for trees larger than two inches in diameter.

D. Use only hand methods or air spade for grubbing within equipment protection zones.

3.5 STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip excavation limit of cover and other areas of topsoil to a depth of at least 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials within the excavation limits as shown on the Project Drawings and other areas as approved by the ENGINEER.

C. All stripped material underlain by waste rock or tailing shall be disposed of as subgrade fill material beneath the geomembrane, unless otherwise approved by the ENGINEER. Stripped material underlain by tailing, waste rock, or ore roasts shall NOT be used as topsoil as designated on the Drawings, unless its use is approved by the ENGINEER.

D. Stockpile topsoil suitable for reuse away from edge of excavations without intermixing with subsoil or other materials. Grade and shape to drain surface water and place silt fences around stockpile to prevent migration of fines from the stockpile areas or otherwise as directed by the ENGINEER. Cover or stabilize to prevent windblown dust and erosion by water.

3.6 DISPOSAL

A. Burning will not be allowed.

B. Brush, trees, and stumps may be chipped and stockpiled for onsite reuse as approved by the ENGINEER.

C. All non-organic waste material including, but not limited to: waste rock, tailing, stripped material underlain by waste material, and any other materials designated by the ENGINEER shall be disposed of as subgrade fill material beneath the geomembrane cap system, unless otherwise approved by the ENGINEER.

D. Remove obstructions, demolished materials, organic matter, trash and debris not suitable for reuse onsite and legally dispose of them at an approved off-site facility.

E. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials, and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 31 10 00

SECTION 31 20 00 - EARTH MOVING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements for furnishing all equipment and materials and conducting all work related to earthwork activities including: excavation of waste soil/rock materials; general excavation; trench excavation; rock removal; site grading; trench excavation protection with sheeting and shoring as required; hauling; stockpiling; subgrade fill; excavation and trench backfilling; compaction; placing riprap and stone; and construction quality control testing.

1.2 WORK INCLUDES

A. Excavating waste or clean overburden areas to subgrade.

B. Stockpiling of saturated waste or saturated clean overburden.

C. Constructing berm at the OU1 waste repository.

D. Installing groundwater and surface water controls.

E. Placing and compacting waste rock, tailing, and ore roast materials.

F. Placing and compacting cover system base and final grading.

G. Preparing subgrade and cover.

H. Placing vegetative support layer.

I. Placing topsoil.

J. Constructing access/haul roads.

K. Constructing permanent soil slopes.

L. Placing riprap and stone fill.

M. Placing streambed material and stream structures.

1.3 RELATED SECTIONS

A. Section 01 45 00 Construction Quality Control

B. Section 01 11 00 Summary

C. Section 31 10 00 Site Clearing

D. Section 31 23 19 Dewatering and Surface Water Control

E. Section 31 25 00 Erosion and Sedimentation Control

F. Section 31 56 10 Cover System Performance Testing

G. Section 31 56 50 Geosynthetics

H. Section 31 59 70 Geomembrane

I. Section 31 71 20 Drainage Geocomposite

J. Section 31 80 00 Blasting Controls

K. Section 31 90 00 Revegetation

1.4 REFERENCES

A. For products or workmanship specified by association, trades, or Federal standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

B. The date of the standard/reference is the most recent/updated, in effect as of the date of the Contract Documents except when a date is specified.

C. OSHA Title 29 CFR 1926 - Excavation Safety.

D. AASHTO T 96: Resistance to Abrasion of small size coarse aggregate by use of the Los Angeles Machine.

E. ASTM C 25: Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime.

F. ASTM C 88: Standard Test Method for Soundness of Aggregates by use of Sodium Sulfate or Magnesium Sulfate.

G. ASTM C 127: Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate.

H. ASTM C 136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

I. ASTM D 422: Standard Test Method for Particle-Size Analysis of Soils.

J. ASTM D 1557: Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.

K. ASTM D 2216: Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

L. ASTM D 2487: Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

M. ASTM D 2922: Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (shallow depth).

N. ASTM D 3017: Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (shallow depth).

O. ASTM D 3740: Standard Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.

P. ASTM D 4318: Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soil.

Q. ASTM D 5084: Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

R. ASTM D 5268: Standard Specification for Topsoil Used in Landscaping Purposes.

S. ASTM D 5519: Standard Test Methods for Particle Size Analysis of Natural and Man-Made Riprap Materials.

T. ASTM D 6938: Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

U. Vermont Agency of Transportation 2018 Standard Specifications for Construction, or latest edition.

1.5 REQUIREMENTS

A. Perform all work in compliance with appropriate OSHA Regulations.

B. Perform all work in accordance with an approved Work Plan.

1.6 DEFINITIONS

A. Compacted Fill or Common Borrow: Material obtained from an approved on-site or off-site borrow source or other approved borrow sources and consisting of a well graded mixture of silt, clay, sand and gravel material free from tailing, waste rock, ore roasts, organic matter or other deleterious material and meeting the requirements of this Section.

B. Cover System: The cover system consists of a 60-mil geomembrane overlain by drainage geocomposite, vegetative support soil, and topsoil.

C. Cross Vane: A cross vane is an upstream angled line of boulders or logs embedded into both streambanks to concentrate the streamflow towards the center of the stream and also provide stream habitat to be constructed in accordance with the contract drawings.

D. ENGINEER: The designated ENGINEER for this project is responsible for ensuring that the construction activities are being performed in accordance with approved Work Plans, the Ely Copper Mine Superfund Site Operable Unit 01 Final Remedial Design (OU1 Final RD) Basis of Design Report, OU1 Final RD Construction Drawings, and OU1 Final RD Technical Specifications.

E. Fill: Material consisting of a mixture of silt, clay, sand and gravel material free from tailing, waste rock, ore roasts, organic matter, or other deleterious material. All specification references that do not specify "waste fill" apply only to materials defined as "fill."

F. Fines: Material finer than the U.S. No. 200 sieve (ASTM D 422).

G. Firm and Stable: A surface free of excessively wet or dry zones, soft or loose zones, excessive deflection, and or weaving. To be determined and approved by the Quality Control Supervisor (QCS) and the ENGINEER.

H. Gravel: Aggregate consisting of clean, hard gravel, crushed gravel or crushed stone meeting the requirements of this Section.

I. J-Hook: A J-hook vane is an upstream pointing line of rocks installed extending from the streambank to deflect flow away from the bank and provide stream habitat to be constructed in accordance with the details.

J. Limestone: Agricultural or geologic limestone or dolostone meeting the requirements of Part 2 of this Section.

K. Off-site Borrow Sources: Fill materials obtained from an off-site borrow source meeting the requirements of this Section and subject to testing for approval.

L. Low-permeability soil: Soil having a maximum hydraulic conductivity of 1 x 10-4 cm/sec.

M. Optimum water content: The soil moisture content which will result in a maximum dry unit weight when subjected to the compactive effort specified by ASTM D 698.

N. Ore Roasts: Deep red, hematite rich soil containing significant levels of metals but does not produce acidic leachate.

O. Organic Material: Material derived from plants such as (but not limited to) peat, wood chips, leaves, grass, branches, or roots.

P. Pass: One pass is defined as a dozer, roller, or other piece of equipment traveling over an active work area in one direction. When a dozer, roller, or other piece of equipment travels over an active work area in one direction, then backs over the same area it shall be considered two passes. Passes shall be overlapped a minimum of 2 feet to ensure complete coverage of the entire surface of a layer being compacted.

Q. Percent compaction: Percent compaction is defined as follows:

$$\text{Percent Compaction} = \frac{(K_d)_{IP}}{(K_d)_{max}} \times 100\%$$

Where:
$(K_d)IP$ = the in-place dry density of a particular soil

(K_d)max = the maximum dry density of that same soil, determined by compaction test according to ASTM D 1557 procedures.

R. Proof Rolling: Rolling a subgrade surface with equipment having an equivalent ground pressure of a loaded 12-yard tandem axle dump truck for the purpose of detecting soft or loose areas.

S. Quality Control Supervisor (QCS): The CONTACTOR's personnel with delegated authority to oversee and direct the on-site construction quality control management program.

T. Riprap: A graded mixture of boulders, cobbles, and gravel meeting requirements of this Section.

U. Rock: Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling, and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also, large boulders, buried masonry, or concrete exceeding 1 cubic yard in volume.

V. Streambed Material: A graded mixture of cobbles, gravel and streambed filler material meeting the requirements of this Section.

W. Step Pools: A series of rock sills with pools to provide grade control and habitat to be constructed in accordance with the details.

X. Stone: Aggregate consisting of clean, hard gravel, crushed gravel, or crushed stone meeting the requirements of this Section.

Y. Subgrade: Material underlying the cover system that consisting of fill, waste fill, or undisturbed tailing sand. Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

Z. Suitable Fill, Suitable Material or Common Borrow: Material imported to the Site or excavated on-site from an ENGINEER-approved borrow source that is free from tailing (as applicable), waste rock (as applicable), ore roasts (as applicable), deleterious substance, and unsuitable materials, which meets the specification requirements for a designated fill.

AA. Tailing: Milled waste material from mineral processing consisting of silty sands, sandy silts, and plastic silts and clays.

BB. Tailing Fill: Tailing that has been relocated and placed as cover system cushion material.

CC. Tracking: Running/tracking a tracked vehicle such as a bulldozer to create tread grooves perpendicular to the slope to roughen slope. Tracking would be used to prepare a soil surface for subsequent soil placement or to prepare a surface for seeding.

DD. Topsoil: Salvaged on-site materials, off-site material or manufactured material as specified herein and containing sufficient organic material to promote growth for revegetation in accordance with Section 31 90 00 - Revegetation.

EE. Unsuitable Materials: All soil materials that contain tailing, waste rock, ore roasts, slag, heap-leach material, biodegradable material, timbers, roots, frozen material, stones larger than specified herein, debris, trash, contaminants, and any other objectionable material as determined by the ENGINEER to be unsuitable for uses as fill. Gap-graded or segregated materials shall not be permitted unless approved by the ENGINEER.

FF. Vegetative Support Soil: Material imported to the Site or excavated on-site from the approved on-site borrow source that is free from tailing, waste rock, ore roasts, deleterious substance, and unsuitable materials, which meets the specification requirements for common borrow.

GG. Waste Fill: Waste rock, ore roasts, spoils, building debris, contaminated soil, or other material designated for placement within the limits of the geosynthetic cover system. All specification references that do not specify “waste fill” or “tailings fill” apply only to materials defined as “fill.”

HH. Waste Rock: Commingled, non-milled, processed, waste material from mining, consisting primarily of soils, gravels, cobbles, boulders, ore, cap rock, wood and other waste and debris, and clearing and grubbing waste. Upon final placement in the OU1 waste repository, waste rock will be referred to as waste fill.

II. Well-graded: A grading of material that has no specific concentration or lack thereof, of one or more sizes.

1.7 SUBMITTALS

A. Pre-construction Submittal: Submit a Construction Work Plan (CWP) to describe the means and methods for all earthwork activity in advance of the start of construction. The CWP must be approved by the ENGINEER prior to any earthwork activities. Prepare a work plan that may include the following:

1. Proposed material source(s).

2. On-site borrow source operation and maintenance plan.

3. Proposed soil processing, placement, compaction, and moisture control equipment, including:

    a. Equipment catalog with weight, dimensions, and operating data.

4. Proposed methods of protection of Work, including temporary dewatering, drainage, irrigating and moisture conditions, and frost protection measures.

5. Proposed excavation, stockpiling, regrading and staging plan describing handling and transport of on-site and off-site materials.

6. Other information requested by the ENGINEER.

B. Submit a list of equipment proposed for use in hauling, placing, and compacting (where applicable) the materials specified herein if requested by the ENGINEER.

C. Prior to conducting excavation and/or heavy equipment activities within the Underground Workings Restriction Zone, the CONTRACTOR shall obtain the services of a Professional Engineer Registered in the State of Vermont to perform an assessment of the geotechnical stability of this work zone after considering the specific activities to be performed near the Deep Adit; Burleigh Shaft and Chamber; West Adit; and the Pollard Adit. Based on this assessment, the CONTRACTOR shall submit a CWP Addendum describing how the work will be safely performed in this Restriction Zone including:

1. Appropriate specifications for the equipment and personnel that can safely enter, travel across, and/or work in this area.

2. An activity-specific Failure Effects Mode Analysis (FMEA) per EPA Guidance for sites that contain potential hazards related to flooded underground workings (Best Practices for Preventing Sudden, Uncontrolled Fluid Mining Waste Releases, EPA Office of Superfund Remediation and Technology Innovation, July 21, 2017).

D. Submit the name and location of off-site borrow sources, if used, and material suppliers for soil materials to be used to construct fills specified herein if requested by the ENGINEER. Include the type of materials to be obtained. Provide from the same source throughout the work. Change of source requires resubmittal and approval.

E. Provide documentation that an off-site borrow source, if used, complies with applicable Federal, State, and local regulations governing operation (i.e., borrow source operating permit).

F. Submit an affidavit from the source OWNER for each type of off-site soil borrow material stating that to the best of the source OWNER's knowledge, the site of the source material was never used as a dump for chemical, toxic, hazardous or radioactive materials and is not now nor ever has been listed as a suspected depository for chemical, toxic, hazardous or radioactive materials by any Federal, State, or other governmental agency, department or bureau. The borrow material obtained from off-site shall be free of chemical contamination.

G. Provide material testing reports from a qualified testing agency indicating and interpreting test results for compliance with requirements for specific materials including but not limited to classification according to ASTM D 2487 (prior to delivery and one per 5,000 CY delivered), gradation and particle size analysis according to ASTM D 422 (prior to delivery and one per 5,000 CY delivered), laboratory compaction test results according to ASTM D 1557 (prior to delivery and one per 5,000 CY), minimum three (3) tests per limestone source per limestone material for calcium carbonate according to ASTM C 25, and soil chemical analysis for RCRA 8 metals according to EPA Method 6010/7241/72470). The ENGINEER reserves the right to disqualify the source based on the results of chemical testing.

H. If requested by the ENGINEER, submit a plan for revised on-site haul road(s) prior to start of the work. The plan must be approved by the ENGINEER. The on-site haul road shall include at a minimum a plan view and typical section of the revised haul road(s).

I. Submit gradation data for riprap and limestone materials.

J. Submit calcium carbonate content for limestone riprap and stone fill materials.

K. Submit proposed amendment(s) for the topsoil cover. Provide organic material quantity and source.

L. Submit proposed streambed restoration materials/mixture(s). Provide particle size analysis, source, color and shape of the material for approval by the ENGINEER.

M. Conduct interface friction testing using materials in accordance with Section 31 56 10 – Cover System Performance Testing.

N. Submit the name and qualifications of the third-party soil testing laboratory to be used for borrow source and in-place soil material testing.

O. Submit laboratory testing reports and daily field inspection/testing reports prepared by the third-party testing laboratory.

1.8 QUALITY ASSURANCE/QUALITY CONTROL

A. Codes and Standards: Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

B. CONTRACTOR Provided Third-Party Soil Testing Service: The third-party soil testing service must demonstrate geotechnical testing experience and shall have sufficient facilities to perform the required quantity of tests at a rate commensurate with the proposed work schedule and meet the requirements of ASTM D 3740. The soil testing service shall provide access to the OWNER's Representative and/or ENGINEER for observation of the facilities and methods used in the geotechnical testing, if requested.

C. The third-party Soil Testing Service is responsible for collecting representative samples and will perform laboratory and in-situ tests for compacted common borrow, vegetative support layer, topsoil, imported soil, stone, and riprap to evaluate whether the materials meet the requirements specified herein.

D. The gradation of riprap and stone will be visually estimated in stockpiles and during placement. Additional gradation testing (ASTM D 5519, Method C) may be performed if requested by the ENGINEER prior to placement.

E. CONTRACTOR Provided Surveyor: The CONTRACTOR is responsible for providing all construction layout. Surveys for construction layout elevations and locations of the Work shall be performed by or under the supervision of a qualified surveyor licensed in the State of Vermont.

1.9 JOB CONDITIONS

A. General:

1. Final grade lines will be determined by the ENGINEER in the field based on the conditions encountered and may vary from those shown on the construction drawings.

2. Final grade lines will in all cases be determined by the ENGINEER.

3. Artifacts from historic mine operations may be encountered during excavation. ENGINEER shall be notified if, and when, artifacts are encountered. Handling of artifacts shall be at the direction of the ENGINEER.

4. If human remains are encountered during excavation all work must cease immediately. Notify ENGINEER immediately for further directions.

B. Protection:

1. Should uncharted piping or other utilities be encountered during excavation, consult the ENGINEER immediately for direction.

2. Barricade and/or install warning signs or lights as required for protection from open excavations occurring as part of this Work. If warning lights are used, operate warning lights during hours from dusk to dawn each day and as otherwise requested.

C. Dust Control:

1. Use means necessary to control dust on and near the Work and on and near all borrow areas if such dust is caused by operations during performance of the work.

2. Thoroughly treat all surfaces as required to prevent dust from being a nuisance or health risk to the workers, public, neighbors, and concurrent performance of other work on the site.

3. Conduct air monitoring as required in Section 01 56 00 Dust Control.

D. Groundwater and Surface Water Runoff Control:

1. Groundwater and surface water runoff control shall be performed by the CONTRACTOR in accordance with Section 31 23 19 – Dewatering and Surface Water Control.

2. The CONTRACTOR shall provide adequate pumping and drainage facilities to maintain excavated or fill areas sufficiently dry from groundwater and/or surface water runoff so as not to adversely affect construction procedures nor cause excessive disturbance of underlying natural ground. The drainage of all water resulting from pumping shall be managed so as not to cause physical or environmental damage to adjacent areas.

3. The CONTRACTOR's pumping and dewatering operations shall be carried out in such a manner as to prevent damage to the work and so that no loss of ground will result from these operations. Precautions shall be taken to protect new work from flooding during storms or from other causes. Pumping shall be continuous, as required, to protect the work and/or to maintain satisfactory progress in the work.

4. Water from trenches, excavations and drainage operations shall be disposed of or treated in such a manner as to avoid public nuisance, injury to worker safety, public health or the environment, damage to public or private property, or damage to the work completed or in progress.

5. The CONTRACTOR shall control the grading in the areas surrounding all excavations so that the surface of the ground will be properly sloped to prevent water from running into the excavated area.

6. Control sediments to minimize impact of work to off-site surface water bodies or drainage systems. Refer to Section 31 23 19 – Dewatering and Surface Water Control.

PART 2 - PRODUCTS

2.1 GENERAL

A. Strictly adhere to the local hauling requirements and traffic laws. Act promptly to respond to any complaints or problems related to trucking. The ENGINEER reserves the right to require the removal of any truck driver or subcontractor from the project who willfully disregards the provisions of this Section, traffic plans, or traffic laws.

B. Material Quality Testing: Each borrow source and material for soil materials shall be subject to specified testing to determine acceptability. Such testing is intended to result in approval or rejection of a material or source. Conduct testing on proposed borrow sources and materials before importing to the Site and before placement in accordance with the requirements of this Section.

2.2 COMMON BORROW/COMPACTED FILL

A. Common Borrow shall be used as subgrade fill, backfilling excavations and trenches, and other miscellaneous fill or backfill conditions as part of the work as indicated on the construction drawings.

B. Common Borrow shall consist of a well-graded mixture of clays, silts, sands and gravels with a maximum particle size of 8-inches and no more than 40 percent passing the No. 200 sieve, unless otherwise directed or approved by the ENGINEER. Common borrow shall be free of trash, ice, snow, tree stumps, and other organic and deleterious

materials. It shall be of such a nature and character that it can be compacted to the specified dry density specified herein, or greater, with a reasonable compaction effort.

C. Processed material from on-site or an approved off-site borrow source which meets the requirements of this Section is acceptable as Common Borrow fill.

2.3 RIPRAP

A. A well-graded mixture of cobbles, and gravel which are blasted, or crushed rock with a bulk specific gravity (saturated surface dry) equal to or greater than 2.9 as determined in accordance with ASTM C 127.

B. A hard, durable, angular, stone of such quality that they will not disintegrate or significantly deteriorate on exposure to freezing and thawing, wetting and drying, and erosion weathering.

C. Riprap shall be a well-graded mixture of cobbles and gravels.

D. Riprap will generally conform to the gradation guidelines as follows:

1. 7-Inch Minus Riprap

Size*	Minimum Diameter
D_{100}	7 inches
D_{85}	6 inches
D_{50}	4 inches
D_{30}	3 inches
D_{15}	2 inches

*Dx= Diameter which x percent is smaller than by weight.

2. 10-Inch Riprap

Size*	Minimum Diameter
D_{100}	10 inches
D_{85}	6 inches
D_{50}	5 inches
D_{30}	4 inches
D_{15}	3 inches

*Dx= Diameter which x percent is smaller than by weight.

3. 18-Inch Riprap

Size*	Minimum Diameter
D_{100}	18 inches
D_{85}	15 inches
D_{50}	9 inches
D_{30}	6 inches
D_{15}	4 inches

*Dx= Diameter which x percent is smaller than by weight.

4. 24-Inch Riprap

Size*	Minimum Diameter

D_{100}	24 inches
D_{85}	18 inches
D_{50}	12 inches
D_{30}	9 inches
D_{15}	6 inches

*Dx= Diameter which x percent is smaller than by weight.

5. Other Riprap gradations, if required, shall be determined by the ENGINEER.

E. The shortest dimension of any piece of riprap should not be less than one-third of its longest dimension and meet the requirements of suitable fill.

F. A maximum sodium sulfate soundness loss of 10 percent when tested in accordance with ASTM C 88.

G. A maximum percent of wear (LA Abrasion Test) of 50 percent in accordance with AASHTO T 96.

H. Processed materials from an ENGINEER-approved off-site borrow source which meet the requirements of the Specifications is acceptable as Riprap.

I. Where Limestone Riprap is required per the contract documents, it shall consist of limestone, dolomitic limestone, or marble with a minimum total calcium carbonates content of 70 percent, unless otherwise approved by the ENGINEER.

2.4 STONE/GRAVEL

A. ¾-inch Crushed Stone: shall meet the requirements of Vermont Agency of Transportation (VAOT) 2018 Standard Specifications for Construction, Section 704.02 Course Aggregate for Concrete.

B. 1½-inch Crushed Stone: shall meet the requirements of VAOT 2018 Standard Specifications for Construction, Section 704.02 Course Aggregate for Concrete.

C. Gravel Surface: shall meet the requirements of VAOT 2018 Standard Specifications for Construction, Section 704.12 Aggregate for Surface Course and Shoulders.

D. Gravel Sub-base: shall meet the requirements of VAOT 2018 Standard Specifications for Construction, Section 704.04 Gravel for Subbase.

E. 1-1/2-inch Round Stone: shall consist of rounded cobbles and gravel generally meeting the gradation requirements of VAOT 2018 Standard Specifications for Construction, Section, 704.02C Course Aggregate for Concrete.

F. Stone Fill, Type II Modified: shall be shaped as nearly as practicable in the form of right rectangular prisms, shall have a minimum density of 150 lbs/ft^3, shall be free from laminations or weak cleavages and conform to the following size guidelines:

	A-axis	B-axis	C-axis
Minimum Size	12 inches	12 inches	12 inches
Maximum Size	24 inches	18 inches	18 inches

G. Stone Fill, Type III Modified: shall be shaped as nearly as practicable in the form of right rectangular prisms, shall have a minimum density of 150 lbs/ft^3, shall be free from laminations or weak cleavages and conform to the following size guidelines:

	A-axis	B-axis	C-axis
Minimum Size	18 inches	18 inches	18 inches
Maximum Size	30 inches	24 inches	24 inches

H. AASHTO No. 57 Coarse Aggregate: shall be an open-graded, self-compacting aggregate blend meeting the gradation requirements specified in the American Association of State Highway and Transportation Officials (AASHTO) M 43 - Standard Specification for Sizes of Aggregate for Road and Bridge Construction, latest Edition.

I. AASHTO No. 8 Coarse Aggregate: shall be an open-graded, self-compacting aggregate blend meeting the gradation requirements specified in Table 703.4 of the American Association of State Highway and Transportation Officials (AASHTO) M 43 - Standard Specification for Sizes of Aggregate for Road and Bridge Construction, latest Edition.

J. AASHTO No. 1 Coarse Aggregate: shall be an open-graded, self-compacting aggregate blend meeting the gradation requirements specified in Table 703.4 of the American Association of State Highway and Transportation Officials (AASHTO) M 43 - Standard Specification for Sizes of Aggregate for Road and Bridge Construction, latest Edition.

K. Hard Rock and Limestone Mix: Hard rock and Limestone Material shall be free of clay, loam, organic matter, and shall be made of hard durable broken stone; solid and non-friable consisting of a 1:1 mix of non-limestone rock and limestone.

1. Stone Size: Gradation size ranging from 1 to 3 inches (approximate D_{50} size of 2 inches).

2. Limestone shall consist of limestone, dolomitic limestone, or marble with a minimum total calcium carbonates content of 70 percent, unless otherwise approved by the ENGINEER.

2.5 COBBLES AND BOULDERS

A. Hard durable rounded to sub-rounded stone of such quality that they will not disintegrate or significantly deteriorate on exposure to freezing and thawing, wetting and drying and erosion weathering.

B. Waste rock shall not be used for cobbles and boulders.

C. Blasted or crushed rock shall not be used for cobbles and boulders.

D. Streambed Material shall conform to the gradation guidelines as follows:

Sieve Size	Percent Finer by Weight
5 in (125 mm)	100
4 in (100 mm)	95
3.5 in (90 mm)	85
3.0 in (75 mm)	75
2.5 in (63 mm)	45
1.0 in (25 mm)	30
0.5 in (12.5 mm)	20
No. 7 (2.8 mm)	10
No. 25 (0.71 mm)	5
No. 100 (0.15 mm)	0

E. Rock for Streambed Material shall have a color that blends in with the local environment and shall be sourced from a local quarry. The rock shall have a minimum specific gravity of 2.5, as determined according to AASHTO T 85, bulk-saturated by surface-dry basis. Rock shall be hard and circular or oval shaped. Angular rock shall not be used. Rock shall not be shale or have shale seams.

F. Streambed Filler Material shall be clean fill material that 50 percent of the material is passed by the No. 200 sieve.

2.6 COVER SYSTEM CUSHION LAYER

A. The cover system cushion layer shall consist of on-site tailing waste.

B. Should off-site materials be required for completing the cover system cushion layer construction, off-site borrow meeting the specification for VAOT 704.01A Fine Aggregate for Concrete shall be imported by the CONTRACTOR for placement.

C. Protrusions greater than 0.5 inch shall be removed from the finished surface.

2.7 VEGETATIVE SUPPORT SOIL

A. A well-graded mixture of clays, silts, sands and gravels generally meeting the gradation of screened on-site borrow and meeting the requirements of common borrow defined in Part 2.2 of this Section, including the exceptions included in Part 2.7.B.

B. The maximum particle size shall be 4 inches in any dimension.

C. Processed material from on-site or if required, approved off-site borrow source, which meets the requirements of this Part 2.2.A of this Section is acceptable.

2.8 TOPSOIL

A. Soil which shall be free from tailing, waste rock, ore roasts, and reasonably free from brush, objectionable weeds, other litter, clay lumps, roots, clumps of organic matter, and/or rocks greater than 4-inches (maximum dimension), and other materials or substances that might be harmful to plant growth or a hindrance to grading, planting, and maintenance operations.

B. Topsoil shall be classified as a SM, ML, SC or CL under the Unified Soil Classification System (ASTM D 2487).

C. Topsoil shall contain between five percent to twenty percent organic matter as determined in accordance with ASTM D 5268, or as directed by the ENGINEER.

D. Topsoil shall have a pH between 5.5 and 7.6.

E. Topsoil shall be naturally occurring soil or soil amended by adding organic matter and other materials using a plan approved by the ENGINEER.

2.9 DENSE-GRADED CRUSHED STONE FOR HAUL ROADS

A. Dense-graded crushed stone for haul roads shall consist of clean, hard, uniformly graded crushed stone free from dirt and deleterious material.

B. Dense-graded crushed stone shall meet the specification for VAOT 704.06A.

2.10 SAND FILL

A. A well-graded material free of sharp edges, silt, loam, clay or organic matter.

B. Sand Fill shall meet the specification for VAOT 703.03A.

2.11 GROUND LIMESTONE

A. Ground Limestone: Agricultural limestone shall be a calcitic or dolomitic ground limestone containing not less than 70 percent of total calcium carbonates. The limestone shall confirm to the requirements of all State and Federal regulations and to the standards of the Association of Official Agricultural Chemists. Limestone shall meet the following sieve analysis: 95 percent passing through a 20-mesh sieve, 60 percent passing through a 60-mesh sieve, and 50 percent passing through a 100-mesh sieve.

B. Ground agricultural limestone shall be applied to the OU1 waste repository subgrade prior to filling with waste soil and rock, as well as to completed waste soil/rock excavation areas prior to construction of clean soil cover system.

2.12 BORROW SOURCE TESTING

A. Borrow source testing shall be conducted on all soil materials proposed for construction. Testing frequency shall be as listed. The testing requirements for soils obtained from each borrow source(s) are provided below:

1. Common Borrow, Stone Bedding, Coarse Sand, and Gravel:

Test	Methodology	Frequency
Grain Size (to the #200 Sieve)	ASTM D 422	3 tests/source/material
Moisture-Density Relationship	ASTM D 1557	3 tests/source/material

2. Low Permeability Soil:

Test	Methodology	Frequency
Grain Size (Sieve only)	ASTM D 422	3 tests/source/material
Moisture Content	ASTM D 2216	3 tests/source/material
Atterberg Limits	ASTM D 4318	3 tests/source/material
Moisture-Density Relationship	ASTM D 1557	3 tests/source/material
Hydraulic Conductivity (1)	ASTM D 5084	3 tests/source/material

Note: (1) Hydraulic conductivity sample shall be prepared at 92% maximum dry density (as determined by ASTM D 1557) and tested at a net confining stress of 3 psi and gradient as specified by ASTM D 5084.

3. Hard Rock and Limestone:

Test	Methodology	Frequency
Particle Size	ASTM D 5519, Method A	1 test/source/material
Calcium Carbonate	ASTM C 25	3 tests/source/material

PART 3 - EXECUTION

3.1 GENERAL

A. Prior to initiating any work covered by this Section, become thoroughly familiar with all Site features, Site conditions, and all portions of the Work in this Section.

B. Verify that work areas have been properly prepared, stripped and dewatered to remove vegetative matter, roots, objectionable and loose materials, materials that are determined to be objectionable that might interfere with the bonding of fill to foundation, the bonding of fill to fill, and the compacting of materials.

C. Do not perform any earthwork as specified in this Section in any specific work area until all clearing and grubbing is completed in that area.

3.2 LINES AND GRADES

A. Lay pipes to lines and grades indicated on the construction drawings. The ENGINEER reserves the right to make changes in lines and grades when required for project conditions.

B. Maintain grade alignment of pipe using string line parallel with grade line and vertically above centerline of pipe.

1. Establish string line on level batter boards at intervals of not more than 25 feet.

2. Install batter boards spanning trench, rigidly anchored to posts driven into ground on both sides of trench.

3. Set three (3) adjacent batter boards before laying pipe to verify grades and lines.

4. Determine elevation and position of string line from elevation and position of offset points or stakes located along pipe route.

5. Do not locate pipe using side lines for line or grade.

6. Alignment and elevations can also be maintained by use of lasers.

3.3 EXCAVATION AND TRENCHING

A. Excavation stability is the responsibility of the CONTRACTOR. Excavations shall be performed in accordance with local, state, and federal requirements.

B. Excavation extents may vary from those shown on the construction drawings. Final limits will depend on location of tailing, waste rock, ore roasts, and/or fill and will be as directed by the ENGINEER. Slope and lengths may differ from those shown on the construction drawings.

C. Do not advance open trenches more than 150 feet ahead of installed pipe.

D. Cut excavations or trenches to width indicated on the construction drawings or sufficiently wide to enable installation and allow inspection. Remove water or materials that interfere with work.

E. Remove soft, wet, or otherwise unsuitable materials from final excavation limits, as determined by the ENGINEER. Replace unsuitable material with fill (suitable for the proposed application) and compact as directed by the ENGINEER or in accordance with the requirements specified herein. For areas underlying the cover system, replace unsuitable material and compact as directed by the ENGINEER or in accordance with this Section.

F. Provide uniform and continuous bearing and support for bedding material and pipe, vaults, or other appurtenances.

G. Shape, slope, and support excavations according to the most current requirements of OSHA (29 CFR 1926.651 and any other applicable standards) and the approved Site Health and Safety plan.

H. Take necessary precautions to preserve material below and beyond excavation lines in a sound condition.

I. Preserve existing vegetation to maximum extent practical.

J. Perform required excavations and operations to yield as much suitable material as practical for permanent construction and preserve for use in permanent construction.

K. Separate suitable materials from materials to be wasted and minimize handling by placing directly in designated locations.

3.4 WASTE ROCK EXCAVATION

A. Excavate waste rock in accordance with the OU1 Final RD drawings and technical specifications; and approved project planning documents.

B. Excavate ferricrete and altered glacial till (if found) as directed by the ENGINEER.

3.5 ORE ROASTS EXCAVATION

A. Excavate ore roasts in accordance with the OU1 Final RD drawings and technical specifications; and approved project planning documents.

3.6 ROCK REMOVAL AND EXCAVATION

A. Remove rock to elevations or details indicated on the drawings or as needed to achieve positive drainage in a manner that will leave foundation/subgrade material in an un-shattered and solid condition. Roughen level surfaces and cut sloped surfaces into benches for bond with soil cover if required. Removal of rock beyond lines and grades indicated will not be grounds for a claim for additional payment unless previously authorized by the ENGINEER. Excavation of the material claimed as rock shall not be performed until the material has been cross sectioned by the CONTRACTOR and approved by the ENGINEER.

B. Common excavation shall consist of all excavation not classified as rock excavation.

C. Rock excavation conducted by drilling and blasting shall be performed in accordance with Section 31 80 00 – Blasting Controls, and as approved by the ENGINEER.

3.7 SHEETING AND SHORING

A. As required, sheet, shore, and brace excavations to prevent danger to persons, structures, and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.

B. All excavation greater than 4 feet deep shall be supported or sloped to prevent collapse. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation.

C. Sheeting and shoring shall be designed to be removed upon completion of excavation work.

D. Sheeting, shoring, and bracing, if warranted, shall be designed by a licensed Professional Engineer registered in the State of Vermont. Designs shall be submitted for review/approval by the ENGINEER.

E. Repair damage caused by failure of the sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.

F. Repair damage to new and existing work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

3.8 FOUNDATION PREPARATION

A. Do not place cover system materials above the subgrade until the foundation has been properly prepared and approved by the ENGINEER.

B. Do not prepare foundation for the final 24 inches of subgrade when foundation is frozen.

C. Frost:

1. Do not prepare foundation for the final 24 inches of subgrade when foundation is frozen.

2. Excavate frozen materials where the foundation subgrade under fill is found to contain frozen areas, as determined by the ENGINEER and backfill with suitable fill material.

3. Do not excavate to indicated depth when freezing temperatures may be expected, unless fill can be placed, or subgrades can be protected from frost.

4. Fill shall not be placed over frozen soil which is more than one-inch (1) inch thick and which has been compacted to specified criteria. Compacted soil that is frozen to a depth greater than one (1) inch shall be stripped/removed prior to placing compacted fill. Remove all frozen uncompacted soil prior to placing additional fill.

D. Following excavation to design grade, or placing fill above the exposed subgrade, soil subgrades shall be proof-rolled to identify soft or loose zones. Proof-rolling shall be accomplished with at least ten (10) passes in each perpendicular direction using a minimum 10-ton vibratory roller. Where soft or unstable zones are encountered, the CONTRACTOR shall over-excavate soft material as determined by the ENGINEER and backfill with suitable waste fill or fill material designated by the ENGINEER to create a firm and stable subgrade. Compaction shall be in accordance with the requirements specified herein.

3.9 SITE GRADING

A. Perform all earthworks to the lines and grades as shown on the Construction Drawings, within the allowable tolerances described herein, or as directed by the ENGINEER.

B. Shape, trim, and finish slopes of regraded and fill areas to provide free drainage, or as shown on the Construction Drawings.

C. Neatly blend all new grading into surrounding, existing terrain.

D. Finished site grading shall provide adequate positive surface drainage, as approved by the ENGINEER.

E. Make grade changes gradual, smooth, and rounded, recognizing that pointed/abrupt changes in grade shown on the Construction Drawings are for plan presentation purposes only.

F. Any eroded or damaged area shall be repaired promptly.

3.10 HAUL ROADS

A. Maintain all haul roads in good condition at all times.

B. Conform to local, county, and state haulage requirements.

C. Construct on-site haul roads in accordance with approved Program Work Plans and Task Work Plans.

3.11 BACKFILLING AND PLACEMENT OF FILL AND WASTE FILL MATERIALS

A. Backfill excavations and trenches to contours and elevations shown on the construction drawings with unfrozen fill materials, suitable for the intended application.

B. Do not change elevations or subgrades without a directive from the ENGINEER.

C. Take necessary precautions to preserve material below and beyond excavation lines in a sound condition. Natural on-site soil has an elevated silt content (percent passing the No. 200 sieve) and will be sensitive to moisture and easily disturbed under construction traffic. Subgrades damaged/disturbed by construction traffic shall be over-excavated to stable material and replaced with suitable backfill at no additional cost to the OWNER.

D. Fill shall be placed by depositing in horizontal layers not exceeding the maximum loose lift thickness as specified herein before compaction. Each layer shall be compacted by suitable vibratory compactors or tampers, which will secure the required minimum degree of compaction. No other type of equipment shall be used for compaction, except as specifically designed as vibrating compaction equipment, or where specifically noted otherwise herein or approved by the ENGINEER.

E. Prior to backfilling of waste soil and rock within the OU1 waste repository, or construction of clean soil covers, ground agricultural lime/limestone shall be spread within the fill limits at an approximate rate of 3 tons per acre (tons/acre).

F. Employ placement methods that do not disturb or damage utilities in trench or adjacent structures.

G. Frost:

1. Do not excavate to indicated depth when freezing temperatures may be expected, unless fill can be placed, or subgrades can be protected from frost.

2. Fill shall not be placed over frozen soil which is more than one-inch (1) inch thick and which has been compacted to specified criteria. Compacted soil that is frozen to a depth greater than one (1) inch shall be stripped/removed prior to placing compacted fill. Remove all frozen uncompacted soil prior to placing additional fill.

H. Protect fill area by grading to drain and providing a smooth surface which will shed water. Grade the surface of the areas to prevent ponding of surface runoff water in areas to receive compacted fill.

I. To the extent practicable, each layer of fill shall be compacted to the specified density the same day it is placed.

J. Fill that is too wet for proper compaction shall be removed, replaced, scarified or otherwise dried to the proper moisture content for compaction to the required density. If the fill material cannot be dried within forty-eight (48) hours of placement, it shall be replaced with drier fill. Soil material that has been removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. CONTRACTOR can assist drying by discing, harrowing, or pulverizing until moisture content is reduced to a satisfactory level.

K. Fill that is too dry for proper compaction shall receive water uniformly applied over the surface of the loose layer. Sufficient water shall be added to allow compaction to the required density. The addition of water to improve workability is NOT required for the placement of waste fill. Waste fill shall be placed and compacted without the introduction of water to the extent practical.

L. Fill shall be placed in horizontal layers. Where the horizontal layer meets a natural rising slope, the layer shall be keyed into the slope so that the lift meets the minimum thickness specification across the full extent of fill placement.

M. Crushed stone shall be spread uniformly so the required thickness after compaction shall be obtained. The material shall be densified by vibratory tampers, hand tamping or other approved means, to the final compacted grades as required. In no case shall crushed stone be placed in excess of twelve (12) inches for each lift before compaction.

N. Waste Fill:

1. Placement of waste fill shall be dumped on the surface layer being placed and then spread to the desired thickness. The material shall be distributed by blading or

dozing in a manner that will ensure proper placement in the fill embankment so that voids, pockets, and bridging are held to a minimum.

2. The maximum layer/lift thickness shall be twenty-four (24) inches.

3. After each layer of waste fill and fill (clean) has been placed, it shall be compacted as specified herein.

4. In the event that acid-generating waste rock and/or tailings remain in-place in areas where waste excavation limits are reached as indicated by the plans or determined by the ENGINEER (e.g. based on paste pH soils screening), ground agricultural lime/limestone shall be mixed within initial (first) lift of waste fill or fill (clean) at an approximate rate of 1.5 CY per 25 CY of waste fill or fill (clean) placed. Mixing of lime/limestone within the waste rock, tailings, and/or soil by discs, harrow, or other approved methods shall provide acceptable even distribution within the waste material.

   In the event that amending the initial lift of waste fill or fill (clean) is not possible or practical, lime/limestone can be applied to the excavation surface at an approximate rate of 3 tons per acre (tons/acre).

O. Coordinate excavation and placement operations such that fill materials are well mixed and blended to provide homogeneity and compaction. Distribute fill such that it is free from lenses, pockets, streaks, lumps, or layers of material differing substantially in texture, gradation, or moisture content from the surrounding material to form as homogeneous a layer of material as practical.

P. Rework materials that have not been placed in accordance with these Specifications. Reworking may include removal, recompacting, reconditioning, or combinations of these procedures, as required by the ENGINEER.

Q. Ensure bonding of new fill to previously placed sloping fill by benching in 2 feet horizontally, as each layer is placed and compacted.

R. All waste fill and fill (clean) placement shall comply with the approved Construction Work Plan (CWP). In the event of conflict between the CWP and the Technical Specifications, the Technical Specifications shall take precedence.

3.12 OU1 WASTE REPOSITORY FILLING AND GRADING

A. Extensive rework, grading, crushing, and consolidation of the waste fill and fill (clean) material below the bottom of the cover system with a large bulldozer(s) will be conducted to achieve approximate desired grade and compaction. Grading efforts will be conducted to work smaller rock in and around larger waste rock material to eliminate large voids.

B. Waste fill and fill (clean) placed below the cover system shall be extensively reworked, graded and compacted to provide a sound working surface and subgrade for the tailings cushion layer and subsequent cover system.

C. After each layer of waste fill or fill (clean) has been placed, it shall be compacted by running a bulldozer over the entire surface of the layer a minimum of ten (10) passes, as specified herein.

D. The surface to receive geosynthetics shall be constructed to the lines, grades, and cross sections indicated on the construction drawings and shall be graded relatively smooth and free of protrusions that could damage the geosynthetics, as directed by the ENGINEER. The ENGINEER reserves the right to increase or decrease the grade elevations or make such other changes in the grading as may be deemed necessary.

E. Subsequent to achieving subgrade elevations of the cover system, the geosynthetic layers shall be installed, followed by installation of the vegetative support soil layer. Backfilling and compaction of the vegetative support soil shall be in accordance with the specifications defined herein.

3.13 COMPACTION

A. General:

1. Control waste fill and fill (clean) compaction during construction providing a minimum percentage of density specified for each area classification. Calibration of the nuclear density gauge using sand cone tests shall be conducted on a daily basis over the first 5 days of compaction with calibration checks twice per week thereafter.

2. CONTRACTOR shall match compaction equipment and methods to the material and location being compacted to obtain the specified compaction, with consideration of the following guidelines:

    a. Vibratory compaction is preferred for dry, granular materials, unless noted otherwise herein, or as approved by the ENGINEER. Suitable vibratory compaction equipment includes minimum 10-ton smooth-drum or sheepsfoot rollers.
    b. Hand compaction equipment such as impact rammers, plate or small drum vibratory rollers or pneumatic buttonhead compactors should be used in confined areas.
    c. Hydraulic compaction by pounding or jetting will not be permitted except in unusual conditions, and then only upon written approval by the ENGINEER and after a demonstration of effectiveness.
    d. Backhoe mounted hydraulic or vibratory tampers may be used for compaction of backfill in trenches over 4 feet in depth, provided that the specified density is achieved. The upper 4 feet shall be compacted as detailed above or with hand-guided or self-propelled vibratory compactors or static rollers.

B. Compaction Requirements: Compact waste fill and fill (clean) to not less than the percentages of maximum dry density (determined in accordance with ASTM D 1557), and tested at the frequency of testing specified below:

Construction Element	Maximum Loose Lift Thickness (inches)	Minimum Percentage of Maximum Dry Density (%) (determined by ASTM D 1557)	Frequency of Testing
Granular Soils and Common Borrow/Fill: Vegetated Areas & Low Permeable Soil	12	92	1 per 1,000 SF
Common Borrow: Traffic Areas	12	92	1 per 1,000 SF
Select Gravels: Temporary/Permanent Access Roads/Traffic Areas	12	95	1 per 100 LF or 1,000 SF
Tailings Fill: Tailing Cushion Layer	6	92	1 per 1,000 SF
Waste Fill and Fill (clean)	24	92 (See Note 1)	(See Note 1)
Pipe Trench Bedding & Backfill	8	92	2 (minimum) per trench

Note:

1. Waste fill and fill (clean) shall be graded and compacted to a uniform firm and stable surface and in a manner to minimize large voids as specified in this Section. In-place density testing is not required for waste fill and fill (clean) materials where over-sized stone/gradation will not allow. Acceptable compaction shall be determined by the ENGINEER based on behavior of the material under the minimum number of passes and compaction effort applied as required herein.

C. The CONTRACTOR shall dig test holes and provide access to all backfill areas at no additional compensation when requested by the ENGINEER if an area has been covered without approval or is suspected of not meeting the specifications.

D. For each test which does not meet the specifications, the CONTRACTOR shall pay for the cost of the test and shall replace all material included in that lift or sector with acceptable material and compact to specification, at no additional compensation.

E. Waste Fill, and other materials with cobbles/boulders shall be placed in maximum 24-inch thick loose lifts unless otherwise approved by the ENGINEER. In deeper waste fill areas, rock fragments may be used as common fill provided boulders greater than 3 feet in size are removed. To the extent practical, a sufficient amount of waste fill should be placed along with the waste rock to create a well-graded choked matrix. Pieces of waste fill (i.e. waste rock) greater than 2 feet in diameter should be spaced to allow easy, unimpeded advancement of compaction equipment between large fragments.

F. Waste Rock Fill should be placed and compacted without the adding of water to achieve optimal moisture content to the extent practical. Adding water to achieve the optimum moisture content is not required to avoid introducing additional water to environmentally impacted material. Waste ill and fill (clean) with moisture contents exceeding 3 percent of the optimum moisture content shall be dried to help facilitate compaction.

G. Where compaction testing cannot be performed due to the gradation of the material, each lift shall be compacted by tracking the lift with a minimum of ten (10) passes of heavy tracked machinery, such as a Caterpillar D-6 bulldozer, or larger. If the vibratory roller can access and travel over the material, additional compaction efforts shall be applied with at least ten (10) passes of a minimum 12-ton smooth-drum or sheepsfoot roller. A pass shall be as defined in Part 1.6.O above. The Quality Control Supervisor (QCS) and ENGINEER shall monitor the placement and the reaction of the materials under compaction efforts. Sufficient compaction shall be determined based on firm and stable subgrades observed under compaction efforts.

H. Vibratory rolling is preferred when applying compaction efforts; however, static rolling may be necessary to prevent the moisture from being drawn up through the fill material thus creating an unstable lift. The QCS and ENGINEER shall monitor the placement and the reaction of the materials under compaction efforts.

I. Soft or loose zones shall be removed, replaced and compacted with dry suitable material. Fill placement shall not continue if excessive deflection and/or weaving is observed on a lift by the QCS or ENGINEER, and appropriate corrective field measures approved by the QCS and ENGINEER shall be implemented to address such lifts. Lifts shall be observed and approved as firm and stable by the QCS and ENGINEER before additional lifts are placed.

J. All fill placement shall comply with approved Work Plans. In the event of conflict between Work Plans and the Technical Specifications (including the Supplementary Conditions), the Technical Specifications shall take precedence.

K. Place compacted waste fill and fill (clean) in a manner that prevents mixing with other soil materials.

3.14 PREPARING THE COVER SYSTEM FOUNDATION – GREATER THAN 48 INCHES BELOW FINAL SUBGRADE ELEVATION

A. Waste fill placed greater than 48 inches below final subgrade elevation shall be placed in maximum 24-inch thick loose lifts and tracked with a Caterpillar D-6 bulldozer (or larger) for a minimum of ten (10) passes or until compaction is sufficient to create a firm and stable lift as specified above and as approved by the ENGINEER. Lifts shall be observed and approved as firm and stable by the QCS and ENGINEER before additional lifts are placed. Clusters of boulders shall be avoided to the extent practical, and the CONTRACTOR shall ensure that waste fill is compacted around any boulders. Boulder size shall not exceed 1.5 times the lift thickness and boulders larger shall be crushed prior to placement.

B. Waste fill placement shall occur in a manner consistent with the approved Work Plan addressing waste relocation and placement.

C. Nesting of cobbles, boulders, wood debris, and other deleterious material shall be avoided to the extent practical as determined by the ENGINEER.

D. The foundation topography of the Operable Unit 01 waste repository shall be shaped to create drainage toward either internal drainage swales or to the diversion channels as per the construction drawings.

E. If field conditions at the time of the completion of final foundation differ from the Basis of Design assumptions for grading or settlement, the ENGINEER may require an evaluation by a qualified geotechnical professional that confirms that the field adjustments for waste fill placement, foundation preparation, and/or final grades will meet, at a minimum, the performance requirements established in the design for the cover system.

3.15 PREPARING THE COVER SYSTEM FOUNDATION – LESS THAN 48 INCHES BELOW FINAL SUBGRADE ELEVATION

A. Prepare subgrade to be protective of geomembrane. Subgrade will be graded smooth to allow intimate contact between geomembrane and subgrade surface. Surface shall comply with Section 31 56 50 - Geosynthetics.

B. The upper 48 inches of subgrade shall be placed in maximum 12-inch thick loose lifts and compacted to at least 92% of the maximum dry density as determined by ASTM D 1557, Modified Proctor. In the event compaction cannot be achieved due to variability or excessive stone content of the waste material, compaction shall be achieved using either the test strip method or visual observations during compaction to achieve a firm and stable lift in accordance with the requirements specified herein.

C. If testing cannot be performed, waste fill within the upper 48 inches of subgrade shall be placed in maximum 12-inch thick loose lifts. Each lift shall be tracked with a minimum of ten (10) passes of a Caterpillar D-6 bulldozer (or larger) and compacted with a minimum of ten (10) passes of a minimum 12-ton smooth-drum vibratory roller. Vibratory rolling is preferred but static rolling may be necessary to prevent the moisture from being drawn up through the fill material thus creating an unstable lift. The QCS shall monitor the placement and the reaction of the materials to compaction by rolling. Soft or loose zones shall be removed, replaced and compacted with dry suitable material. Waste fill placement shall not continue if excessive deflection and/or weaving is observed on a lift by the QCS or ENGINEER, and appropriate corrective field measures approved by the QCS and ENGINEER shall be implemented to address such lifts. Lifts shall be observed and approved as firm and stable by the QCS and ENGINEER before additional lifts are placed.

D. The upper 6-inches (minimum) of the subgrade shall comprise the cover system cushion and shall be tailing fill or imported sand meeting the specifications defined in this Section and/or screened till with a gradation similar to the tailings approved by the ENGINEER. The maximum particle size shall be 0.5 inch. This material shall be suitable as a geomembrane base layer complying with Section 31 59 70.

E. Waste fill, regardless of particle size, are specifically not to be used in the upper 6 inches of fill, unless otherwise approved by the ENGINEER.

F. Waste fill placement shall occur in a manner consistent with the approved Work Plan addressing waste relocation and placement.

G. Nesting of cobbles, boulders, wood debris, and other deleterious material shall be avoided.

H. The subgrade topography shall be shaped to create drainage toward either internal drainage swales or to the diversion channels and as per the construction drawings.

I. Survey elevation of subgrade before placing geomembrane to assure elevation meets or exceeds that required by the design. Frequency of survey shall be sufficient to confirm that field grades coincide with planned grades. Survey frequency shall be in accordance with Section 01 78 29 (Survey) or as approved by the ENGINEER.

3.16 STREAMBED MATERIAL PLACEMENT

A. The stream bed shall be over-excavated by a minimum of 1 foot beyond the estimated vertical waste excavation extents to accommodate the full streambed material thickness. The top of the placed streambed material shall be at the proposed streambed elevation as indicated in the construction drawings.

B. Carefully place the streambed material within the excavated stream channel in 6-inch thick loose lifts. Dumped rock will not be accepted. Place the full lift thickness in one operation in a manner to prevent segregation and to avoid displacement of the underlying material. Do not place streambed material by dumping into chutes, or by similar methods likely to cause segregation. Fill all voids in the streambed mixture with the streambed filler material. Fill shall extend 100 percent of the rocks height on the bottom layer and 67 percent of the rocks height on the stream bed surface or top layer.

C. Use water pressure, metal tamping rods or similar hand-operated equipment to force streambed filler material into all surface voids in the streambed mixture.

D. Rearrange individual rocks if necessary to ensure uniform distribution. Stream layering shall be placed so that it shingles in a downstream direction. Layering must be placed in a manner to promote interlocking.

E. Any ruts created by construction equipment during installation of the streambed material must be filled in by hand.

3.17 STONE PLACMENT FOR ROCK CROSS VANE

A. The stream shall be over-excavated by rock thickness to accommodate both the footer rock and top rock. The top of the placed sill rock shall be at the proposed rock cross vane elevation.

B. Rocks shall be placed individually. Place rock to produce a uniformly non-segregated structure. Place rock such that void spaces are minimized. Perform manual choking with smaller material when placement by conventional equipment fails to minimize void spaces.

C. Footer rocks are placed in the trench touching end to end. The maximum gap between each footer rock is three (3) inches. Place rock to minimize voids. Rocks shall be rectangular and relatively flat on each side. Weir Rocks are then placed on top of the footer rock in a staggered fashion (i.e., over adjacent footer rock and skewed slightly upstream of the footer rock), the maximum gap between each weir rock is three (3) inches and the maximum gap between weir rock to footer rock is 3 inches. The top of the weir rock should only be slightly above the stream invert.

D. Choke all voids on the upstream side of the structure with small stones, no more than 6-inches in diameter, to prevent water from passing between gaps. The sill should be choked with No. 57 Coarse Aggregate.

E. Rock Cross Vanes should be constructed from the center extending outwards towards the bank. The maximum slope of the cross vane arm from the bank full elevation to the stream bed elevation is 8%. The arm should be constructed at a 20 to 30-degree angle from the stream bank. Each arm should extend 1/3 of the bank full width and the weir section of the vane should also be 1/3 of the bank full width.

F. Construct all in-stream structures to within 1/2 foot of the horizontal dimensions and 3 inches of the vertical dimensions as indicated in the construction drawings. The ENGINEER will inspect the stream flow and hydraulic characteristics of the water in the stream channel after construction of the in-stream structure. The ENGINEER may direct the CONTRACTOR to remove or relocate the in-stream structures to meet the performance specifications.

3.18 STONE PLACMENT FOR J-HOOK

A. Rocks shall be placed individually. Place rock to produce a uniformly non-segregated structure. Place rock such that void spaces are minimized. Perform manual choking with smaller material when placement by conventional equipment fails to minimize void spaces.

B. Only footer rocks shall be placed on the hook section of the J-Hook. The header rocks shall be installed on the vane arm of the J-hook.

C. Choke all voids on the vane arm and hook section with small stones, no more than 6-inches in diameter, to prevent water from passing between gaps. Behind the vane arm should be choked with No. 57 Coarse Aggregate.

D. J-Hooks should be constructed from the hook section extending outwards towards the bank. The maximum slope of the vane arm from the bank full elevation to the stream bed elevation is 8%. The arm should be constructed at a 20 to 30-degree angle from the stream bank. The vane arm and hook section shall extend no more than 2/3 bank full width.

E. Construct all in-stream structures to within 1/2 foot of the horizontal dimensions and 3 inches of the vertical dimensions. The ENGINEER will inspect the stream flow and hydraulic characteristics of the water in the stream channel after construction of the in-stream structure. The ENGINEER may direct the CONTRACTOR to remove or relocate the in-stream structures to meet the performance specifications.

3.19 STONE PLACMENT FOR ROCK STEP POOLS

A. The stream shall be over-excavated by rock thickness to accommodate both the footer rock and step rock. The top of the placed step rock shall be at the proposed step elevation.

B. Rocks shall be placed individually. Place rock to produce a uniformly non-segregated structure. Place rock such that void spaces are minimized. Perform manual choking with smaller material when placement by conventional equipment fails to minimize void spaces.

C. Footer rocks are placed in the trench touching end to end. The maximum gap between each footer rock is three (3) inches. Place rock to minimize voids. Rocks shall be rectangular and relatively flat on each side. Step Rocks are then placed on top of the footer rock in a staggered fashion (i.e., over adjacent footer rock and skewed slightly upstream of the footer rock).

D. Choke all voids on the upstream side of the structure with small stones, no more than 6-inches in diameter, to prevent water from passing between gaps.

E. Construct all in-stream structures to within 1/2 foot of the horizontal dimensions and 3 inches of the vertical dimensions. The ENGINEER will inspect the stream flow and hydraulic characteristics of the water in the stream channel after construction of the in-stream structure. The ENGINEER may direct the CONTRACTOR to remove or relocate the in-stream structures to meet the performance specifications.

3.20 RIPRAP PLACEMENT

A. Riprap shall be placed in a manner which will produce a well-graded mass of rock with the minimum practical percentage of voids, and shall be constructed, within the specified tolerances, to the lines and grades shown on the Contract Drawings or staked in the field. A tolerance of plus one-half (1/2) of the average stone dimension of gradation range above the neat line and one-fourth (1/4) of the same dimension is allowed below the neat line from the slope lines and grades shown on the Contract Drawings will be allowed in the finished surface of the Riprap, except that the extreme of this tolerance shall not be continuous over an area greater than 200 square feet. The average tolerance of the entire job shall have no more than 50 percent of the tolerances specified above.

B. Geotextile fabric, where required, shall be placed prior to placing Riprap/Stone Fill in accordance with Section 31 56 10 – Geosynthetics.

C. Riprap (and stone bedding, when required) shall be placed uniformly and carefully over geotextile fabric to minimize voids and to prevent tearing of damage to the geotextile fabric. Any damage to the geotextile during placement shall be repaired/replaced before proceeding with the work.

D. Riprap and stone fill bedding shall be placed in one consistent operation to preclude disturbance or displacement of substrate. Placement shall begin at the bottom of the area to be covered and continue up-slope. Subsequent loads of material shall be

placed against previously placed material in such a manner as to ensure a well-graded mass of rock with the minimum practical percentage of voids and shall be constructed to the lines and grades shown on the drawings.

E. Placing Riprap (and stone bedding, where required) by methods which tend to segregate the particle sizes shall not be permitted. Riprap (and stone bedding, where required) shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the filter material. Rearranging of individual stones shall be required to the extent necessary to obtain a well-graded distribution of stone sizes as specified above.

F. Compaction of Riprap (and stone bedding, where required) will not be required, but Riprap and stone bedding shall be machine placed (to the extent practical) to chink the stone in-place and finished to present an adequately even surface free from mounds or windrows.

G. Large stones shall be well distributed and the entire mass of stones in their final position shall be graded to conform to the gradations specified herein.

H. The finished Riprap shall be free from objectionable pockets of small stones and clusters of larger stones. Placing Riprap in layers will not be permitted.

3.21 VEGETATIVE SUPPORT AND TOPSOIL PLACEMENT

A. The CONTRACTOR shall schedule the work to minimize the time between geocomposite placement and vegetative support soil placement, and between vegetative support soil and topsoil placement.

B. The vegetative support layer shall be placed in a full layer thickness in one operation in a manner that minimizes stress or potential damage to the cushion geotextile or drainage geocomposite. At no time will the layer thickness be less than 12 inches during placement with equipment. The vegetative support layer shall be placed from the base of the slope to the top where grades are at or steeper than 7.5H:1V. The vegetative support layer may be placed in any direction on slopes shallower than 7.5H:1V.

C. Only low ground pressure vehicles (track equipment) of 8 psi or less shall travel on the vegetative support layer or topsoil. At no time will construction equipment come into direct contact with the cushion geotextile or drainage geocomposite.

D. Vegetative support soil shall not be stockpiled directly on the geocomposite drain net. Stockpiling shall only be permitted on previously placed, full-depth vegetative support material.

E. The CONTRACTOR shall immediately repair any damage to the cushion geotextile or drainage geocomposite resulting from vegetative support layer placement.

F. The CONTRACTOR shall perform the vegetative support soil and topsoil placement in a manner that minimizes material waste.

G. The CONTRACTOR shall push rocks, wood, or other debris greater than 4-inches in any dimension to the top of slope, or limit of cover system area, using a bulldozer and /or hand picking, to the extent practical during placement of the vegetative support soil and topsoil.

H. Following placement of the topsoil, prior to hydroseeding, the cover system areas shall be walked by laborers and visible rocks, wood, or other debris greater than 4-inches in any dimension shall be removed from the topsoil layer and disposed of outside the cover system area as directed by the ENGINEER.

I. The topsoil layer shall be placed in a full layer (6-inches) thickness in one operation in a manner that minimizes stress or potential damage to the cushion geotextile or drainage geocomposite. The topsoil shall be placed from the base of slopes to the top where grades are at or steeper than 7.5H:1V. The topsoil layer may be placed in any direction on slopes shallower than 7.5H:1V.

J. The CONTRACTOR shall perform the vegetative support soil placement in a manner that minimizes wrinkles in the drainage geocomposite. At the discretion of the ENGINEER, the CONTRACTOR shall provide laborers to monitor/remove wrinkles and work in concert with equipment operators during vegetative support soil placement.

K. Immediately track vegetative support soil and topsoil layers after fine grading has been completed. Utilize tracked low ground pressure bulldozers with grousers of sufficient height to leave visible depressions in the subgrade. Operate equipment parallel to the direction of water flow, leaving track depressions that are perpendicular to the slope, which will reduce the erosion potential of the subgrade.

L. Perform depth hole testing by hand excavation to verify placement depth of the vegetative support soil and topsoil layers. Depth hole testing shall be conduct at a rate of no less than 2 per acre per layer.

3.22 GRAVEL AND STONE PLACEMENT

A. Place gravel and stone in channels, swales and toe berms in the sizes specified and to the lines and grades shown on the construction drawings.

B. Smooth the gravel or stone fill in such a manner as to produce a well-graded, stable mass of stone with a minimum practical percentage of voids. The finished stone fill shall be free from objectionable pockets of unacceptable soil fines, small stones, and clusters of large rocks.

C. Place gravel or stone fill in a manner that prevents damage to geotextile (where required). Stone shall be dropped from a height no greater than 2 feet above the geotextile.

D. Place gravel or stone fill materials to full layer thickness in one operation in such a manner as to minimize segregation and avoid displacement of underlying materials.

E. Do not change finished elevations or subgrades without approval from the ENGINEER.

F. Stone fill has no moisture or density placement requirements.

3.23 TOLERANCES

A. Subgrade on the slopes in the cover system area designed at 3.5 horizontal (H) to 1 vertical (V) shall be established within the allowable tolerances of 3.40H:1V and 3.60H:1V. The limits of the cover system areas shall be as shown on the Construction Drawings.

B. Subgrade throughout the remaining cover system areas shall be finished to within an allowable tolerance of plus or minus 0.5%. Subgrade shall be prepared to meet the intent of lines and grades shown on the Construction Drawings. Positive drainage shall be maintained.

C. Vegetative Support Soil (VSS) shall be placed within an allowable tolerance of 3-inches above and 0-inches below the minimum depth for the cover system area, as shown on the Construction Drawings, or as otherwise approved by the ENGINEER. Positive drainage shall be maintained.

D. Topsoil shall be placed within an allowable tolerance of 3-inches above and 0-inches below the minimum depth shown on the Construction Drawings, or as otherwise approved by the ENGINEER. Positive drainage shall be maintained.

END OF SECTION 31 20 00

SECTION 31 23 19 – DEWATERING AND SURFACE WATER CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Temporary construction dewatering.

2. Dewatering of waste materials.

3. Temporary diversion/pumping of Ely Brook to facilitate waste removal and brook reconstruction in-the-dry.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 31 10 00 Site Clearing

B. Section 31 20 00 Earth Moving

C. Section 31 25 00 Erosion and Sedimentation Control

D. Section 31 90 00 Revegetation

1.3 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system(s) of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

B. Obtain all necessary permits for groundwater discharge.

C. Dewater excavated waste materials to achieve compaction required during placement in the Valley Cell.

D. Ely Brook Diversion/Pumping Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system(s) of sufficient scope, size, and capacity to divert/pump Ely Brook to facilitate waste removal and permit excavation and reconstruction of Ely Brook per the design drawings in dry conditions. The CONTRACTOR shall be required to divert/pump a maximum stream flow of 15 cubic feet per second (cfs), which is estimated to be a 2-year storm event.

1.4 SUBMITTALS

A. Pre-construction Submittal: Submit a Dewatering Work Plan to describe the means and methods for all dewatering activity in advance of the start of dewatering. The plan must be approved by the ENGINEER prior to any dewatering activities initiating. The Dewatering Work Plan shall include the following:

1. Proposed material source(s).

2. On-site borrow operation plan.

3. On-site waste staging plan.

4. Proposed soil processing, placement, compaction, and moisture control equipment, including:

   a. Equipment catalog with weight, dimensions, and operating data.
   b. Soil moisture content testing.

5. Proposed methods of protection of Work, including temporary dams and/or hydraulic structures, pumping and piping systems, temporary dewatering, drainage, irrigating, emergency contingencies, and moisture conditions and frost protection measures.

6. Proposed excavation, stockpiling, regrading and staging plan describing handling and transport of on-site and off-site materials.

7. Other information requested by the ENGINEER.

B. Shop Drawings: For dewatering systems. Show arrangement, locations, and details of wells and well points; dams and other diversion structures, pumps, power units, and piping/discharge lines; and means of discharge, control of sediment, and disposal of water.

C. Ely Brook Bypass Construction Work Plan: The CONTRACTOR shall submit an addendum to the Construction Work Plan (CWP) to describe the specific work plan for the Ely Brook Bypass at least 30 days prior to initiating the bypass work. The Ely Brook Bypass Plan shall contain the details of the bypass and dewatering activities proposed. The Ely Brook Bypass Plan shall contain the following minimum information, as applicable:

   a. Details of the equipment to be used and available on-site as emergency contingencies (ie: dams, wells, diversion structures, pumps, power units, piping/discharge lines, etc.) with manufacturer's product specifications and rated pump curves, as appropriate.
   b. Describe Station limits for each phase/sequence of work.
   c. Details and methods regarding the proposed sequencing of dewatering and surface water control to facilitate staged excavation activities and streambed reconstruction.
   d. Estimated timeline for each stage of work.

e. Details regarding contingency plans for unanticipated and/or forecasted inclement weather, including methods of protecting active work areas, completed work areas, and future phase downstream work areas.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with governing EPA and VTDEC regulations before beginning dewatering and obtain all necessary permits. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Dispose of water pumped or drained from the construction site in a suitable manner to avoid public nuisance, injury to public health, damage to public and private property, and damage to the work completed or in progress.

C. All damage resulting from the dewatering operations, or the failure of the CONTRACTOR to maintain the work in a suitable dry condition shall be repaired by the CONTRACTOR, at no additional cost to the OWNER.

1.6 PROJECT CONDITIONS

A. Perform dewatering work as necessary to properly excavate, stage, place, and compact waste materials as required by the Contract Drawings. Manage dewatering to avoid discharges to site features not impacted by acid mine drainage. Discharges originating from impacted site features shall be buffered using limestone check dams where possible.

B. Ely Brook Bypass: Perform dewatering work as necessary to properly control/divert Ely Brook around the planned reconstruction zone(s). Sequence and manage dewatering and surface water controls to handle a peak flow rate of 15 cfs (2-year storm event) within Ely Brook, and avoid discharges to site features not impacted by acid mine drainage. CONTRACTOR shall also provide emergency contingencies for addressing stream flow rates that exceed the required 15 cfs (2-year storm event).

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, mine adits, excavation areas, construction zones, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or groundwater from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.

2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation. Utilize temporary covers (i.e. skrim) to protect staged waste materials and prepared subgrades from storm events and resulting runoff.

B. Install dewatering system(s) to ensure minimum interference with haul and access roads, parking areas, and other adjacent occupied and used facilities.

1. Do not close or obstruct haul roads, access roads, parking areas, or other adjacent occupied or used facilities without permission from the ENGINEER. Provide alternate routes around closed or obstructed traffic ways if required by the ENGINEER.

3.2 INSTALLATION

A. Construct dewatering pads prior to staging saturated waste materials.

B. Provide temporary grading to facilitate dewatering and control of surface water.

C. Monitor dewatering systems continuously.

D. Protect and maintain temporary erosion and sedimentation controls during dewatering operations.

E. Install dewatering system utilizing wells, well points, sumps, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.

2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

3. Use limestone check dams to maintain pH in acidic discharges.

F. Before excavating below ground-water level, place system into operation to lower water at least 24 inches below planned surface of excavation. Operate system continuously until excavation is completed or until dewatering is no longer required.

G. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

H. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations and other excavations.

1. Maintain piezometric water level a minimum of 24 inches below surface of excavation.

I. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to OWNER.

J. Remove dewatering system from Project site upon completion of dewatering activities. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

3.3 ELY BROOK BYPASS

A. Sequencing:

1. To facilitate waste removal, brook reconstruction in-the-dry, and protect remediated areas from acid mine drainage, the Ely Brook Bypass shall be completed in defined Work Zones sequentially from upstream to downstream along the alignment based on the following sequence:

   a. Work Zone 1: Station 19+25 to 15+60
   b. Work Zone 2: Station 15+60 to 11+85
   c. Work Zone 3: Station 11+85 to 6+55
   d. Work Zone 4: Station 6+55 to 1+70
   e. Work Zone 5: Station 1+35 to 0+00

2. CONTRACTOR shall install cofferdams at upstream and downstream edges of each Work Zone defined above prior to the start of work within that zone. Once cofferdams have been installed, CONTRACTOR shall divert Ely Brook around the Work Zone utilizing bypass pumps and piping, or other diversion methods submitted by the CONTRACTOR and approved by the ENGINEER. Bypass pumps shall discharge water onto a temporary geotextile and stone outlet protection to prevent scour at the discharge location.

3. Once the bypass is operational, CONTRACTOR shall rough grade the stream bed within the Work Zone. All earth moving activities shall be performed in the dry condition. Sediment laden groundwater from temporary dewatering pumps shall be pumped through a water filter bag and discharged onto a stabilized area.

4. Following rough grading, CONTRACTOR shall over-excavate the streambed, as required, and install streambed design features (ie: rock step pools, rock toe protection, log cross vanes, rock riffle sills, rock cross vanes, and j-hooks) in accordance with the design drawings and details.

5. Once streambed design features have been installed, the CONTRACTOR shall fine grade the stream channel in accordance with the grading plan, profile and cross-sections.

6. Following fine grading, CONTRACTOR shall seed the Work Zone in accordance with the seeding plans and stabilize with specified erosion control products in accordance with the design drawings and details.

7. Once the Work Zone has been seeded and erosion and sediment control measures have been installed, the CONTRACTOR shall remove the upstream cofferdam and re-construct the cofferdam at the downstream end of the next subsequent Work Zone.

8. The CONTRACTOR shall perform the above-described sequence for each Work Zone.

B. CONTRACTOR may propose alternate means and methods for the Ely Brook Bypass, provided the proposed methodology meets the intent of the sequencing described herein. CONTRACTOR shall submit his/her methodology as required herein for approval by the ENGINEER prior to initiating work.

C. CONTRACTOR shall provide temporary grading, as needed, to facilitate dewatering and control of surface water.

D. CONTRACTOR shall monitor surface water controls (pumping/bypass efforts) and any required temporary interior dewatering systems continuously.

E. CONTRACTOR shall protect and maintain temporary erosion and sedimentation controls during all bypass and/or dewatering operations.

F. Provide isolated dewatering systems, as necessary, to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades within the Ely Brook channel. Temporary dewatering systems required within the Ely Brook Bypass Work Zone(s) shall be installed and operated as specified herein.

G. CONTRACTOR shall provide and implement contingencies, as needed, to address forecasted storm events/stream flows that exceed the required 15 cfs design flow rate (2-year storm).

H. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to OWNER.

I. Remove bypass dewatering system from Project site upon completion of work. Backfill temporary drainage swales, ditches, and diversion channels and restore to original grade with topsoil, seed, and plantings per the contract drawings.

3.4 FIELD QUALITY CONTROL

A. All subgrades must be inspected and approved by the ENGINEER prior to proceeding with work. Sufficient time must be allowed for the ENGINEER to observe and perform any necessary tests on the subgrade.

3.5 DAMAGES

A. Promptly repair damages to adjacent facilities caused by dewatering and/or bypass operations.

END OF SECTION 31 23 19

SECTION 31 25 00 – EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 WORK INCLUDES

A. This section provides requirements for the preparation and approval of a CONTRACTOR prepared Erosion Prevention and Sediment Control (EPSC) Plan. The Erosion Prevention and Sediment Control Plan shall provide measures to be provided and maintained throughout the construction activities in accordance with Vermont Standards and Specifications for Erosion Prevention and Sediment Control, the Vermont General Permit for Stormwater Runoff from Construction Sites, the Contract Drawings, and other relevant requirements.

B. This section provides requirements for furnishing, installing, and the inspection and maintenance of erosion control measures during earth disturbing activities.

C. Provide materials, equipment, and labor necessary for the installation, inspection, and maintenance of silt and erosion control structures as specified herein or as required to protect surface waters.

D. At the completion of remedial construction, provide materials, equipment, and labor necessary for the removal, transport, and disposal of silt and erosion control structures not specified to remain. Remove, transport, and dispose of sediment resulting from erosion control measures collected from disturbed areas by means consistent with the overall intent of this specification and which do not result in additional erosion.

1.2 RELATED SECTIONS

A. Section 31 10 00 Site Clearing

B. Section 31 20 00 Earth Moving

C. Section 31 23 00 Dewatering and Surface Water Control

D. Section 31 80 00 Blasting Controls

E. Section 31 90 00 Revegetation

1.3 SUBMITTALS

A. The CONTRACTOR shall submit the following items to the ENGINEER prior to initiating construction activities:

1. An Erosion Prevention and Sediment Control Plan for approval by the EPA, ENGINEER, and Vermont Department of Environmental Conservation (VTDEC) submitted at least thirty (30) calendar days prior to initiating construction activities.

2. Submit at least fourteen (14) calendar days prior to initiating construction activities, verification from regulating agencies that necessary permits are in place prior to commencement of earth disturbing activities. Prepare and submit any additional documentation required for approval.

3. Submit at least fourteen (14) calendar days prior to initiating construction activities, provide material submittals for all major components of erosion and sediment control measures, including but not limited to: mulch, soil stabilization blankets, silt fencing, waddles, etc.

1.4 STORMWATER EROSION AND SEDIMENT CONTROL GUIDELINES

A. State of Vermont Agency of Natural Resources, Department of Environmental Conservation, The Vermont Standards and Specifications for Erosion Prevention and Sediment Control (Vermont Standards and Specifications), latest Edition.

B. State of Vermont Agency of Natural Resources, Department of Environmental Conservation, General Permit 3-9020 (2006) for Stormwater Runoff from Construction Sites as amended February 2008.

1.5 EROSION PREVENTION AND SEDIMENT CONTROL PLAN

A. The CONTRACTOR shall develop an Erosion Prevention and Sediment Control Plan for the Work. The Erosion Prevention and Sediment Control Plan shall be approved by the ENGINEER and approving local/state authority. The Erosion Prevention and Sediment Control Plan shall provide measures to be installed and maintained throughout the construction activities in accordance with Vermont Standards and Specifications, the Vermont General Permit for Stormwater Runoff from Construction Sites, the Contract Drawings, and other relevant requirements. The CONTRACTOR shall follow the approved Erosion Prevention and Sediment Control Plan during the execution of the Work.

B. The CONTRACTOR shall provide erosion and sediment control measures throughout the construction activities as indicated in the approved EPSC Plan and as required by Vermont Standards and Specifications.

C. The CONTRACTOR shall notify the EPA, VTDEC, and other approving local authority (if applicable) one (1) week prior to the pre-construction conference, one (1) week prior to the commencement of land disturbing activity, and one (1) week prior to the final inspection.

D. In accordance with the Vermont General Permit for Stormwater Runoff from Construction Sites and as required by VT stormwater regulations, during construction runoff from the Site shall not discharge with turbidity above 25 NTU's. The Project involves significant earthwork activities requiring appropriate best management practices (BMPs) to be installed and maintained throughout the construction activities to prevent exceedances of turbidity regulatory requirements.

1.6 REVIEW AND/OR INSPECTION OF EROSION AND SEDIMENTATION CONTROL MEASURES

A. Construction under this Project may be subject to review and/or inspection by the appropriate local, State, and Federal agencies responsible for ensuring the adequacy of erosion and sedimentation control measures.

B. If required, the CONTRACTOR shall allow agents of the VTDEC and local authorities onto project work areas for inspection and cooperate with agents in addressing identified erosion and/or sediment issues. The VTDEC and local authorities may request additional measures be provided to minimize any on-site or off-site erosion and sedimentation control problems observed during construction. All VTDEC and local inspections and comments should be directed to the CONTRACTING OFFICER or ENGINEER. Any VTDEC and local authority's jurisdiction inspection reports shall be documented and provided to the ENGINEER.

C. Daily statement of erosion and sediment control inspections shall be provided in the CONTRACTOR's daily field reports.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Erosion and sedimentation control products shall be delivered, stored, and handled on-site in accordance with manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Mulch:

1. Straw, hay, or wood cellulose fiber mulches shall meet the requirements of the Vermont Standards and Specifications for Mulching.
2. Straw or hay mulch shall consist of late cut, matured, and cured hay or straw that is free from primary noxious weed seeds.

B. Mulch Anchoring:

1. Provide peg and twine, mulch netting, wood cellulose fiber, or tackifiers in accordance with Vermont Standards and Specifications for Mulching.
2. Netting shall be 100% degradable.
3. Tackifier shall consist of commercially developed products for tacking of hay or straw. Binder shall be free of refuse, physical contaminants, and materials toxic to plant growth.

C. Seed for Erosion Control:

1. Provide annual ryegrass or winter rye depending upon time of year in accordance with Vermont Standards and Specifications for Temporary Critical Area Plantings.

D. Silt Fence:

1. Provide in accordance with Vermont Standards and Specifications for Silt Fence.
2. Silt fence shall consist of Envirofence™, as manufactured by Mirafi Inc.™ (or an approved equal) having an equivalent opening size of 30 (or an approved equal).
3. At critical locations, or as indicated or directed by the ENGINEER, provide hog or chicken wire reinforcing with 6-inch or smaller openings or provide and approved integral silt fence and plastic mesh reinforcing, as necessary.

E. Fertilizer:

1. Refer to Section 31 90 00 Revegetation.

F. Lime:

1. Refer to Section 31 90 00 Revegetation.

G. Permanent Seeding:

1. Refer to Section 31 90 00 Revegetation.

PART 3 - EXECUTION

3.1 PERFORMANCE

A. General:

1. The CONTRACTOR shall implement and maintain erosion and sedimentation control measures which effectively prevent accelerated erosion and sedimentation.

2. Earth moving activities shall be conducted in such a manner as to prevent accelerated erosion and sedimentation.

3. Land disturbance shall be kept to a minimum.

4. The erosion and sediment control measures shall be constructed in accordance with the Vermont Standards and Specifications for Erosion Prevention and Sediment Control.

5. Temporary erosion and sediment control measures shall be installed as the first step in construction, shall be continuously maintained, and shall not be removed until permanent cover is completely established and stabilized.

6. Removal of temporary erosion and sediment control measures requires the approval of the ENGINEER, at a minimum.

7. The following work areas will require erosion and sediment control measures:

    a. Perimeters of soil excavations, filling, and/or grading areas;
    b. Pipe trenching;
    c. Drainage swales or ditches;
    d. Constructed wetlands or other re-vegetated areas;
    e. Temporary stockpile areas; and
    f. Any other disturbed areas.

8. Furnish and place silt fence, hay bales, etc. as temporary erosion and sedimentation control devices at locations as shown on the Drawings or as conditions warrant to control erosion.

9. Erosion control measures shall be employed to protect the site within the limit of work and any adjacent surface waters, drainage ways, or wetlands.

10. Permanent erosion control measures shall be installed within seven (7) days of completion of finish grading activities. Areas to be completed with a vegetative cover shall be seeded and mulched.

B. Diverting Surface Water:

1. Build, maintain, and operate berms, channels, flumes, sumps and other temporary diversion and protection works needed to divert surface water through or around the construction site and away from the construction work while construction is in progress.

2. Storm runoff from disturbed areas must discharge through temporary erosion control measures prior to discharge into a natural drainage way.

C. Erosion Control Provisions (as necessary):

1. Provide and maintain erosion and sediment control best management practices to prevent sediment being transported from work areas with turbidity greater than 25 NTUs to surface waters. BMPs shall include as required, sediment basins, sediment traps, filter bags, sediment barriers, check dams, diversions, and mulching in accordance with the Vermont Standards and Specifications.

2. Protect areas where existing banks are to be disturbed by constructing straw/hay bale or earth dikes at the top of slope to divert storm runoff from the disturbed area or at the toe of the slope to retain sediments, as conditions permit.

3. Contain discharge from any necessary pumping operations during dewatering operations with a dike constructed to prevent siltation of down gradient areas. Protect the discharge pipe outlet area against erosion by flowing water through a rock or timber apron.

4. Prior to removal of sediment barriers, remove retained silt or other materials at no additional cost to the Contract.

D. Seed for Erosion Control:

1. Temporary Seeding: Minimum application rate shall be in accordance with Vermont Standards and Specifications for Temporary Critical Area Plantings, based on seed mix and on seeding dates.

E. Mulching:

1. Apply straw or hay mulch at 2 ton/acre (90 lbs/1000 sq.ft.) or such that over 90% surface coverage is provided.

2. Straw or hay mulch shall be anchored with 100% biodegradable methods:

a. Wood cellulose fiber: Apply with hydroseeder immediately after mulching. Use 500 to 750 lbs (11 to 17 lbs/1000 sq.ft.) wood fiber per acre.

b. Mulch Netting: Staple the light-weight paper, jute, wood fiber, or plastic nettings to soil surface according to manufacturer's recommendations. Mulch netting must be biodegradable and suitable for foot traffic. To avoid wildlife entanglement, netting with fused joints is not approved.

c. Peg and Twine: After mulching, divide areas into blocks approximately 1 sq. yd. in size. Drive 4 to 6 pegs per block to within 2 to 3 inches of soil surface. Secure mulch to surface by stretching twine between pegs in a crisscross pattern on each block. Secure twine around each peg with 2 or more tight turns. Drive pegs flush with soil.

d. Tackifier: Mix and apply polymeric and gum tackifiers according to manufacturer's instructions. Avoid application during rain. A 24-hour curing period and a soil temperature higher than 45 degrees Fahrenheit are required.

F. Silt Fence: Install down gradient from disturbed locations as shown on the Drawings or as directed by the ENGINEER. Install silt fencing per Vermont Standards and Specifications for Silt Fence and manufacturer's requirements.

G. Hay bales for Erosion Control:

1. Place as shown on Drawings or as conditions change and additional controls are needed to provide temporary control of erosion or pollution or both.

2. Stake bales with the required stakes.

H. Other Sediment Barriers: Sediment barriers constructed from berms of erosion control mix, compost/bark, or compost-filled filter socks may be used at locations suitable for their use and as approved by the ENGINEER.

3.2 MAINTENANCE

A. General

1. Erosion and sediment control activities shall be conducted in accordance with the approved EPSC Plan.

2. Erosion and sedimentation control measures shall be inspected by the CONTRACTOR on a daily basis, immediately prior to forecasted precipitation events, and at least twice daily during prolonged rainfall events. The CONTRACTOR shall perform maintenance and/or repairs to the erosion and sedimentation control measures as soon as needed.

3. CONTRACTOR shall maintain the integrity of erosion control measures throughout the construction period, including during any shut-down period(s).

4. All access roads shall be maintained during construction in a smooth and passable condition. Rutting, potholes, displacement of gravel and ditching for drainage shall be maintained in a manner acceptable to the ENGINEER. At the end of the Project, all areas of access roads shall be returned to acceptable pre-construction condition.

END OF SECTION 31 25 00

SECTION 31 56 10 - COVER SYSTEM PERFORMANCE TESTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Criteria for soil and geosynthetic material interface friction and transmissivity testing.

B. Reporting and submittal requirements of test results.

1.2 WORK INCLUDES

A. Interface friction and transmissivity testing for geosynthetic materials using samples of actual materials for cap construction.

1.3 RELATED SECTIONS

A. Section 31 20 00 Earth Moving

B. Section 31 56 50 Geosynthetics

C. Section 31 59 70 Geomembrane

D. Section 31 71 20 Drainage Geocomposite

E. Section 31 90 00 Revegetation

1.4 REFERENCES

A. ASTM D 4716 Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.

B. ASTM D 5321 Standard Test Method for Determining the Shear Strength of Soil and Geosynthetic and Geosynthetic and Geosynthetic Interfaces by the Direct Shear Method.

1.5 QUALITY ASSURANCE

A. Testing of the transmissivity and shear strength will be performed by a U.S. Army Corps of Engineers-approved laboratory and in accordance with Part 3 of this Section.

1.6 SUBMITTALS

A. Results of the transmissivity and shear strength testing shall be submitted to the ENGINEER no later than 30 days prior to mobilizing and installing any tested materials on-site.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. The CONTRACTOR shall use the soil and geosynthetic materials identified in the appropriate Sections listed in Part 1.3 of this Section. The CONTRACTOR shall clearly identify the material source used for testing. Any change in material source or type between testing and project completion will require ENGINEER approval and complete retesting at no additional cost.

PART 3 - EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall obtain representative samples of each type of material they proposed for the project in large enough quantities to perform all tests required by the laboratory.

B. The samples shall be of the actual product and shall be representative of the materials to be used at the site.

C. The CONTRACTOR shall be responsible for obtaining and shipping the testing materials to a third-party laboratory.

D. Shear resistance testing will be determined for the following interfaces:
   1. Vegetative Support Soil/ Drainage Geocomposite.
   2. DGC/Geomembrane.
   3. Geomembrane/Tailing Subgrade.

E. The CONTRACTOR shall obtain approval from the ENGINEER for the proposed testing laboratory, testing program, materials and procedures prior to implementing testing.

3.2 INTERFACE TESTING

A. Interface testing will be performed by direct shear, in accordance with ASTM D 5321, to determine adhesion and angle of friction for each interface and for the Drainage Composite internal strength. Direct shear tests will be performed using a 12-inch by 12-inch shear box. After construction of the test interface, the entire specimen will be soaked in tap water under a normal stress of 50 pounds per square foot (psf). The duration of the soaking period for geosynthetic/geosynthetic interfaces shall be a minimum of 15 minutes and the soaking period for geosynthetic/soil interfaces shall be

a minimum of 24 hours. After soaking, each test interface will be consolidated under a specific normal stress of 288, 720, or 1,000 psf until vertical displacements are stabilized. After consolidation, each specimen will be sheared under its applied normal stress at a displacement ratio of 0.04 inches per minute to determine the peak shear and large displacement "residual" strengths. The shear strength shall be determined for both adhesion and friction angle. The total displacement for each specimen will be a minimum of 2 inches.

B. The interfaces may be tested individually or as a composite of all three interfaces at once. All interfaces shall be tested three times.

C. Using the average lowest peak shear strength and average residual shear (as appropriate) for the three interfaces if tested individually or the average peak shear strength and average residual shear strength for the composite samples, the factor of safety (FS) against veneer failure, as calculated by the methods presented in Attachment A (Koerner and Soong [1998] Limit Equilibrium Method) shall be:

1. Static Case using Peak Shear Strength (interface adhesion and interface friction) FS equal to or greater than 1.5.
2. Static Case using only Peak Interface Friction Angle FS equal to or greater than
3. Static Case using Residual Shear Strength (interface adhesion and interface friction) FS equal to or greater than 1.1.
4. Seismic Case using Peak Shear Strength (adhesion and friction) FS equal to or greater than 1.5.

D. Transmissivity testing will be performed by short-term transmissivity (T_{lab}) in accordance with ASTM D 4716 for the for the Drainage Geocomposite (DGC) with the following conditions:

1. Testing configurations include steel plate/Site-specific vegetative support soil/DGC/ geomembrane/steel plate.
2. Applied normal stress is 1000 psf.
3. Hydraulic gradients shall be 0.05, 0.15, and 0.29.
4. Seating period shall be at least 100 hours or until equilibrium is reached, whichever is greater.

E. The minimum hydraulic transmissivity (T_{lab} obtained from ASTM D 4716 test with the vegetative support soil) for the geocomposite drainage layer shall be as follows:

1. Drainage Geocomposite equal to or greater than 2.5×10^{-3} m^2/sec as tested in accordance with paragraph D above.
2. The above transmissivity is based on design requirements after considering the product of all appropriate long-term reduction factors due to creep, geotextile intrusion, chemical degradation of polymeric compound, physical clogging, biological clogging, chemical clogging, scaling effect, and a design FS equal to 2.0.

F. The laboratory shall report all relevant product test data as specified in ASTM D 5321 and ASTM D 4716. The CONTRACTOR shall submit the report to the ENGINEER at least 30 days prior to the mobilization and use of the material on-site.

G. The testing results shall be provided simultaneously to the CONTRACTOR and the ENGINEER.

H. The ENGINEER may accept or reject the materials submitted for testing based on test results.

3.3 VEGETATIVE SUPPORT LAYER STONE SIZE DETERMINATION

A. If requested by the ENGINEER, the CONTRACTOR shall provide the required material, equipment and labor to perform a Two-Phase Geomembrane Cushion Testing Program to determine alternative stone size acceptability for the Vegetative Support Layer.

B. The CONTRACTOR shall work cooperatively with the ENGINEER and others in performing the testing.

END OF SECTION 31 56 10

ATTACHMENT A – Factor of Safety Analysis Method

SECTION 31 56 50 - GEOSYNTHETICS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Quality Assurance Testing.

B. Product Manufacture.

C. Installation of Geosynthetic Materials.

1.2 WORK INCLUDES

A. The Work specified in this section includes the furnishing and installation of non-woven and woven geotextiles, synthetic geogrid reinforcement, and associated drainage pipes.

1.3 RELATED SECTIONS

A. Section 31 20 00 Earth Moving

B. Section 31 56 10 Cover System Performance Testing

C. Section 31 59 70 Geomembrane

D. Section 31 71 20 Drainage Geocomposite

1.4 QUALITY ASSURANCE TESTING

A. Quality assurance testing and inspection shall be in accordance with Manufacturer's recommendation and industry standards. Further details are provided in Section 31 59 70 – Geomembrane and Section 31 71 20 – Drainage Geocomposite.

B. Obtain samples of each type of geosynthetics delivered and test for conformance to these specifications as specified in Section 31 59 70 - Geomembrane and Section 31 71 20 – Drainage Geocomposite.

1.5 SUBMITTALS

A. The CONTRACTOR shall provide the ENGINEER with the following items: a Construction QA/QC Plan based on Manufacturer recommendations, shop drawings and a written description detailing the proposed methods to be employed for performing the Work. All materials and supplies to be incorporated in the Work shall be described, including seaming plans, installation procedures, and quality control programs, and any

other information needed to show proposed methods for conforming to the Drawings and Specifications.

B. Documentation of the Manufacturer's qualifications and quality control program.

C. Submit certified test reports that the geosynthetics are manufactured in accordance with the Manufacturer's Quality Control program.

D. Submit all documentation including Installers qualifications and experience as specified herein and in Section 31 59 70 – Geomembrane and Section 31 71 20 – Drainage Geocomposite.

E. Process submittals to the Construction Quality Assurance Officer.

1.6 DEFINITIONS

A. Construction Quality Assurance Officer (CQAO) – The ENGINEER will serve as the CQAO and is responsible for approving the Construction Quality Assurance Plan (CQAP) and for observing and documenting activities related to quality during construction.

B. Manufacturer – party responsible for manufacturing the geosynthetic.

C. Testing Laboratory – a U.S. Army Corps of Engineers-approved geosynthetic testing laboratory independent from the Manufacturer and Installer responsible for conducting laboratory tests on samples of geosynthetics.

D. Installer – party responsible for the field handling, transportation, storing and deploying the geosynthetics.

PART 2 - PRODUCTS

2.1 MANUFACTURING

A. Geosynthetics shall consist of new, virgin material manufactured specifically for this work and will have satisfactorily demonstrated, by prior testing, to be suitable and durable for such purposes.

B. Non-Woven geotextile shall consist of a non-woven polypropylene geotextile such as Mirafi 180N™, as manufactured by Tencate Geosynthetics™, or equal, with the following properties:

1. Weight - 8 ounces per square yard (nominal).
2. Apparent Opening Size - 80 U.S. Sieve (minimum average roll value).
3. Trapezoidal Tear Strength - 80 pounds (minimum average roll value).
4. Puncture Strength - 500 pounds (minimum average roll value).
5. The ENGINEER shall review other properties of the selected geotextile and approve prior to installation.

C. Woven geotextile shall consist of high-tenacity polypropylene yarns, which are woven into a network such that the yarns retain their relative position. Woven geotextile shall consist of Mirafi HP570™, as manufactured by Tencate Geosynthetics™, or equal, with the following properties:
   1. Tensile Strength (at Ultimate) – 4,800 pounds per foot.
   2. Tensile Strength (at 5% strain) – 2,400 pounds per foot (machine direction); 3,000 pounds per foot (cross direction).
   3. Apparent Opening Size – 30 U.S. Sieve (minimum average roll value).
   4. The ENGINEER shall review other properties of the selected geotextile and approve prior to installation.

D. Geogrid Reinforcement: Geogrid reinforcement shall consist of polypropylene extruded into a grid structure. Biaxial geogrid shall consist of Mirafi BXG120™ geogrid as manufactured by TenCate Geosynthetics™, or equal, with the following properties:

   1. Aperture Dimensions (Nominal) – 1.0 inch by 1.3 inch
   2. Tensile Strength at 2% Strain – 410 x 620 pounds per foot
   3. Tensile Strength at 5% Strain – 810 x 1,340 pounds per foot
   4. Ultimate Tensile Strength – 1,310 x 1,970 pounds per foot

E. The drainage geocomposites shall be of a bi-planar or tri-planar construction consisting of a core material with a geotextile bonded to both sides. The geotextile shall meet the requirements for the geotextile in Part 2, 2.1.B of this Section. The drainage geocomposite shall have a minimum transmissivity as specified in Section 31 56 10 – Cover System Performance Testing, Part 3.2.E. The geocomposite shall comply with Section 31 71 20 – Drainage Geocomposite or equivalent specification approved by the ENGINEER.
   1. The drainage geocomposite shall have a geotextile bonded to both sides throughout the limits of the cover system.

F. The geomembrane shall be linear low-density polyethylene (LLDPE) geomembrane. The geomembrane shall have a minimum thickness of 60 mil. The geomembrane shall comply with Section 02597 or equivalent specification approved by the ENGINEER.
   1. The LLDPE shall be textured on both sides.

G. Pipes, culverts, drain tubing fittings and other components shall be high density polyethylene pipe manufactured by Hancor, Inc.™ or equivalent.
   1. Pipes, culverts and tubing 24 inches in diameter or smaller shall be equivalent to Hancor AASHTO single wall pipe.
   2. Pipe and culvert larger than 24 inches in diameter shall be equivalent to Hancor Sure-Lok® ST pipe.

2.2 WARRANTY

A. Materials shall be warranted against Manufacturer's defects for a period of 5 years from the date of completed installation.

B. Installation shall be warranted against defects in workmanship for a period of 1 year from the date of completed installation.

PART 3 - EXECUTION

3.1 SUBGRADE

A. The subgrade shall be prepared in accordance to Manufacturer's recommendation and those specifications for foundation preparations included in Section 31 20 00 – Earth Moving.

B. All subgrade damaged by construction equipment and deemed unsuitable shall be repaired prior to placement of the geosynthetic at the CONTRACTOR's expense. All repairs shall be approved by the ENGINEER.

C. The subgrade shall be accepted by the Installer by a written certification.

3.2 FIELD INSTALLATION

A. Field installation will be in accordance with the ENGINEER approved plans and follow Manufacturer's recommendations.

B. Field installation shall be in a manner that assures efficiency of material, minimization of seams and proper placement of seams.

C. No equipment, tools or personnel that can readily cause damage to geosynthetics shall be allowed on the geosynthetic during and after installation.

D. CONTRACTOR shall provide adequate temporary loading that will not damage the geosynthetic as needed to prevent uplift by wind.

E. If a phased approach is to be employed the CONTRACTOR shall incorporate a plan with the ENGINEER's approval to protect the leading edge(s) of the geosynthetic appropriately to protect it from damage and provide for a clean tie-in to future installation.

3.3 JOINING

A. Join geosynthetics in accordance with ENGINEER approved plans and following Manufacturer's recommendations.

3.4 TESTING

A. The ENGINEER shall stipulate the experience required by the geomembrane Manufacturer and Installer as required in the appropriate specification.

B. Construction Quality Assurance: The CONTRACTOR shall prepare a Construction Quality Control Plan (CQCP). The CQCP shall address the means and methods to be employed for the installation of geosynthetics. The CQCP shall outline all required tests, testing frequency, observations and documentation of results as described in Section 31 56 10 – Cover System Performance Testing, Section 31 59 70 - Geomembrane, and Section 31 71 20 – Drainage Geocomposite.

C. Manufacturing Testing: The geosynthetic Manufacturer shall supply certified test reports in accordance with Part 1.4.A of these Specifications.

D. Field Testing: Field testing shall be conducted by the means and methods presented in the CQCP. Field testing shall be conducted in a manner and method that minimizes the need for repairs or rework.

END OF SECTION 31 56 50

SECTION 31 59 70 - GEOMEMBRANE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Products

B. Manufacturing

C. Testing

D. Installation

1.2 WORK INCLUDES

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to install a 60 mil linear low-density polyethylene (LLDPE) geomembrane liner that meets the requirements set forth in these Sections.

1.3 RELATED SECTIONS

A. Section 31 20 00 Earth Moving

B. Section 31 56 10 Cover System Performance Testing

C. Section 31 56 50 Geosynthetics

D. Section 31 71 20 Drainage Geocomposite

1.4 REFERENCES

A. The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

1. ASTM D 570 Standard Test Method for Water Absorption of Plastics.
2. ASTM D 638 Standard Test Method for Tensile Properties of Plastics.
3. ASTM D 746 Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
4. ASTM D 792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
5. ASTM D 1004 Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
6. ASTM D 1203 Standard Test Method for Volatile Loss from Plastics Using Activated Carbon Methods.

7. ASTM D 1204 Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.
8. ASTM D 1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
9. ASTM D 1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique.
10. ASTM D 1603 Standard Test Method for Carbon Black In Olefin Plastics.
11. ASTM D 1693 Standard Test Method for Environmental Stress Cracking of Ethylene Plastics.
12. ASTM D 1898 Standard Recommended Practice for Sampling of Plastics.
13. ASTM D 3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry.
14. ASTM D 4437 Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes
15. ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
16. ASTM D 5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.
17. ASTM D 5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
18. ASTM D 5323 Standard Practice for Determination of 2% Secant Modulus for Polyethylene Geomembranes.
19. ASTM D 5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test.
20. ASTM D 5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
21. ASTM D 5617 Standard Test Method for Multi-Axial Tension Test for Geosynthetics.
22. ASTM D 5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.
23. ASTM D 5820 Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
24. ASTM D 5885 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry.
25. ASTM D 5994 Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
26. ASTM D 6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced using Thermo-Fusion Methods.
27. ASTM D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.
28. ASTM D 6747 Standard Guide for Selection of Techniques for Electrical Detection of potential Leak Paths in Geomembranes.
29. ASTM E 96 Standard Test Methods for Water Vapor Transmission of Materials.
30. FTM 101 Puncture Resistance and Elongation Test (1/8 inch Radius Probe Method), Federal Test method 2065.
31. GRI Test Method GM12 Asperity Measurement of Textured Geomembranes Using a Depth Gage.
32. GRI Test Method GM14 Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes.
33. Where reference is made to one of the above standards, the most recent revision in effect at the time of the work shall apply.

1.5 QUALITY ASSURANCE TESTING

A. Quality assurance testing and inspection shall be in accordance with the Manufacturer's recommendations and these Specifications.

B. CONTRACTOR shall obtain samples from each lot of each type of geomembrane delivered and test for conformance to these Specifications.

C. CONTRACTOR shall perform or have performed the testing outlined in Section 31 56 10 – Cover System Performance Testing, and report the results to the ENGINEER.

1.6 SUBMITTALS

A. CONTRACTOR shall submit the following items to the ENGINEER:

1. Pre-installation Submittals.

    a. Supplier's name, production facility, and identification of resin used to manufacture the geomembrane.
    b. Copies of dated quality control certificates provided by resin supplier.
    c. Statement that the amount of manufacturing-recycled polymer added to resin does not exceed 2% by weight.
    d. CONTRACTOR's certification that the material was manufactured and tested in accordance with these specifications, together with a report of the test results, shall be furnished at the time of shipment. The ENGINEER shall review and approve of the geomembrane prior to installation.
    e. Report of test results per Section 31 56 10 – Cover System Performance Testing.
    f. Pre-qualifications
        1) Manufacturer shall have a minimum of 5 years continuous experience in manufacture of LLDPE geomembrane, or experience totaling 10,000,000 square feet of manufactured LLDPE, or geomembrane manufacture for a minimum of 10 completed sites.
        2) Installer shall have a minimum of 5 years continuous experience in installation of LLDPE geomembrane or experience totaling 2,000,000 square feet of installed LLDPE geomembrane for a minimum of 10 completed sites in operation for at least 2 years.
            a) Personnel performing seaming operations shall be qualified by experience or training.
            b) Minimum of one seamer shall have experience seaming a minimum of 2,000,000 square feet of LLDPE geomembrane using the same type of Manufacturer-approved seaming apparatus in use at the Site.
            c) The most experienced seamer shall provide direct supervision over less experienced seamers.
    g. CONTRACTORs QA/QC manual for geomembrane installation.
    h. Geomembrane material, panel installation diagram.
    i. Manufacturer's certification of materials.

2. Installation and Post-Installation Submittals.

a. Daily Inspection and testing reports.
b. Quality Control Documentation.
c. Subgrade surface acceptance certificates signed by the Installer for each area that will be covered by geomembrane.
d. As-built drawings.

1.7 DEFINITIONS

A. Construction Quality Assurance Officer (CQAO) – The ENGINEER will serve as the CQAO and is responsible for approving the Quality Assurance/ Quality Control Plan and for observing and documenting activities related to quality during construction.

B. Formulation – The mixture of a unique combination of ingredients identified by type, properties, and quantity. For LLDPE geomembranes, a formulation is defined as the exact percentages and types of resin(s), additives, and carbon black.

C. Installer – party responsible for the field handling, transportation, storing and deploying the geomembrane.

D. Linear Low-Density Polyethylene (LLDPE) – An ethylene/a-olefin copolymer having a linear molecular structure. The comonomers used to produce the resin can include hexane, octane, or methyl pentene. LLDPE resins have a natural density in the range of 0.915 to 0.926 g/ml.

E. Manufacturer – party responsible for manufacturing the Geomembrane.

F. Testing Laboratory – a U.S. Army Corps of Engineers approved geosynthetic testing laboratory independent from the Manufacturer and Installer responsible for conducting laboratory tests on samples of geomembrane.

PART 2 - PRODUCTS

2.1 MATERIAL

A. The LLDPE geomembrane sheets shall be manufactured from pure virgin resin. The pure virgin resin shall be mixed with 2 to 3 percent carbon black. No reclaimed polymer shall be added to the resin. Polymer recycled during the manufacturing process may be permitted if done with an appropriate cleanliness and if the recycle polymer does not exceed 2 percent by weight. The carbon black is to be preblended according to specifications of the Geomembrane Manufacturer. The resin shall have a melt flow index value of less than 1.0 g/10 min per ASTM D 1238 and a density of 0.926 g/ml or lower.

B. The LLDPE geomembrane shall have a formulated sheet density of 0.939 g/ml or lower. Density can be measured by ASTM D 1505 or ASTM D 792. If the latter, Method B is recommended.

2.2 MANUFACTURING

A. The sheet material shall be capable of being bonded to itself by thermal bonding in accordance with the sheet Manufacturer's recommendations and instructions and seaming requirements of this section.

B. Extruded sheets shall be at least 10 feet in width. Each roll shall be identified by a number and date of manufacture. Paint or markers used for identification shall be of a type which will not degrade the material.

C. The delivered geomembrane sheets shall conform to the following minimum properties.
   1. Textured geomembrane shall conform to Table 1 values.

D. The values listed in the table are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

E. The various properties of the LLDPE geomembrane shall be tested at the minimum frequencies shown in Table 1. If the specific Manufacturer’s quality control guide is more stringent, it must be followed in like manner.

F. Workmanship and Appearance
   1. Textured geomembrane shall generally have uniform texturing appearance. It shall be free from such defects that would affect the specified properties and hydraulic integrity of the geomembrane.
   2. General manufacturing procedures shall be performed in accordance with the Manufacturer’s internal quality control guide and/or documents.

G. Manufacturer’s Quality Control (MQC) Sampling
   1. Sampling shall be in accordance with the specific test methods listed in Table 1. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.
   2. The number of tests shall be in accordance with the appropriate test methods listed in Table 1.
   3. The average of the test results should be calculated per the particular standard cited and compared to the minimum values listed in the table, hence the values listed are the minimum average values and are designated as “min. ave.”

H. MQC Retest and Rejection
   1. If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the Manufacturer’s quality manual.

I. Packaging and Marking
   1. The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of delivery, unless otherwise specified in the contract or order.
   2. Marking of the geomembrane rolls shall be done in accordance with the Manufacturer’s accepted procedure as set forth in their quality manual.

Table 1. Linear Low-Density Polyethylene (LLDPE) Geomembrane (TEXTURED)

Properties	Test Method	Test Value (60 mils)	Testing Frequency (minimum)
Thickness – mils (min. ave.) • Lowest individual for 8 out of 10 values • Lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	Per roll
Asperity Height mils (min. ave.) *(1)*	GM 12	10	Every 2nd roll *(2)*
Density g/ml (max.)	D 1505/D 792	0.939	200,000 lb
Tensile properties *(3)* (min. ave.) •Break strength -- lb/in •Break elongation - %	D 6693, Type IV	 90 250	20,000 lb
2% Modulus – lb/in. (max.) cel	D 5323	3600	per formulation
Tear Resistance – lb (min. ave.)	D 1004	33	45,000 lb
Puncture Resistance – lb (min. ave.)	D 4833	66	45,000 lb
Axi-Symmetric Break Resistance Strain - % (min)	D 5617	30	per formulation
Carbon Black Content - %	D 1603 *(4)*	2.0-3.0	45,000 lb
Carbon Black Dispersion	D 5596	*(5)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(6)* (c) Standard OIT **-or** (d) High Pressure OIT	D 3895, D 5885	100 / 400	200,000 lb
Oven Aging at 85 oC *(7)* (c) Standard OIT (min. ave.) - % retained after 90 days **- or**(d) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721, D 3895 D 5885	35 / 60	per formulation
UV Resistance *(8)* (c) Standard OIT (min. ave) -**or** (d) High Pressure OIT (min. ave.) - % retained after 1600 hours *(10)*	D 3895 D 5885	N.R. *(9)* 35	per formulation

Notes

(1) Of 10 readings; 8 out of 10 must be 27 mils, and lowest individual reading must be 25 mils; also see Note 9.

(2) Alternate the measurement side for double sided textured sheet.

(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.

• Break elongation is calculated using a gage length of 2.0 in. at 2.0 in./min.

(4) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:

• 9 in Categories 1 or 2 and 1 in Category 3

(6) The Manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(7) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(8) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C

(9) Not recommended since the high temperature of the Std-OIT test produces and unrealistic result for some of the antioxidants in the UV exposed samples.

(10) UV resistance is based on percent retained value regardless of the original HP-OIT value.

J. Stacking of geosynthetic materials roll restrictions within staging areas: Geomembrane material rolls shall not be stacked higher than 2 rolls high. Geocomposite material rolls shall not be stacked higher than 5 rolls high.

2.3 SEAMING AND TESTING EQUIPMENT

A. Welding

1. Maintain a minimum of two spare operable seaming machines.
2. Seaming equipment shall not damage geomembrane.
3. Use extrusion welding apparatus equipped with gauges indicating temperature of extrudate at the equipment nozzle or use hand-held gauges to measure extrudate temperatures.
4. Use self-propelled fusion welding machines equipped with gauge indicating heating element temperature and gauge indicating speed of travel.
5. Place electric generator on smooth base such that no damage occurs to geomembrane.

B. Vacuum testing equipment shall consist of a vacuum box.

C. Air pressure testing equipment shall consist of an air pump and air pressure monitoring device.

D. Tensiometer capable of maintaining a constant jaw separation rate of 2 inches per minute.

PART 3 - EXECUTION

3.1 FIELD INSTALLATION

A. Panel Placement: Based on the approved geomembrane panel installation diagrams and material certifications, the individual sheets will be numbered and seams will be identified by using the numbers of the sheets, which create the seam. The proposed layout of panels shall be set and approved, assuring efficiency of material, minimization of welds and proper placement of welds. Any variation from the panel diagram must be approved by the ENGINEER. Should a variance be obtained, the CONTRACTOR shall modify the panel diagram to show the "As-Built" configuration. The prime considerations in seaming shall be to minimize the number of seams made. All overlaps for field seams shall be shingled in a downslope direction.

B. Subgrade: No geomembrane shall be placed over unsuitable or unapproved subgrade. The Installer shall furnish a subgrade acceptance form prior to the installation of each panel indicating acceptance of the subgrade. The following conditions shall be minimum for the subgrade:

1. The subgrade soil shall be as specified in Section 31 20 00 – Earth Moving and Section 31 56 50 – Cover System Performance Testing.
2. No stones or sharp objects shall be present on the area to be lined.

3. The subgrade surface should not be pebbly or tracked and rutted by equipment and shall be free from pockets, holes, and discontinuities which will cause bridging which would, in the judgment of the ENGINEER, overstress the geomembrane.
4. Surface moisture shall not be excessively wet or dry or in any condition which will impede proper installation. Under no condition shall the geomembrane be placed over standing water on the subgrade.

C. Water and Wind: The CONTRACTOR shall use whatever methods deemed necessary to prevent water or wind from getting under the partially installed geomembrane. Should excessive moisture become trapped below the membrane or if wind damage has been incurred, the CONTRACTOR will be required to perform all work, including removing and replacing as much of the in-place geomembrane as the ENGINEER directs, to assure that the integrity of the geomembrane and the underlying subgrade has not been compromised.

D. Placement: Placement of the geomembrane shall be done such that good fit (thermal expansion or contraction shall be considered), without bridging or excessive contraction, is provided in all corners and grade changes. Excessive slack shall be avoided to minimize rippling. The liner sheets shall be unrolled, deployed and backfilled in a manner which minimizes wrinkles and prevents the occurrence of folds and creases. The wrinkle height to width ratio for installed geomembrane shall not exceed 0.5. In addition, geomembrane wrinkles shall not exceed 6 inches in height. Wrinkles that do not meet these criteria shall be cut out and repaired in accordance with the Installer's QC manual and these Specifications. Liner deployment shall not be performed when precipitation is occurring, when excessive moisture or wet conditions exist, when ambient temperatures are below 32^{o}F or above 104^{o}F, or when high winds or other adverse climatic conditions exist, unless approved by ENGINEER.

E. Liner Protection: No equipment, tools or personnel that can readily cause damage to the liner shall be allowed on the liner during and after installation. Personnel working on the liner shall not smoke, wear potentially damaging shoes, dispose of trash or other debris, or engage in any activity that could damage the liner.

F. Temporary Ballast Loading: Adequate loading that will not damage the liner shall be placed by the CONTRACTOR over the liner during installation as needed to prevent uplift by wind and by rapid changes in barometric pressure. This temporary ballast loading shall be in addition to the anchor trenches as shown on the Drawings. Sufficient temporary ballast loading shall be placed along panel edges, in particular, as needed to minimize the risk of wind flow under the panels. Temporary ballast loading may consist of sand filled bags. Bags used for containing sand shall be resistant to degradation by ultraviolet rays.

G. Anchor Trenches: The liner shall be anchored in anchor trenches at the locations shown on the Drawings. Liner anchor trenches shall be no less than 24-inches in width and 24-inches in depth, and the corners of the trenches shall be slightly rounded to minimize sharp bends in the liner. After placement of the liner along one side and across the bottom of the trench, the trench shall be backfilled with compacted vegetative support soil.

H. Repairs: All liner defects (scratches, blisters, rips, punctures, tears, holes, pinholes creases, folds, etc.) and holes created by removal of samples or coupons for destructive

testing shall be marked and repaired by completely covering the defect or hole with an oval-shaped piece of the corresponding geomembrane material, that extends out 6 inches from the repair and continuously welding the patch to the liner or sheet using an extrusion weld. Liner repairs shall be documented including date, liner panel number, repair location, type of defect, description of repairs made and results of testing.

I. As-Built Panel Diagram: The CONTRACTOR shall prepare the "As-Built" panel diagram locating and identifying seams, individual rolls and panels as they have been placed. The CONTRACTOR shall also indicate in that diagram the date on which each seam was performed, the patches and repairs, and the dates each were performed.

3.2 SEAMING METHODS

A. Geomembrane field seaming shall be performed in accordance with the following:

1. All liner shall be ballasted immediately after deployment to prevent uplift by winds. Welding of field seams shall not take place except during suitable ambient weather conditions, as confirmed by field trial test welds.
2. All liner sheets must be continuously and tightly bonded using continuous extrusion fillet welds or double wedge fusion welds and automated welding equipment approved by the ENGINEER. Field seaming shall be conducted in the dry, on a compacted smooth surface, and in such a manner to prevent dust, dirt, or other foreign material from being included in the seam.
3. Adjoining liner sheets shall be overlapped a minimum of 4 inches by adequately lapping the edges of the sheets. The overlap shall not exceed 6 inches for double-wedge fusion welds. The edges to be welded shall be wiped and cleaned thoroughly to remove any dirt, dust, moisture or other foreign materials. All field seams must be uniform in appearance, width and properties, and shall not exhibit warping due to overheating from welding. The peel and shear strengths of the welded seams must comply with the strength criteria provided by the Manufacturer. “T” seams should be patched in accordance with Section 31 59 70 – Geomembrane.

B. Repair Procedures:

1. Acceptable repair procedures include the following:

a. Patching: use of same geomembrane material extrusion welded into place. Use to repair large holes, tears, nondispersed raw materials, and contamination by foreign matter. All panel intersections shall be patched.
b. Capping: strip of same geomembrane material extrusion welded into place over inadequate seam. Use to repair large lengths of failed seams.
c. Spot welding or seaming (Grid and Weld): Bead of molten extrudate placed on flaw. Used to repair scuffing, dimpling, or other minor, localized flaws. Spot welding shall not be used to repair holes in the geomembrane liner.
d. Removal and replacement: Remove bad seam and replace with strip of same geomembrane material welded into place. Use to repair large lengths of failed seams.

e. Extrusion welding flap: Repairs of this type shall not be used unless approved by ENGINEER, and only if the flap is a minimum of 1.5 inches long. Repairs of this type shall not exceed 100 feet in length.

2. For each repair method:

a. Ensure that surfaces are clean, dry, and prepared in accordance with specified seaming process.
b. Ensure seaming equipment used in repairing procedures meet requirements of this Section.
c. Extend patches or caps at least 6 inches beyond the edge of the defect. Round corners of patches with radius of approximately 6 inches.

3.3 TESTING

A. Materials

1. Resin – Factory sampling and testing of raw materials shall be in conformance with ASTM D 1898. Factory test reports for the resin shall include the proportions of resin, carbon black and other additives, and test results for melt index, specific gravity, environmental stress crack resistance, low temperature brittleness and oxidative induction time. These reports shall be submitted for approval by the ENGINEER before installation of any liner material. The following tests and minimum frequency of testing shall be undertaken by the Liner Manufacturer. The resin density and melt index shall be reported for both the unblended resin and the blended resin after adding carbon black and antioxidants. The oxidative induction time shall be reported for the blended resin.

2.

Resin Property	**Method**	**Minimum Frequency**
Density	ASTM D 792	Once per Batch of Resin
Melt Index	ASTM D 1238, Condition E	Once per Batch of Resin
Oxidative Induction Time	ASTM D 3895	Once per Batch of Resin

3. Factory Liner Testing – Factory test reports for each roll of liner shall include test results for the following properties: tensile strength and elongation at yield and at break; tear resistance; puncture resistance; minimum and average thickness; density; carbon black content; and carbon black dispersion. These reports shall be submitted for approval by the ENGINEER before installation of the liner. Failure of any of the tests shall result in rejection of the corresponding liner rolls. Tensile tests (ASTM D 638) and tear resistance tests (ASTM D 1004) shall be performed in both the machine and transverse directions. Certification of the liner modulus of elasticity, dimensional stability, volatile loss, water absorption and water vapor transmission shall be provided by the liner Manufacturer in writing. In support of the certification, the Liner Manufacturer shall submit at least one test result for each

property performed within one year prior to the date of the certification on liner manufactured with each type resin supplied to the project.

4. CONTRACTOR Liner Quality Assurance Testing: The CONTRACTOR shall obtain and secure samples (coupons) of the geoembrane at a minimum frequency of 1 sample per 100,000 sf of material delivered and test for conformance with the following properties: tensile properties (yield strength, yield elongation, break strength, break elongation) by ASTM D 6693; tear resistance by ASTM D 1004; puncture resistance by ASTM D 4833; thickness by ASTM D 5994; density by Method D 1505/D 792; carbon black content by ASTM D 1603; carbon black dispersion by ASTM D 5885; and asperity height by GRI GM 12. The results of the testing will be compared to the values in Table 1. Additional samples of geomembrane may be collected and tested by the CONTRACTOR. Failure of any sample to meet or exceed the requirements specified herein shall be considered cause for rejection of the material or installed geomembrane section from which the sample was collected to the extent designated by the ENGINEER. If the CONTRACTOR or Manufacturer can establish to the ENGINEER, via additional test results, that the failed sample is representative of a smaller section of geomembrane cap, then only that portion will be rejected.

B. Field Seams.

1. Daily Qualifying Welds – At the beginning of each working day, after any interruption in power, after any prolonged idle period during the day, and at the request of the ENGINEER at any other time during the day, each seamer/welder shall prepare a 3-foot (for extrusion welds) to 10-foot (for double-wedge fusion welds) long test strip using the welding apparatus assigned to him. Five samples from the test strip shall be cut at locations selected by the ENGINEER and tested by the CONTRACTOR in both shear and peel for compliance with these specifications in the presence of the ENGINEER. The sample weld shall successfully pass the test requirements before either the welder or welding apparatus are allowed to operate on production welds.

2. Non-Destructive Testing of Welds - The CONTRACTOR shall continuously test every field weld (i.e., 100 percent of the length of all field seams), including field welds around patches, using non-destructive testing techniques. These tests shall be performed in the presence of the ENGINEER. Extrusion welds shall be tested using a vacuum box and test procedures specified in ASTM D 4437. Once the soap solution is uniformly placed over the weld and suction applied to the seam, any bubble formation must be noted and the corresponding defective area identified, marked, and subsequently repaired.

    a. Double-wedge fusion welds with a continuous air gap between the two welds, shall be non-destructively tested by pressurizing the gap between the two welds to a pressure between 25 and 30 lb/in^2 and monitoring the pressure for any decline with time, in accordance with ASTM D 5820. After allowing 2 minutes for relaxation, the pressure shall be monitored over a test period of not less than 5 minutes. A weld will be considered satisfactory if either of the following criteria are satisfied:

1) the loss in pressure is equal to or less than 2 lb/in^2 and the pressure stabilizes within the 5-minute test period; or

2) if criteria (1) is not satisfied, the additional pressure drop is equal to or less than 1 lb/in^2 during an additional test period of 5 minutes (i.e., the total pressure drop is less than or equal to 3 lb/in^2 over a 10-minute test period), and the pressure stabilizes during the second test period.

b. The length of a welded section tested by air pressure shall not exceed 500 feet, without prior approval by the ENGINEER. If a non-compliant pressure drop is noted, pressure testing may be repeated in a step fashion each time halving the length of weld being tested until the extent of the defective weld is determined. Vacuum box testing (ASTM D 4437) may also be used to locate a defect in the top weld or in the top of the air channel.

c. Once the defect is found, it shall be clearly identified, marked and repaired. Any defective seams shall be repaired so that it meets or exceeds the minimum requirements specified herein.

3. Sampling and Destructive Testing

a. Testing – The CONTRACTOR shall obtain and secure samples of the liner and field seams for destructive testing at locations designated by the ENGINEER. Samples shall be obtained at a frequency as determined by the methodology of GRI GM 14 “Selected Variable Intervals for Taking Geomembrane Destructive Seam Samples using the Method of Attributes” (Attachment A). The following shall be assumed in developing the GRI GM 14 methodology:
   1) Total seam length shall be the total length estimated for each construction season.
   2) The anticipated failure percentage shall be 2 percent unless otherwise authorized by the ENGINEER.
   3) The initial seam sampling frequency shall be 1 sample every 750 feet.

b. Sampling – The CONTRACTOR shall obtain seam samples, in triplicate, from the designated location for field and laboratory testing. One portion of the sample shall be retained by the CONTRACTOR for field testing. If the results of field tests performed by the CONTRACTOR, in the presence of the ENGINEER, indicate compliance with these specifications then the CONTRACTOR shall send the second portion of the sample to an independent laboratory for testing paid for by the CONTRACTOR, and the third portion will be retained by the ENGINEER’s designated representative for archive storage. If the results of peel and shear tests performed by the CONTRACTOR in the field do not meet or exceed the requirements specified herein, the CONTRACTOR shall apply for temporarily determining the extent of repairs pending performance of independent quality control tests by the ENGINEER.

The portions of seam samples provided for independent laboratory destructive testing, and provided to the ENGINEER's designated representative for archive storage, shall each be not less than 12 inches wide by 18 inches long in the direction of the seam. The seam shall be centered along the sample length. Each of the triplicate sample portions shall be properly marked and identified by the CONTRACTOR. The CONTRACTOR shall repair all holes created by sampling in accordance with these Specifications in Repairs.

c. Seam Strength Criteria – All welded field seams shall meet the following criteria:

1) When the weld is tested in shear in accordance with ASTM D 6392, the specimen shall exhibit a film tear bond failure (FTB), and the strength shall be equal to or greater than 90 lb/in (ppi). The tests shall be performed at 20 in/min (ipm) until rupture.
2) When the weld is tested in peel in accordance with ASTM D 6392, the specimen shall exhibit an FTB and/or the liner must fail before the weld, and the strength shall be equal to or greater than 90 lb/in (ppi). The peel strength criteria shall apply to both the top and bottom welds of double wedge fusion welds. The tests shall be performed at 20 ipm until rupture.

d. Pass/Fail Criteria – The following pass/fail criteria shall be used to determine compliance of field seams with the above strength criteria:

1) All five seam specimens from a given sample or coupon tested in peel (both top and bottom for double wedge fusion welds) and all five specimens tested in shear shall exhibit the required strengths, and display FTB failures (i.e., 0 percent strength failures and 0 percent non-FTB failures); or

2) All five seam specimens from a given sample or coupon tested in peel and all five specimens tested in shear shall exhibit the required strengths and at least four out of five test specimens, for each type of test, shall exhibit a FTB failure (i.e., 0 percent strength failures and up to 10 percent non-FTB failures); or

3) If a field seam fails the criteria specified herein, and the CONTRACTOR wishes to establish to the ENGINEER that the failed sample represents a smaller section of the field seam than designated by the ENGINEER, additional coupons may be obtained at progressively increasing distances from both sides of the failed sample, at locations approved by the ENGINEER, until two consecutive samples on each side of the original sample pass the field seam criteria. At that point, the extent of the original defect in both directions along the field seam will be considered isolated and the CONTRACTOR will then cap/patch, re-weld and re-test the entire length of sampling.

4. Quality Assurance Forms – The CONTRACTOR shall adopt and use quality assurance forms approved by the ENGINEER during all applicable phases of liner installation, inspection and testing. The forms must be submitted to the ENGINEER at least two weeks prior to liner installation for review and approval.

5. Certification – The CONTRACTOR's installation supervisor shall observe and check all phases of the liner installation. When the liner is finally accepted, the CONTRACTOR shall submit written certification that the installation conforms to the requirements of the Liner Manufacturer.

END OF SECTION 31 59 70

ATTACHMENT A

GRI GM14 - “Selected Variable Intervals for Taking Geomembrane Destructive Seam Samples using the Method of Attributes”

SECTION 31 71 20 – DRAINAGE GEOCOMPOSITE

PART 1 - GENERAL

1.1 SECTION INCLUDES

1.2 Specifications for installation and testing of the Drainage Geocomposite (DGC).

1.3 WORK INCLUDES

A. The CONTRACTOR shall furnish all labor, material, and equipment to complete installation of the Drainage Geocomposite, including all necessary and incidental items, in accordance with the Drawings and these Specifications.

1.4 RELATED SECTIONS

A. Section 31 20 00 Earth Moving

B. Section 31 56 10 Cover System Performance Testing

C. Section 31 56 50 Geosynthetics

D. Section 31 59 70 Geomembrane

1.5 REFERENCES

A. The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

1. ASTM D 1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Process Plastometer.
2. ASTM D 1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique.
3. ASTM D 1621 Standard Test Method for Compressive Properties of Rigid Cellular Plastics.
4. ASTM D 3776 Standard Test Methods for Mass Per Unit Area (Weight) of Fabric
5. ASTM D 4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle Furnace Technique.
6. ASTM D 4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
7. ASTM D 4491 Standard Test Method for Water Permeability of Geotextiles by the Permitivity Method.
8. ASTM D 4439 Standard Terminology for Geosynthetics
9. ASTM D 4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

10. ASTM D 4595 Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
11. ASTM D 4632 Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).
12. ASTM D 4716 Standard Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using Constant Head.
13. ASTM D 4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile.
14. ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
15. ASTM D 5199 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
16. ASTM D 7005 Standard Test Methods for Determining the Bond Strength (Ply Adhesion) of Geocomposites.
17. ASTM G 154 Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
18. GRI-GC 8 Standard Guide for Determination of the Allowable Flow Rate of a Drainage Geocomposite.

1.6 QUALITY ASSURANCE

A. Quality Assurance during installation of DGC will be provided by the ENGINEER as described in the Project CQA Plan.

1.7 SUBMITTALS

A. CONTRACTOR shall submit the following items to the ENGINEER:

1. Manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment. The ENGINEER shall review and approve of the Drainage Geocomposite prior to installation.
2. Report of test results per Section 31 56 10 – Cover System Performance Testing.
3. CONTRACTORs QA/QC manual for Drainage Geocomposite installation.
4. Manufacturer's certification of materials.
5. Daily Inspection and testing reports.
6. As-built drawings.
7. Geocomposite Panel Installation Diagram (pre-built panel plan).
8. Geotextile used for geocomposite repairs and butt seams.

1.8 DEFINITIONS

A. MD – Machine Direction as defined by ASTM D 4439.

B. CD – Cross-Machine Direction as defined by ASTM D 4439.

PART 2 - PRODUCTS

2.1 MATERIALS

A. The polymer used to manufacture the Geonet core of the DGC shall be polyethylene. Manufacturer shall certify that no regrind material is used in the Geonet manufacturing process.

B. The drainage core of the DGC shall be manufactured by extruding polyethylene to form a tri-planar void maintaining structure, or by extruding two crossing strands of polyethylene to form a bi-planar net structure. The geotextile shall meet the property requirements listed in Table 1.

C. The geotextile of the DGC shall be UV resistant, continuous filament, needle punched, non-woven polypropylene geotextile. The geotextile shall meet the property requirements listed in Table 2.

D. Labels on each roll of DGC shall identify the length, width, lot and roll numbers, and name of Manufacturer.

E. If requested by the ENGINEER, the Manufacturer of the DGC shall submit documents for the ENGINEER's review that the DGC to be supplied to the project site has proven installation. As a minimum, the Manufacturer shall certify that:

1. At least one million square feet of the proposed DGC has been installed at least (to be determined by the ENGINEER. The proposed DGC has been installed at least 10 projects that are in operations for a minimum two years.
2. The proposed DGC has been installed on at least five (5) landfill caps of similar size, and with slopes similar to this project.
3. It has not supplied any drainage product that has been documented to be contributing towards a catastrophic system failure.

TABLE 1: REQUIRED DRAINAGE GEOCOMPOSITE PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUES
Geonet			
Structure	Tri-planar or Bi-planar		
Thickness (min.)	ASTM D 5199	mil	340
Tensile Strength (min.)	ASTM D 4595	lb/ ft	425
Density (min.)	ASTM D 1505	g/cm3	0.94
Melt Flow Index (max.)	ASTM D 1238	g/10 min	1.0
Carbon Black Content (min.)	ASTM D 4218	%	2
Creep Reduction Factor[(1)]	GRI- GC 8	-	1.1
Geocomposite			
Ply Adhesion (min.)	ASTM D 7005	lb/inch	0.5
Transmissivity2 – Machine Direc-tion (min.)	ASTM D 4716 GRI – GC 8	(m2/sec)	see Section 31 56 10 – Cover System Performance Testing

Notes:

1. The creep reduction factor is determined from 10,000 hour test duration, extrapolated to 30 years and using a compressive load of 1,000 psf.

2. If requested by the ENGINEER, transmissivity tests may be conducted at the frequency of 200,000 square feet per test. The transmissivity to be determined shall be the appropriate Manufacturer's stated transmissivity for the following testing scenario. The normal compressive load shall be 1,000 psf at hydraulic gradients of 0.1 and 0.29. Testing boundary conditions from the top to bottom are: upper steel load plate/Ottawa sand/Geocomposite/Geomembrane/lower load plate (the flat side of the geocomposite facing the soil boundary), with a minimum seating period of 100 hours.

TABLE 2: REQUIRED GEOTEXTILE PROPERTIES

PROPERTY	**TEST METHOD**	**UNITS**	**VALUE**
Serviceability Class	Class 2		
UV Resistance @ 500 Hours (MIN)	ASTM G 154 or D 4355	%	70
Grab Tensile Strength (MARV)	ASTM D 4632	lbs	160
Grab Elongation (MARV)	ASTM D 4632	%	50
Trapezoid Tear (MARV)	ASTM D 4533	lbs	80
Puncture Strength (MARV)	ASTM D 4833	lbs	110
AOS (MaxARV)	ASTM D 4751	USSieve	80
Permittivity (MARV)	ASTM D 4491 Falling head	sec -1	1.1

2.2 SUBMITTALS

A. The CONTRACTOR shall submit the following to the ENGINEER:

1. The CONTRACTOR shall submit one copy of a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the DGC attesting that the DGC meets the physical and manufacturing requirements stated in these Specifications. The CONTRACTOR shall also submit a sample (12" x 12") of the DGC to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. The CONTRACTOR's plan for shipping, handling, and storage shall be submitted for review.

3. The CONTRACTOR shall submit and have approved by the ENGINEER a DGC panel layout prior to placement of the DGC. The predominant flow direction of the DGC is in the machine (roll) direction. The DGC shall be installed with the machine direction parallel to the slope to maximize its flow capability.

4. For DGC delivered to the site, quality control certificates, signed by the Manufacturer's quality manager, shall be provided for every roll of DGC. Each certification shall have the roll identification number(s), test methods, frequency,

and test results. At a minimum, the test results and frequency of testing shall be as shown in Table 3 of this section.

5. Furnish copies of delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

TABLE 3: REQUIRED MANUFACTURER'S QUALITY CONTROL TEST DATA

PROPERTY	TEST METHOD	UNITS	FREQUENCY
Resin Tests			
DENSITY	ASTM D1505	g/cm^3	Per Lot
MELT FLOW INDEX	ASTM D1238	g/10 min	Per Lot
Geonet Tests			
THICKNESS	ASTM D5199	mm	50,000 ft^2
CARBON BLACK CONTENT	ASTM D4218	%	50,000 ft^2
TENSILE STRENGTH-MD	ASTM D4595	lbs/ft	50,000 ft^2
Geotextile Tests			
WEIGHT	ASTM D3776	Oz/sy	100,000 ft^2
AOS	ASTM D4751	US Sieve (mm)	500,000 ft^2
PERMITTIVITY	ASTM D4491 Falling head	sec^{-1}	500,000 ft^2
GRAB TENSILE STRENGTH	ASTM D4632	lbs	100,000 ft^2
TRAPEZOID TEAR	ASTM D4533	lbs	100,000 ft^2
PUNCTURE STRENGTH	ASTM D4833	lbs	100,000 ft^2
Geocomposite Tests			
PLY ADHESION	ASTM D7005	lbs/in	100,000 ft^2
TRANSMISSIVITY-MD	ASTM D4716	m^2/sec	200,000 ft^2

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. Handling and Placement

1. After the substratum/geomembrane has been installed/constructed, tested and approved by the ENGINEER, the surface shall be cleaned and free of excess dirt and debris.

2. The CONTRACTOR shall handle all geocomposite in such a manner as to ensure it is not damaged in any way. Precautions shall also be taken to prevent damage to underlying layers during placement of the geocomposite.

3. The geocomposite roll should be installed in the direction of the slope, following the labeled instructions as provided by the Manufacturer with respect to the top/bottom sides.

4. Special care shall be taken so that only full-length rolls are used at the top of long, steep slopes.

5. In the presence of wind, all geocomposite shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material. All sandbags shall be removed for reuse in other locations or disposal during VSS placement.

6. If necessary, the geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

7. When placed in an anchor trench, the geocomposite shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the geocomposite.

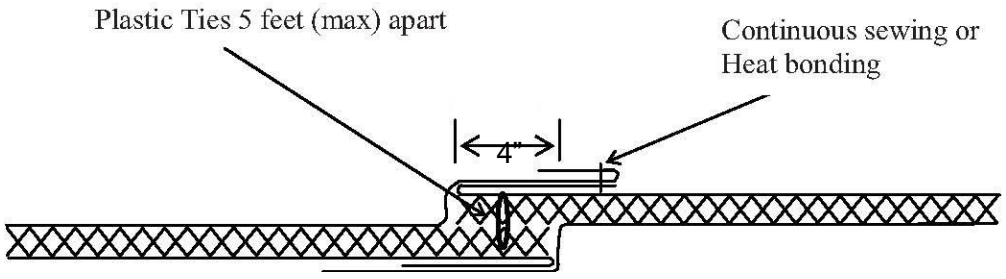
8. For areas where there are obstructions (such as outlet pipes or monitoring wells) while deploying the geocomposite, the geocomposite shall be cut to fit around the obstruction. Care shall be taken as to make sure there is no gap between the obstruction and the geocomposite. The geocomposite shall be cut in a way that the lower geotextile and geonet core is in contact with the obstruction and the upper geotextile has an excess overhang. There must be enough of the upper geotextile to be able to tuck the upper geotextile back under the geocomposite to protect the exposed geonet core, and prevent soil particles from migrating into the geonet core flow channels.

B. Seams and Overlaps

1. Each component of the geocomposite (geotextile(s) and geonet) shall be secured or seamed to the like component at overlaps.

   Adjacent edges of geonet along the length of the geocomposite shall be overlapped 4 inches, as seen in Figure 1. These overlaps shall be joined by tying the geonet cores together with white or yellow cable ties or plastic fasteners. These ties shall be spaced at a maximum of every 5 feet along the roll length, or a maximum of 2 feet if the geocomposite is installed vertically.

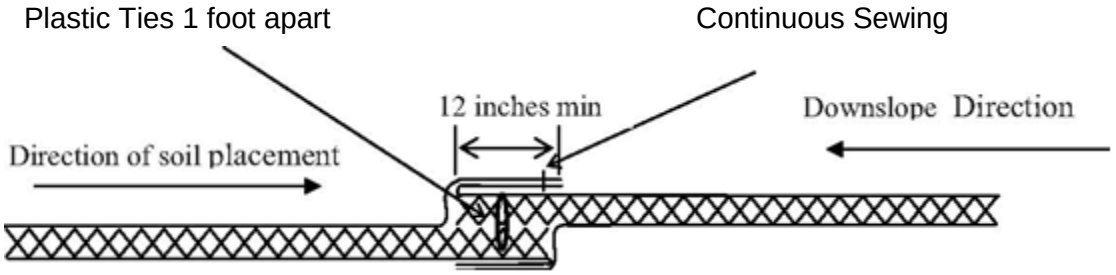
Figure 1: Overlap Along Roll Length (MD)



2. Adjoining geocomposite rolls (end to end) along the roll width shall be shingled down in the direction of the slope, with the geonet portion of the top geocomposite overlapping the geonet portion of the bottom geocomposite a minimum of 12 inches across the roll width, see Figure 2. Geonet shall be tied every 12 inches

across the roll width and every 6 inches in the anchor trench or as specified by the ENGINEER.

Figure 2: Overlap Along Roll Width (CD)



3. Geotextile Component

   a. The bottom layer of geotextile (where present) shall be overlapped.

   b. The top layers of geotextile shall be sewn together. Geotextiles shall be overlapped a minimum of 4 inches prior to seaming. The seam shall be a two-thread, double-lock stitch, or a double row of single-thread, chain stitch. It is important that the geotextiles be joined continuously along the roll as to prevent any fugitive particle migration into the geonet core flow channels.

C. Repair

1. Any small holes or tears in the top geotextile shall be patched with an 8” x 8” geotextile piece. The patching geotextile shall be the same as the DGC geotextile to be approved by the ENGINEER. The patch shall be centered over the hole/tear and heat bonded to the top geotextile. Care must be taken to avoid burn through of the geotextile. If the damaged area of the geotextile is greater than this standard patch size, a bigger size patch is recommended. If the geotextile is damaged beyond 50 percent of the width of the roll, a continuous piece of fabric the same width as the geocomposite may be cap-stripped directly to the adjacent seams by sewing a portion of the new geotextile in place.

2. Any large rips, tears or damage areas on the deployed geocomposite core shall be removed and patched by placing a patch extending 12” beyond the edges of the damaged areas. The patch shall be secured to the original geonet tying every 6 inches with approved tying devices. If the hole or tear width across the roll is more than 50 percent the width of the roll, the damaged area shall be cut out.

D. Cover Soil Placement

1. Placement of the cover soil is recommended to proceed immediately following placement and inspection of the geocomposite. Cover soil shall comply with Section 31 20 00 – Earth Moving.

2. In applying cover soil or other material over the geocomposite, no equipment shall drive directly across geocomposite. Acceleration or deceleration shall be in a smooth and gentle manner. Operator shall not make any sudden turns or stops

when driving on the geonet or geocomposite. If any tear or local damage occurs to the geotextile, geonet or geocomposite, patching technique as described in the above section shall be used.

3. The full thickness of the vegetative support layer (material specified in Section 31 20 00 – Earth Moving) shall be placed and spread utilizing vehicles with a low ground pressure (LGP). The cover soil shall be placed on the geocomposite from the bottom of the slope proceeding upwards and in a manner, which prevents instability of the cover soil or damage to the geocomposite on slopes at or steeper than 7.5H:1V. The vegetative support layer can be spread in any direction in a manner which prevents instability of the cover soil or damage to the geocomposite on slopes shallower than 7.5H:1V.

4. CONTRACTOR shall provide laborers to work in concert with heavy equipment operators during VSS placement to minimize wrinkles from occurring during cover soil placement.

END OF SECTION 31 71 20

SECTION 31 80 00 - BLASTING CONTROLS

PART 1 – GENERAL

1.1 DESCRIPTION

A. The work in this section includes furnishing all labor, equipment, materials, and services and performing operations required to excavate and/or fragment bedrock and rock utilizing controlled blasting techniques such that: the blast rock will be of manageable size to allow earthwork equipment to move and spread, damage is prevented to adjacent properties, historical mine features, mine workings, and other construction work, and such that resulting ground vibrations and air-blast overpressures are consistently maintained below the maximum levels specified herein.

B. Protecting the existing adjacent properties, workers, and the general public from damage or injury from improper handling of explosives, fly rock, excessive ground vibrations, and excessive air-blast overpressure levels.

C. Furnishing, installing, and implementing an audible warning system to indicate impending blasting and familiarize workers, OWNER, ENGINEER, and the general public with the system implemented.

D. Furnish, install, and implement seismograph monitoring equipment to monitor ground vibrations and air-blast overpressures at nearby structures and/or mine features.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 31 10 00 Site Clearing

B. Section 31 20 00 Earth Moving

C. Section 31 25 00 Erosion and Sedimentation Control

1.3 DEFINITIONS

A. Air Blast: A transient air pressure impulse generated by explosions.

B. Blast Consultant: The Blast Consultant shall be a person with extensive knowledge of noise vibration, and visual impacts of blasting operations, and who is specialized in the detonation of explosives. The Blast Consultant shall be provided by the CONTRACTOR.

1. The Blast Consultant must have at least 20 years of experience in construction blasting. They must be able to demonstrate involvement in at least five (5) projects with blasting of similar nature.

C. Blast Control Specialist: Person authorized to act on behalf of the CONTRACTOR and licensed by the state or local regulatory agency to possess, transport, and use explosives.

D. Blaster-in-Charge or Blasting Supervisor: The single designated and licensed person with complete responsibility and total authority over all decisions involving safe handling, use and site storage of explosives.

E. Fly Rock: Debris that is ejected or propelled through air by blast.

F. Frequency: Ground vibration oscillation at peak event, expressed in Hertz.

G. Peak Particle Velocity (PPV): Maximum of three (3) velocity components measured in the vertical, longitudinal and transverse directions. Velocity units are expressed in inches per second (in/sec).

H. Air-Overpressure: Temporary changes in ambient air pressure caused by blasting. Air-overpressure is expressed in units of psi or dB or dBL (linear decibel scale). Measurements for blasting are made with microphones having a flat frequency response for over-pressure in the 2 to 200 Hz range. A-weight or C-weight microphones shall not be used for these measurements.

I. Scaled Distance: A factor describing relative vibration energy based on distance and charge-per-delay. For ground vibration control and prediction purposes, Scaled Distance (Ds) is obtained by dividing the distance of concern (D) by the square root of the charge-per-delay (W), Ds = D/(W)0.5. Minimum scaled distance limits are used to establish charge weights and the units of scaled distance (Ds) are ft-lb-0.5. For air overpressure/airblast control and prediction purposes the scaled distance shall consist of applying the cube root of the charge weight.

J. Charge-per-Delay: For vibration control, any charges firing within any 8-millisecond time period are considered to have a cumulative effect on vibration and air-overpressure effects. Therefore, the maximum charge-per-delay (W) is the sum of the weight of all charges firing within any 8-millisecond time period. For example, if two 10-lb charges fire at 100 ms and one 15-lb charge fires at 105 ms, the maximum charge per delay would be 35 lbs.

K. Production Holes: Blast holes in the main body of the rock mass being removed by drilling and blasting.

L. Stemming: Crushed stone, tamped clay or other inert earth material placed in the unloaded collar area of blast holes for the purpose of confining explosive charges and limiting rock movement and air-overpressure (air blast). Stemming must be clean, crushed stone with size approximately 0.05 times the diameter of the blast hole. Drill cuttings or soil are not allowed for stemming material.

M. Primary Initiation: The method whereby the blaster initiates the blast(s) from a remote and safe location. Primary initiation systems use pneumatic tubing or shock-tubes to convey firing energy from blasters to blast locations.

N. Sub-drilling: The portion of the blast hole that is drilled below or beyond the desired excavation depth or limit. Sub-drilling is generally required to prevent the occurrence of high or tight areas of un-fractured rock between blast holes.

O. Prohibited Persons: Persons prohibited from handling or possessing explosive materials as defined by the seven categories described in Section 555.11 of 27 CFR (ATF Rules).

P. Delay: A distinct pause of pre-determined time between detonations of single charges or groups of charges.

1.4 QUALITY ASSURANCE

A. Codes, Permits and Regulations:

1. The CONTRACTOR shall comply with all applicable laws, rules, ordinances and regulations of the Federal Government, the State of Vermont, and the Town governing the transportation, storage, handling, and use of explosives. All labor, materials, equipment and services necessary to make the blasting operations comply with such requirements shall be provided without additional cost to the OWNER.

2. The CONTRACTOR shall obtain and pay for all permits and licenses required to complete the work of this section. In case of conflict between regulations, or between regulations and Specifications, the CONTRACTOR shall comply with the strictest applicable codes, regulations or specifications.

1.5 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. Unless otherwise noted, the latest edition of the publications shall be used. The publications are referred to within the text by the basic designation only. Comply with the applicable rules, regulations, and standards established by the Regulatory Agencies, codes, and professional societies listed herein, including rules and regulations for storage, transportation, and use of explosives.

B. Whenever blasting operations are in progress, explosives shall be stored, handled and used as provided in: the Federal Occupational Safety and Health Act of 1970 and the Construction Safety Act of 1969, as amended; Safe Explosives Act, Title XI, Subtitle C of Public Law 107-296, Interim Final Rule; and Organized Crime Control Act of 1970, Title XI, Public Law 91-452, Approved October 15, 1970, as amended; and State of Vermont, Title 20: Internal Security and Public Safety, Chapter 177: Explosives and Fireworks.

C. Ensure that all explosives deliveries to work sites are done in compliance with recent rules and regulations issued by the Department of Transportation (DOT) and the Transportation Security Administration (TSA) on commercial transportation of explosives pursuant to the mandates of the USA PATRIOT ACT of 2001. Under TSA rules, commercial drivers with hazardous materials endorsement shall undergo a personal background records check, training and testing.

D. Comply with all the applicable provisions of OSHA of 1970, 29 CFR, Section 1910.109.

E. U.S. Code of Federal Regulations (CFR)

1. CFR 27, U.S. Department of Justice, Alcohol, Tobacco, Firearms and Explosives Division (ATF). 27 CFR Part 555, Implementation of the Safe Explosives Act, Title XI, Subtitle C of Public Law 107-296; Interim Final Rule.

2. Organized Crime Control Act of 1970, Title XI, Public Law 91-452, Approved October 15, 1970, as amended.

3. CFR 49, Parts 100-177 (DOT RSPA); 301-399 (DOT FHA).

4. Federal Occupational Safety and Health Act of 1970, as amended.

5. Construction Safety Act of 1969, as amended.

F. State Agencies:

1. State of Vermont, Title 20: Internal Security and Public Safety, Chapter 177: Explosives and Fireworks.

2. Vermont State Construction Standards, Vermont Agency of Transportation (VAOT) Standard Specifications, Section 205.

G. Non-regulating Industry Support Organizations:

1. Vibration Subcommittee of the International Society of Explosive ENGINEERs (ISEE), blast monitoring equipment operation standards (1999).

2. IME (Institute of Makers of Explosives) Safety Library Publications (SLPs).

H. Federal Agencies:

1. USACE EM 385-1-1 Section 29 (Safety and Health Requirements – Blasting).

2. Reference EM 385-1-1 Section 21 (Safe Access and Fall Protection).

1.6 SUBMITTALS

A. Quality Control Submittals:

1. Qualifications of Blast Control Specialist: Submit at least 30 days prior to blasting WORK. Blast Control Specialist shall be persons responsible for blasting and pre-blasting services and shall be licensed blasters in the State of Vermont and shall have had acceptable experience in similar excavations in rock and controlled blasting techniques. The Blast Control Specialist shall have a minimum of ten (10) years' experience within blast design and vibration and air-blast monitoring, and significant involvement as the Blast Control Specialist in a minimum of ten (10) previous projects of similar nature. The Blast Control Specialist shall be subject to the approval of the Blast Consultant.

2. A Rock Excavation Plan describing details for CONTRACTOR's proposed rock excavation methods shall be submitted as an addendum to the Construction Work Plan at least 30 days prior to start of WORK.

3. A detailed blasting plan for each blast shall be submitted at least 48 hours prior to beginning any WORK for that blast.

4. A Vibration and Air-Blast Monitoring Plan shall be submitted as an addendum to the Construction Work Plan at least 30 days prior to start of WORK.

B. Blasting Plan and Blasting Schedule.

1. One (1) month prior to commencing drilling and blasting operations, the CONTRACTOR shall submit a Blasting Plan, reviewed and approved by the Blasting Consultant, to the ENGINEER for review. The Blasting Plan shall contain the details of the drilling and blasting patterns and controls proposed for both the controlled and production blasting. The Blasting Plan shall contain the following minimum information, as applicable:

    a. Details of the drilling equipment to be used and detailed description of method to safely perform the controlled blasting.
    b. Limits of cut or lift.
    c. Station limits of proposed shot, the number of blasts, time of each blast.
    d. Plan and section views of proposed drill pattern indicating hole size, hole depths and angles, hole pattern and spacing and expected rock types.
    e. Drill hole diameters (preshear, productions) and depth including subdrilling depths.
    f. Drill steel diameter and bit types.
    g. Stemming length and type of material used for stemming.
    h. Loading details including trade names, types, quantity of explosives (including manufacturer’s data sheets).
    i. Average bench height.
    j. Proposed initiation and delay sequence of blast holes.
    k. Weight of explosives per hole and per delay and powder factors, including weight of explosives per square yard of finished backslope.
    l. Anticipated vibration levels and peak particle velocities at locations specified by the ENGINEER.
    m. Anticipated blast decibel level at nearest dwelling.
    n. Methods of matting or covering of the blast area to prevent fly rock and excessive air-blast overpressure.
    o. Details of an audible advance signal system to be employed at the job site as a means of informing workers, ENGINEER, and the general public that a blast is about to occur.
    p. Means and methods for fragmentation or surface blasting of large boulders and blast rubble.
    q. Vibration monitoring and air overpressure monitoring plan. Plan shall include the collection of vibration background data and air overpressure background data prior to blasting.

2. At any time the CONTRACTOR proposes to change the drilling or blasting methods, the CONTRACTOR shall submit a revised Blasting Plan for the affected WORK not later than one (1) week prior to the proposed commencement of the change in the WORK.

3. The Blasting Plan submittal is for quality control and record-keeping purposes. Review of the Blasting Plan by the ENGINEER or Blasting Consultant shall not relieve the CONTRACTOR of their responsibility for the accuracy and adequacy of the plan when implemented in the field.

C. The CONTRACTOR shall submit the following information to the OWNER and/or ENGINEER at least one (1) month prior to commencing drilling and blasting operations:

1. Written evidence of the licensing, experience, and qualifications of the blasters who will be directly responsible for the loading of each shot and for firing it.

2. Name and qualifications of the person(s) responsible for designing and directing the blasting.

3. Name and qualifications of the person(s) responsible for conducting pre-blast conditions surveys.

4. Submit a copy of the blasting permit(s) obtained to conduct blasting on the site.

5. Pre-blast condition survey, as described herein.

D. The CONTRACTOR shall submit a copy of the Blast Consultant-approved general blast plan description and a copy of each Blast Consultant-approved individual blast plan to the ENGINEER for approval prior to blasting.

E. Progress Submittals:

1. The CONTRACTOR shall report to the OWNER and/or ENGINEER in writing all blasting complaints received by the CONTRACTOR within 24 hours of receipt. Each blast complaint report shall include the name and address of the complainant, time received, data and time of blast complained about, and a description of the circumstances which led to the complaint.

F. Project Closeout Submittals.

1. Submit a Blasting Project Summary Report within 30 days of completion of blasting.

1.7 PRE-BLAST CONDITION SURVEY

A. The CONTRACTOR shall record baseline digital photo-documentation video and photographs of the Site structures and surroundings prior to commencing work. Digital photo-documentation includes pre-construction as well as construction progress and post-construction documentation of the mine portals, mine shafts, mine features, existing haul roads, and other areas as directed by the ENGINEER prior to beginning work activities.

1.8 INDEMNITY

A. Notwithstanding full compliance with these specifications, approval of blasting plan, and successful limitation to maximum PPV and air-blast overpressure noted herein, the CONTRACTOR shall be solely responsible for any damage, direct or indirect, arising from blasting and shall hold the OWNER, EPA, and ENGINEER, and their consultants, harmless from any costs, liens, charges, claims or suits, including the costs of defense, arising from such damage, real or alleged. The OWNER, EPA, ENGINEER and their consultants shall be additionally-named insured on any insurance policy covering blasting carried by the CONTRACTOR, and this requirement shall also be enforced on any Subcontractor.

1.9 SEQUENCING AND SCHEDULING

A. Blasting shall be restricted to the times given in the CONTRACTOR Work Plan.

B. Blast only with direct written approval for each blast by the Blast Consultant.

C. Warning signs and public notification are required to avoid all risks to the public that use the site recreationally.

D. The CONTRACTOR shall provide the Vershire Police Department and the Vershire Fire Department with written notice of blasting a minimum of 24 hours in advance of each blast.

1.10 CONTROLLED BLASTING

A. Material which would classify as rock and which requires drilling and blasting to remove will be accomplished by controlled blasting. Controlled blasting is defined as the establishment of a free surface or shear plane in rock along the lines of the specified backslope by the controlled usage of explosives and blasting accessories in appropriately aligned and spaced drill holes.

B. The CONTRACTOR shall perform short test lines of holes consisting of pre-split or cushion blasting if changes in conditions warrant, to determine the loading, spacing and depth or lift required to obtain desired PPV, air-blast pressures and excavation geometry. These tests will be monitored by the Blast Consultant using CONTRACTOR supplied seismographs. As part of the blasting plan, the CONTRACTOR shall prepare graphs depicting the PPV as a function of the distance from the detonation point, for each explosion loading. Explosive loading for production blasting will then be selected from the graph to limit PPV to less than two (2) inches per second measured next to the closest structure adjacent to the blast.

1.11 JOB CONDITIONS

A. Protection:

1. Should uncharted piping or other utilities be encountered during excavation, consult with the ENGINEER immediately for direction.

2. Barricade and/or install warning signs or lights as required for protection from open excavations occurring as part of this work. If warning lights are used, operate warning lights during hours from dusk to dawn each day and as otherwise required.

B. Dust Control:

1. Use means necessary to control dust on and near the work and on and near all borrow areas if such dust is caused by operations during the performance of the work.

2. Thoroughly treat all surfaces as required to prevent dust from being a nuisance or health risk to the workers, public, neighbors, and concurrent performance of other work on the site.

3. Conduct air monitoring as required in work plans and/or work permits, as applicable.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.1 GENERAL

A. The CONTRACTOR is forewarned that existing historical features may be located in close proximity of the blast and that these features shall be protected. The CONTRACTOR shall be responsible for all damage to these features.

B. The CONTRACTOR shall use cast primers/boosters.

C. The CONTRACTOR shall use non-cap sensitive cartridge emulsion blasting agents.

D. Use of black powder, dry bulk ANFO, and slurry/watergel blasting agents shall be prohibited.

E. CONTRACTOR shall use non-electric blasting initiation methods using shock tube.

F. Use of electric and electronic blasting initiation methods shall be prohibited.

G. The CONTRACTOR shall perform a test blast in order to collect data for input to vibration monitoring and air overpressure predictive calculations and to determine appropriate charge weights for production blasting.

H. All explosives shall be of such character and in such amount as permitted by the state and local laws and ordinances and all respective agencies having jurisdiction over them.

I. The CONTRACTOR shall implement a blast notification program, as approved by the ENGINEER, and in accordance with applicable standards.

J. The CONTRACTOR shall use the utmost care so as not to endanger life or property, or disturb materials or historical features outside the limits of the excavation.

K. The WORK shall be conducted in such a manner that rock outside the excavation limits will be undisturbed, nearby structures will not be disturbed in any way, and the shape of the excavation will conform as nearly as possible to the lines and grades shown on the Drawings.

L. To help ensure against potential damage beyond the lines of intended excavation, the CONTRACTOR shall employ the best modern practice of controlled blasting methods.

M. Explosives, including blasting caps, shall be transported and stored in a safe, secure manner in accordance with the requirements of the appropriate public body having jurisdiction in such matters. Only persons experienced in the handling of explosives are to be allowed to use them on the WORK. Where state or local laws require, explosives are to be handled only by licensed personnel.

N. The CONTRACTOR shall provide all necessary approved types of tools and devices required for handling and using explosives, blasting caps, and accessories. The CONTRACTOR shall conform to and obey all federal, state and local laws that may be imposed by any public authority having legal jurisdiction.

O. Blasting shall be monitored by the Blast Consultant using CONTRACTOR-furnished monitoring devices. The Blast Consultant will be responsible for the location and placement of these monitoring devices. The CONTRACTOR will be responsible for the protection of these monitoring devices from its equipment and operations.

P. The CONTRACTOR shall assign a supervisor of mature experience specialized in the use of explosives to the blasting operations, who shall be maintained on a full-time basis during the time that blasting is in progress.

Q. Review of the blast plan by the Blast Consultant and ENGINEER shall not relieve the CONTRACTOR of responsibility for the accuracy and adequacy of the blast plan when implemented in the field. This includes, but is not limited to, obtaining adequate fragmentation, using proper detonation procedures and following proper safety procedures prior to and after the blast.

R. When blasting, ample warning shall be given to all persons within the vicinity prior to blasting. Warning signs shall be erected a minimum of 24 hours prior to the blast time, and workers shall be stationed to warn people before firing any blasts. The warning signs will state the time and date of each blast.

S. After a blast has been fired, the Blast Control Specialist shall make a careful inspection to determine that all charges have exploded before employees are allowed to return to the operation. Misfires shall be corrected in accordance with the requirements of the applicable portions of the federal, state, or local safety codes for blasting. The CONTRACTOR shall be responsible for any and all damage to property or injury to persons resulting from blasting or accidental or premature explosions that may occur in connection with his use of explosives.

T. To ensure the accuracy of firing times of blasting caps, it is required that each cap period come from one lot number. Mixing lot numbers for any one cap period is prohibited.

U. All rock that is loose, hanging or creating a dangerous situation shall be removed or stabilized, to the Blast Consultant's and ENGINEER's satisfaction, during or upon completion of the excavation in each lift as an integral sequence in each cycle of excavation. Drilling of the next lift will not be permitted until this WORK, and any rock stabilization that is necessary has been completed.

V. Material outside of the planned neatline slopes which, in the opinion of the Blast Consultant and ENGINEER, is unstable and constitutes potential slides shall be excavated and removed.

W. No blast shall exceed an in-place volume of 5,000 cubic yards.

3.2 SAFETY PRECAUTIONS

A. Clearing the Danger Area Before Blasting: No blasting shall be permitted until al personnel in the danger area have been removed to a place of safety. A loud, audible, warning system, devised and implemented by the CONTRACTOR, shall be sounded before each blast. The CONTRACTOR shall familiarize all personnel on the Project, EPA, ENGINEER, and their consultants and the general public with the implemented system. The danger area shall be patrolled before each blast to make certain that it has been completely cleared and guards shall be stationed to prevent entry until the area has been cleared by the blaster following the blast.

B. Explosives shall be stored, handled and employed in accordance with Federal, State, and local regulations.

C. No explosives, caps, detonators or fuses shall be stored on the site during non-working hours.

D. The CONTRACTOR shall be responsible for determining other safety requirements unique to blasting operations on this particular site so as not to endanger life, property, utility services, existing features or new construction, or property adjacent to the site.

E. No requirement of, or omission to require, precautions under this Contract shall be deemed to limit or impair responsibility or obligations assumed by the CONTRACTOR under or in connection with this Contract; and the CONTRACTOR shall at all times maintain adequate protection to safeguard the public and all persons engaged in the work, and shall take such precautions as will accomplish such end, without undue interference to the public. The CONTRACTOR shall be responsible for and pay for damage to adjacent structures resulting from work executed under this Section.

3.3 GENERAL BLASTING PROCEDURES AND RECORDS

A. Blasting shall be limited to between the hours of 8:00 am and 4:00 pm, Monday through Friday, unless prior written permission is received from the EPA and/or ENGINEER to blast at other times. Blasting shall be confined to daylight hours.

B. The CONTRACTOR shall notify the EPA and ENGINEER at least 48 hours before blasting operations are to commence.

C. Blasting mats shall be used to cover each blast round in order to prevent the throw of fly rock and minimize air-blast overpressure.

D. The CONTRACTOR shall conduct blasting operations such that damage is prevented to adjacent structures, property and work, and such that peak particle velocity and air-blast overpressure levels do no exceed the maximum specified limits at the locations specified.

E. Blasted rock shall be of a size manageable for movement and spreading by a large bulldozer. Maximum blasted rock sizes shall be 3 feet in any dimension.

F. In order to prevent air-blast focusing, blasting shall not be conducted when temperature inversions or heavy, low-level cloud cover exists.

G. Keep accurate records of each blast. Blasting records shall be available to the EPA and ENGINEER at all times and shall contain the following data as a minimum:

1. Blast identification by numerical and chronological sequence.

2. Location (referenced to stationing, as appropriate), date and time of blast.

3. Type of material blasted.

4. Number of holes, burden and spacing.

5. Diameter and depth of holes.

6. Height or length of stemming.

7. Types of explosives used.

8. Types of caps and delay periods used.

9. Total amount of explosives used.

10. Maximum amount of explosives per delay period of 9 milliseconds or greater.

11. Power factor (pounds of explosive per cubic yard of material blasted).

12. Method of firing and type of circuit.

13. Weather conditions (including wind direction).

14. Direction and distance to nearest structure or position of concern.

15. Type and method of instrumentation.

16. Location and placement of instruments by plotting numbered locations on scaled maps to within ±1 foot where the equipment was placed.

17. Instrumentation records and calculations for determination of ground motion particle velocity or for charge size based on scaled distance.

18. An ongoing log-log plot of both vibration and air-blast data. The CONTRACTOR or his consultant shall maintain an ongoing log-log plot of both ground vibration and air-blast overpressures, and shall submit an updated plot to the EPA and ENGINEER after each blast, highlighting the newest data.

19. Measures taken to limit air overpressure and fly rock.

20. Any unusual circumstances or occurrences during blast.

21. Name of CONTRACTOR.

22. Name, license number and signature of responsible Blasting Supervisor.

23. Summary report of all complaints including complaints regarding blasting-related damage, where applicable.

24. Method used to notify other CONTRACTORs and personnel on-site of a scheduled blast.

25. Within 24 hours after each blast, CONTRACTOR shall submit to the EPA and ENGINEER a summary report addressing items 1 through 24 above for compilation in a three-ring binder and have the CONTRACTOR's current blast reports so compiled and available for immediate review by authorities having jurisdiction, including the EPA and ENGINEER.

26. The CONTRACTOR shall record and provide video recordings of each blast. The video shall be submitted and become part of the Project records.

3.4 BLASTING LIMIT CRITERIA

A. Peak Particle Velocity Limits:

1. The CONTRACTOR shall conduct all blasting activity in such a manner that the peak particle velocity of ground vibration does not exceed the following:

Reference Point or Structure	Maximum Allowable Peak Particle Velocity (in/sec)
Historic Houses/Structural Elements	0.5

Modern Houses/Structures	0.75
1,000 ft from Blast	1.0

B. Air-Blast Overpressure Limit:

1. The CONTRACTOR shall conduct all blasting activity in such a manner that the peak air-blast overpressure measured at a distance of 1,320 feet (0.25-mile) from the point of blast does not exceed 133 dB (0.014 psi).

C. The CONTRACTOR shall be completely responsible for all damages resulting from the blasting operations and shall, at a minimum, take whatever measures are necessary to maintain peak air-blast overpressure and peak particle velocities within the specified limits. Modifications to blasting and excavation methods required to meet these requirements shall be undertaken at no additional cost to the OWNER.

3.5 CONTROLLED BLASTED SURFACES

A. For all rock slopes the CONTRACTOR shall use controlled blasting along the lines of the final rock cut slope face.

B. Controlled blasting refers to the controlled use of explosives and blasting accessories in carefully spaced and aligned drill holes to produce a free surface or shear plane in the rock along the specified excavation backslope. Controlled blasting techniques covered by this Specification includes pre-splitting and cushion (trim) blasting.

C. The purpose of controlled blasting is to ensure long-term rock slope stability by minimizing damage to the rock backslope. The ENGINEER may require the CONTRACTOR to use controlled blasting to form the faces of slopes, even if the main excavation can be ripped.

D. Cuts over 30 feet in height shall be drilled and blasted in more than one lift, with each lift being limited to a maximum of 30 feet. A maximum of a 2-foot offset between lifts shall be permitted to allow for drill equipment clearances. The CONTRACTOR shall begin the control blast hole drilling at a point which will allow for necessary offsets and shall adjust, at the start of the lower lifts, to compensate for any drift which may have occurred in the upper lifts. The use of horizontal lifters will not be allowed.

E. The CONTRACOR will be required to drill from the top of the cut downward for rock cuts greater than ten (10) feet in height.

F. The diameter of the control blast holes shall not be smaller than 2½-inches or greater than 3 inches. The deviation of these drill holes either parallel or normal to the backslope shall not exceed 8 inches. If greater than five percent (5%) of the controlled blast holes are misaligned in any one lift, the CONTRACTOR shall reduce the height of the lifts until the 8-inch alignment tolerance is met.

G. Buffer holes shall be drilled 3 feet out from the controlled blast holes on 4-foot centers. The buffer holes shall be drilled parallel to the controlled blast holes. The load per buffer

holes shall not exceed fifty percent (50%) of the average load per production hole next to the buffer line.

H. All drilling equipment used to drill the control blast shall have mechanical devices affixed to that equipment to accurately determine the precise angle at which the drill steel enters the rock. Control blast hole drilling will not be permitted if these devices are either missing or inoperative. Hand held devices, including levels, shall not be used.

I. Prior to drilling the control blast holes, all overburden and/or loose disintegrated rock shall be removed down to solid rock in the vicinity of the holes.

J. All rock backslope faces shall be scaled of loose fragments.

K. Blast holes for controlled blasting shall be drilled within 3-inches of the staked collar location. If more than five percent (5%) of the holes are outside of the 3-inch tolerance, they shall be filled with crushed stone and re-drilled at the proper location.

3.6 LINE DRILLING, CUSHION BLASTING, PRE-SPLITTING

A. Methods such as line drilling, cushion blasting, or pre-splitting shall be used to control damage beyond the final cut faces shown on the Drawings. Methods such as line drilling and pre-splitting are used to ensure that a shear plane is established between the periphery holes, thus minimizing strain or cracks in the rock beyond the blasting perimeter. Except as otherwise directed by the Blast Consultant, pre-splitting and line-drilled holes shall not be larger than 3 inches in diameter, and spaced no more than 2½-feet apart, center to center, respectively.

B. Cushion blasting is similar to pre-splitting, except that the detonation along the cut face shall be performed after the detonation of the production holes.

C. The CONTRACTOR shall line drill, perform cushion blasting, or pre-split all native, permanently exposed, or steeply inclined cut faces (1H to 1V, or steeper).

D. The line drilling, cushion blasting or pre-splitting blast holes shall be between 2½- and 3 inches in diameter.

E. Cuts with a vertical height greater than 10 feet and an average horizontal thickness of greater than 25 feet as measured from the free face to the back row of blast holes shall be "Pre-split" blasted.

1. Pre-splitting shall be performed for all rock slopes over 10 feet in height. It shall consist of drilling holes on the plane of the final backslope then loading the holes with a continuous or well disturbed explosive charge, and then firing the holes to create a crack along the line of the backslope. Ground vibration is a consideration. The CONTRACTOR shall delay the pre-split holes no more than 25 milliseconds along the pre-split line. The detonation of the pre-split line must precede the detonation of all other blasting in the cut. The pre-split line may be detonated in advance of the main production blasting or fired along with the production blasting, providing that the pre-split line is detonated a minimum of 25 milliseconds ahead of all other blasting.

2. The pre-split holes shall be drilled initially on 30-inch center spacing. Prior to loading these pre-split holes, each hole shall be inspected and tested for the entire length to determine that the hole is free and clear of obstructions. If the hole is obstructed, the hole shall be cleaned prior to loading. All necessary precautions shall be exercised so as to prevent debris from falling into the holes prior to loading, and that the placing of the charge shall not cause caving of materials from walls of the hole.

3. The maximum initial explosive charge used in these holes shall be no more the 0.14 pounds per square foot of rock surface of the final slope face. Ammonium nitrate and fuel oil (ANFO) shall not be allowed to be loaded in the pre-split hole.

4. Depending on the condition of the rock encountered and the smoothness of the final slope face, the explosive loads per square foot and the spacing of the pre-split holes may be altered, as required, after an inspection and evaluation by the ENGINEER.

5. The space in each pre-split hole not occupied by explosives may or may not be stemmed depending on the condition of the rock encountered. In all cases, the top 3 feet of the pre-split holes shall be stemmed.

6. The maximum diameter of the explosives used in pre-split holes shall not be greater than one-half the diameter of the pre-split hole.

7. Only standard explosives manufactured especially for pre-splitting shall be used in pre-split holes, unless otherwise approved by the ENGINEER.

8. If fractional portions of standard explosive cartridges are used, they shall be firmly affixed to the detonating cord in such a manner that the cartridges shall not slip down the detonating cord nor bridge across the holes. Spacing of fractional cartridges along the length of the detonating cord shall not exceed 30 inches center to center, and shall be adjusted to give the desired results.

9. Continuous column cartridge-type of explosives used with detonating cord shall be assembled and affixed to the detonating cord in accordance with the explosive manufacturer’s instructions; a copy of which shall be furnished to the ENGINEER. No detonating cord shall be used on the surface.

10. The bottom charge of a pre-split hole may be larger than the line charges, but shall not be large enough to cause over break. The top charge of the pre-splitting hole shall be placed far enough below the collar, and reduced sufficiently, to avoid over breaking and heaving.

F. Cuts with a vertical height greater than 10 feet and an average horizontal thickness less than 25 feet as measured from the free face to the back row of blast holes shall be "cushion" blasting.

1. Where the horizontal distance from the cut face to the existing rock face is less than 25 feet, the CONTRACTOR may cushion blast in lieu of pre-splitting. Cushion blasting is similar to pre-splitting, except that the detonation along the cut face shall be performed after the detonation of all production holes. The difference in delay time between the trim line and the nearest production row shall not be greater than 75

milliseconds, nor less than 25 milliseconds. With the exception of the above criteria, requirements previously stated for pre-shearing shall also apply to cushion blasting.

3.7 PRODUCTION BLASTING

A. Production blasting, as covered herein, refers to the rock fragmentation blasts resulting from more widely spaced production holes drilled throughout the main excavation area, adjacent to the controlled blast line. Production holes shall be detonated in a controlled delay sequence.

B. All production blasting, including that carried out in conjunction with the blasting test section requirements, shall be performed in accordance with the following general requirements:

1. Production blast holes shall be drilled on the patterns submitted by the CONTRACTOR and approved by the ENGINEER. The production blast holes shall be drilled within two blast hole diameters of the staked collar location. If more than five percent (5%) of the holes are drilled outside of this tolerance, at the option of the ENGINEER, the CONTRACTOR may be required to refill these holes with crushed stone and re-rill them at the proper location.

2. The production holes shall not exceed 4 inches in diameter and shall be drilled to a depth that is below the finished surface elevation, such that unbroken rock does not extend above the finish surface.

3. The depth of individual horizontal lifts, the depth of blast holes, and the amount of explosive per hole and per delay shall vary depending on the average thickness of the lift as measured from the cut face to the existing rock face, and shall not exceed the following amounts:

Lift Thickness	Pounds of Explosive
0' to 20'	50
21' to 50'	Add 15 lbs. Per foot of thickness
Over 50'	500

4. If the blast holes are plugged or unable to be fully loaded, the CONTRACTOR shall be required to deepen or clean out those holes. The blast holes should all be checked and measured before any explosives are loaded into any of the holes to eliminate any safety hazard resulting from drilling near loaded holes.

5. All blast holes should reach their desired depth, and if more than five percent of the holes are short before loading, the CONTRACTOR may be required by the ENGINEER to re-drill the short holes to proper grade at the CONTRACTOR's expense.

6. In order to control blasting effects, the CONTRACTOR must maintain a burden distance that is not more than one-half the bench height.

7. Blast holes shall be covered after drilling to keep overburden from falling into the holes.

8. The row of blast holes immediately adjacent to the controlled blast line shall be drilled on a plane approximately parallel to the controlled blast line. Production blast holes shall not be drilled closer than 3 feet to the controlled blast line, unless approved by the ENGINEER. The bottom of the projection holes shall not be lower than the bottom of the controlled blast holes, or by approval of the ENGINEER may be lower than the controlled blast holes by the amount of sub drilling used on the production holes. Detonation of production holes shall be on a delay sequence towards a free face. Stemming material used in production holes shall be crushed stone and shale, not sand or drill cuttings.

9. It is the CONTRACTOR's responsibility to take all necessary precautions in the production blasting so as to minimize blast damage to the rock backslope.

10. Do not begin production blasting prior to the line drilling, pre-splitting, or as required to preserve the rock beyond the limits of the excavation.

3.8 CONTROL CRITERIA, MONITORING AND EXPLOSIVE PRODUCT REQUIREMENT

A. The CONTRACTOR shall develop a trial blasting technique that identifies and limits the vibrations and damage at varying distances from each shot. This trial blasting information shall be collected and recorded by beginning the WORK at points farthest from areas to remain without damage. The CONTRACTOR can vary the hold spacing, depths and orientations, explosive types and quantities, blasting sequence, and delay patterns to obtain useful information to safeguard against damage at critical areas.

1. If at any time during the progress of the WORK, the methods of drilling and blasting do not produce the desired result of a uniform slope and shear face, within the tolerance specified, the CONTRACTOR shall be required to drill, blast, and excavate in short sections, not exceeding 50 feet in length, until a technique is developed that shall produce the desired results.

B. Drilling logs shall be kept on each blast hole to show open bedding, jointing and open or mud filled seams, zones of soft or weathered rock, mud pockets, etc. These logs shall be provided to the ENGINEER before any blast holes are loaded. The logs shall be used to properly design and load blast holes and use stemming decks in weak zones to protect residents from blowout, fly rock and unusual or hazardous blasting effects.

C. The stemming decks shall be of crushed stone. The material used for stemming decks shall be well graded between one-eighth (1/8) inch and three-eighth (3/8) inches in diameter. Drill cuttings shall not be used.

D. Concentrated charges will not be permitted; only special, controlled blasting procedures will be permitted.

E. Bulk explosives such as ammonium nitrate and fuel oil shall not be used on the Project. When in the opinion of the ENGINEER, any blasting product is either of excessive age or in what appears to be a deteriorated condition, all WORK shall cease until the product's age or quality can be determined.

F. No blasting product shall be brought to the job site if the date codes are missing. At the option of the ENGINEER, the product may be tested by an independent organization to determine its performance as compared to the manufacturer's data sheet. If product performance or composition deviated by more than ten percent (10%) in any manner from the manufacturer's data sheet, that lot number shall be rejected.

3.9 BLAST DESIGN

A. Design each blast to avoid damage to existing facilities, adjacent property and completed work. Consider effects of blast-induced vibrations and air-blast, and fly rock potential in the design of each blast.

B. Whenever peak particle velocity exceeds vibration limits change design of subsequent blasts, as necessary, to reduce peak particle velocity to within limits specified herein, or as established by CONTRACTOR's Blast Control Specialist.

C. Whenever air-blast exceeds limits, change design of subsequent blasts or provide controls necessary to reduce air-blast to within specified limits.

3.10 VIBRATION AND AIR-BLAST OVERPRESSURE MONITORING

A. Vibration and air-blast monitoring shall be performed on, or at, structures or other facilities that are closest to the point of blasting. Monitor more distant facilities that are expected to be sensitive to blast induced vibrations and air-blast overpressure, as appropriate.

B. The CONTRACTOR's Blast Control Specialist shall supervise establishment of monitoring programs and initial operation of equipment, review interpretation of records and recommended revisions of blast designs.

C. Vibration Monitoring:

1. The CONTRACTOR shall monitor each blast with three (3) approved seismographs located, as approved, between the blast area and the closest structures and/or mine features subject to blast damage. Seismographs shall be capable of recording particle velocity for three mutually perpendicular components of vibration in the range generally found with controlled blasting as well as air overpressure. Seismographs must be capable of storing data in digital form, which can be electronically transferred into a computer. The type of seismograph instrumentation, and the method of use, must conform to the general guidelines for proper use of seismographs.

D. Air-Blast Overpressure Monitoring:

1. Three (3) air blast-monitoring systems shall be installed between the main blasting area and the nearest structures and/or mine features subject to blast damage or annoyance. The equipment used to make the air-blast measurements shall be the type specifically manufactured for that purpose.

3.11 FLY ROCK CONTAINMENT

A. Before the firing of any blast, the rock to be blasted shall be covered with approved blasting mats, soil, or other equally serviceable material, to prevent fly rock that may result in damage to life or property.

B. Workers determined to be in the design fly rock zone for a particular blast shall be notified 24 hours in advance of the pending blast, and at least two (2) hours prior to the blast so that they may temporarily relocate during the blast. Signage along South Vershire Road shall be used to supplement the notification process.

C. Suggested methods of protecting structures and historical features from the effects of the blasting, blast induced fly rock, vibration, and air-blast overpressure include, but are not limited to the following:

    1. New sisal rope blasting mats

    2. Wire rope or tire blasting mats

    3. Backfilling

    4. Stemming full-depth

    5. Reduced explosive loads

    6. Use of millisecond delays

D. If fly rock travels beyond the design fly rock zone limits, all blasting operations shall cease. The CONTRACTOR shall review the site and determine the cause and solution to the fly rock problem. Before any further blasting proceeds, a written report, prepared by the CONTRACTOR shall be submitted to the ENGINEER. In the event that the CONTRACTOR and the ENGINEER cannot reach an agreement on the cause and solution to the fly rock problem, progress payments shall be suspended until an agreement is achieved.

E. Delays caused by fly rock incidents do not constitute grounds for extension of Contract Time.

F. If more than three (3) fly rock incidents occur, at the option of the OWNER, the CONTRACTOR may be fined $10,000 for each additional occurrence. A fly rock incident is defined as any fly rock that hits a historical feature.

3.12 DAILY EXPLOSIVE MATERIAL CONSUMPTION AND LOSS

A. The CONTRACTOR shall keep a daily record of transactions to be maintained at each storage magazine. Inventory records shall be updated at the close of every business day. The records shall show the class and quantities received and issued and total remaining on hand at the end of each day. Remaining explosive inventory shall be checked each day, and any discrepancies that would indicate a theft or loss of explosive material would be immediately reported.

B. Should a loss or theft of explosives occur, all circumstances and details of the loss or theft shall be immediately reported to the local law enforcement authorities and the ENGINEER.

3.13 SUSPENSION OF BLASTING

A. If damage to existing facilities, historical features, or adjacent property occurs due to blasting, immediately suspend blasting and report damage to the Blast Consultant and the ENGINEER.

B. Before resuming blasting operations, adjust design of subsequent blasts, or take other appropriate measures to control effects of blasting and submit complete description of proposed changes for reducing potential for future damage to the Blast Consultant.

C. Do not resume blasting until authorized by the Blast Consultant and the ENGINEER.

3.14 SCALING AND STABILIZATION

A. All rock on the cut face that is loose, hanging, or creates a potentially dangerous situation, shall be removed or stabilized to the ENGINEER's satisfaction during or upon completion of the excavation in each lift. Drilling of the next lift or WORK of any sort on the remaining rock cuts shall not be allowed until this WORK has been completed.

B. Rock cut slopes shall be scaled throughout the span of the contract and at such frequency as required to remove all hazardous loose rock or overhangs. The slopes shall be hand scaled using a suitable standard steel mine scaling rod. Subject to the ENGINEER's approval, or other methods, such as machine scaling and hydraulic splitters, may be used in lieu of or to supplement hand scaling. Payment for scaling shall be incidental to the contract unit price for rock excavation.

C. If in-place stabilization is required, as determined by the ENGINEER, rock bolting or other ENGINEER approved stabilization techniques shall be used. Stabilization necessitated, in the opinion of the ENGINEER, by the CONTRACTOR's blasting operations, shall be performed at the CONTRACTOR's expense.

D. Material outside the planned neatline slope which, in the opinion of the ENGINEER, is unstable and constitutes potential slides, shall be excavated and removed. Such material shall be used in the construction of the embankment or disposed of as directed by the ENGINEER. The removal and disposal of this material shall be paid for at the contract unit price for rock excavation if WORK does not require blasting.

3.15 SAFETY PROCEDURES - WARNINGS AND SIGNALS

A. The CONTRACTOR shall establish a method or warning all employees on the job site of an impending blast. The signal should consist of a five minute warning signal to notify all in the area that a blast shall be fired within a five minute period. A second warning signal

shall be sounded one minute before the blast. After the blast is over, there shall be an "all clear" signal sounded so all in the area understand that all blasting operations are finished.

B. Five minutes prior to the blast, five long signals on an air horn or siren shall be sounded. One minute prior to the blast, five short signals on an air horn or siren shall be sounded. The "all clear" shall be one long signal of at least 30 seconds in duration to indicate that all blasting has ceased.

3.16 CHECK FOR MISFIRES

A. The CONTRACTOR shall observe the entire blast area for a minimum of five minutes following a blast to guard against rock fall before commencing WORK in the cut. The five minute delay between blasting and allowing anyone but the Blast Control Specialist to enter the area is needed to make sure that no misfires have occurred.

B. During the five minute delay, it is the Blast Control Specialist’s responsibility to go into the shot area and check all holes to make sure that they have detonated. If any holes have not fired, the Blast Control Specialist shall handle these misfires before others enter the WORK area.

C. The ENGINEER shall, at all times, have the authority to prohibit or halt the CONTRACTOR's blasting operations, if it is apparent that through the methods being employed, the required slopes are not being obtained in a stable condition or the safety and convenience of the public is being jeopardized.

3.17 MISFIRE HANDLING PROCEDURES

A. Should a visual inspection indicate that complete detonation of all charges did not take place, the following procedures shall be followed:

1. If the system was energized and no charges fired for electric systems, the lead wire shall be tested for continuity prior to inspection of the remainder of the blast. For non-electric systems, the lead-in or tube shall be checked to make sure that detonation has entered the blast area.

2. Should an inspection of the electrical trunkline or lead-in tubing line indicate that there is a break in the line or if the tubing did not fire, then the system shall be repaired and the blast re-fired. If the inspection indicates that the trunkline has fired, and misfired charges remain, the Blast Control Specialist shall perform the following:

a. The Blast Control Specialist shall exclude all employees except those necessary to rectify the problem.

b. Traffic shall be closed if a premature explosion could be a hazard to nearby traffic.
c. The Blasting Consultant shall correct the misfire in a safe manner. If the misfire poses a problem that cannot be safely corrected by the Blasting Consultant, then an explosive company representative skilled in the art of correcting misfires shall be called to rectify the problem.

3.18 PUBLIC MEETINGS

A. If warranted, the CONTRACTOR shall make their qualified vibration and air-blast specialists and Blasting Consultant available to conduct public meetings to better inform the public about anticipated drilling and blasting operations. The specialists shall be prepared to answer any questions dealing with the magnitude of seismic motion, air-blast overpressure, and fly rock expected to impact the public.

END OF SECTION – 31 80 00

SECTION 31 90 00 - REVEGETATION

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Revegetating all areas disturbed by construction and supplying slope and erosion control to unprotected slopes.

1.2 RELATED SECTIONS

A. Section 31 20 00 Earth Moving

B. Section 31 25 00 Erosion and Sedimentation Control

1.3 SUBMITTALS

A. The CONTRACTOR shall submit the following items to the ENGINEER at least fourteen (14) calendar days prior to delivery to the Site:

1. Final mix design and agronomic test results of topsoil(s). Include organic content, pH, and N-P-K results.

2. Description of grass seed mixtures, fertilizer, mulch, and lime and the names of material suppliers for each product.

3. Description of seeding, fertilizing, adding lime and mulching equipment and proposed revegetation procedures.

B. The CONTRACTOR shall provide all seed and fertilizer tags from containers delivered and applied to the site to the QA/QC Representative.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver seed mixtures in sealed bags, individually marked for content. Comply with seed supplier recommendations for storage. Mix seed on-site, immediately before application.

B. Deliver fertilizers in bulk quantities with appropriate shipping tags, chemical analysis, and name of Manufacturer or product origin. Comply with Manufacturer recommendations for storage and handling.

C. Deliver mulch and tackifier in Manufacturer-sealed containers. Comply with Manufacturer recommendations for site storage, dilution, mixing, and application.

D. Maintain delivered stocks in cool, dry, covered and protected location prior to site mixing and application. Replace any seed damaged during storage.

PART 2 - PRODUCTS

2.1 SEED MIXTURE

A. Provide certified seed consignments in accordance with the specifications for Vermont approved CONSERVATION MIX seed mixture. The seed mixture shall be packed and labeled in accordance with industry standards as to seed purity and germination.

B. Provide certified seed consignments in accordance with the specifications for RIPARIAN BUFFER seed mixture. This mixture shall be used within and adjacent to the natural channel design of Ely Brook. The seed mixture shall be packed and labeled in accordance with industry standards as to seed purity and germination. The RIPARAIN BUFFER seed mixture shall conform to the following specification:

Riparian Buffer Seed Mix

Scientific name	Common name	Composition
Panicum clandestinum	Deertongue	30.0%
Elymus virginicus	Virginia Wildrye	16.5%
Sorghastrum nutans	Indiangrass	16.0%
Andropogon gerardii	Big Bluestem	10.0%
Panicum virgatum	Switchgrass	7.0%
Chamaecrista fasciculata	Partridge Pea	4.0%
Rudbeckia hirta	Blackeyed Susan	3.0%
Asclepias incarnata	Swamp Milkweed	2.5%
Heliopsis helianthoides	Oxeye Sunflower	2.5%
Juncus effusus	Soft Rush	2.0%
Juncus tenuis	Path Rush	2.0%
Aster novae-angliae (Symphyotrichum n.)	New England Aster	1.8%
Eupatorium perfoliatum	Boneset	1.0%
Vernonia noveboracensis	New York Ironweed	1.0%
Eupatorium fistulosum	Joe Pye Weed	0.5%
Aster umbellatus	Flat Topped White Aster	0.3%

2.2 OTHER PRODUCTS

A. Topsoil: Native organic or organic amended materials from approved on-site or off-site borrow source meeting the requirements of Section 31 20 00 – Earth Moving.

B. Hydraulic Applied Mulch: Cellulose fiber mulch such as Silvar Fiber™ or ENGINEER approved equivalent.

C. Tackifier: M-binder, Verdyol alginate, Plantago gum or ENGINEER approved equivalent non-asphalt tackifier.

D. Water: Water used in hydraulic applications shall be clean, fresh and free of substances which could inhibit vigorous plant growth. The source of the water shall be approved by the ENGINEER prior to its use. Acid mine drainage/contaminated water from the Site shall not be used.

E. Blown Mulching Material: Grass hay or straw mulch shall be free from noxious weeds, mold or other objectionable material. The straw mulch shall contain at least 50 percent by weight material that is six (6) inches or longer.

F. Hydro Application: Wood or cellulose fiber product or ENGINEER approved equivalent specifically designed for use as a hydro-mechanical applied mulch.

G. Mechanically-Bonded Fiber Matrix: The Mechanically-Bonded Fiber Matrix (M-BFM) shall be Conwed Fibers 3000 M-BFM™, as manufactured by PROFILE Products™ or ENGINEER 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 demonstrate the following physical properties:

Property	Typical Requirements
Moisture Content	12% (± 3%)
Wood Fiber	85% max.
Locking Fibers	5% (± 1%)
Cross-linked Tackifier	10% (± 1%)
Water Holding Capacity	1500% min.
Organic Material	95% min.
Ash Content	5% (± 1%)
pH	4.8 (+ 2)
Color	Green

H. Fertilizer: Provide in the following quantities and quality as determined by the agronomic testing:

1. Nitrogen, phosphate, and potassium shall be compound fertilizer.
2. Potassium shall be in the form of K_2O.
3. Phosphate shall be in the form of P_2O_5.

I. Wood Chips: Relatively fresh, undecayed, mechanically chipped on-site or off-site wood, substantially free of soil, tailing, waste rock, ore roasts, or other deleterious material.

PART 3 - EXECUTION

3.1 TOPSOIL PLACEMENT

A. Place soil in one lift to the slopes, and thickness as shown on the Drawings.

3.2 PREPARATION OF SURFACES

A. Remove debris such as large stones and other obstructions that would interfere with normal seeding operations.

B. The plant growth substrate shall be lightly compacted with a track machine (bulldozer) or similar implement to provide a firm seed bed. The track machine shall operate up and down the slope to create cross-slope track “bars.”

C. The seedbed shall be weed-free and use of herbicides will not be allowed.

D. After weed elimination, the seedbed shall be scarified/tilled to a depth of at least 6 inches, fertilized if not hydro-seeded and firmed. Areas not suitable for scarifying/tilling shall be left in a rough condition.

E. In areas where equipment cannot be operated, the seedbed shall be prepared by hand.

F. If the seedbed has become compacted, loosen and smooth the soil surface either after or in conjunction with fertilization if not hydro-seeded.

G. If the topsoil is too loose, compact to provide a firm seedbed.

3.3 FERTILIZER

A. If broadcast, apply fertilizer uniformly. Apply just prior to seeding. Application rate shall be as determined by agronomic testing. The results of the testing shall be reviewed and approved by the ENGINEER.

B. Apply fertilizer with the mulch for hydro-seeding applications.

C. When applying materials by hydro-seeding, fertilizer shall be applied with the mulch.

3.4 SEEDING – GENERAL

A. Conduct seeding no later than September 15 unless approved by the ENGINEER. If seeding is not completed by September 15 other additional temporary erosion control measures such as erosion control mats will be required. CONTRACTOR and ENGINEER will coordinate a revised erosion control plan until seeding is completed the following spring.

B. Conduct seeding within the RIPARIAN BUFFER Seed Mix between May 1 and September 15 unless approved by the ENGINEER.

C. The method of seed application shall be hydraulic application including M-BFM, broadcast, or as otherwise approved by the ENGINEER.

D. Seed application rates shall be 130 lbs per acre (3 lbs per 1,000 square feet), or as otherwise approved by the ENGINEER.

E. Seed application rates for the RIPARIAN BUFFER Seed Mix shall be 20 lbs/acre of the Riparian Mix with an additional 30 lbs/acre of the cover crop Grain Rye (*Secale cereal*).

3.5 LIME

A. Lime shall comply with Section 31 20 00 – Earth Moving.

B. Application rate shall be as determined by agronomic testing.

C. Apply lime such that it is uniformly distributed.

3.6 HYDRO-SEED/MULCH

A. Hydro-seed/Mulch mixture shall be referred to as the “Non-Slope Seed Mixture” for this project. The Non-Slope Seed Mixture shall be applied to cover system areas with slopes shallower than 7.5H:1V, unless directed otherwise by the ENGINEER.

B. The Non-Slope Seed Mixture shall be applied by a CONTRACTOR experienced in hydraulic applications with equipment of adequate volumetric capacity to complete the job in a timely fashion.

C. The Non-Slope Seed Mixture shall consist of hydraulic mulch at 1,500 lbs/acre (Profile’s - Terra-Blend™ with Ultragro™or approved equivalent), seed at 130 lbs/acre, fertilizer (as determined by agronomic testing), and lime (as determined by agronomic testing).

D. Apply the Non-Slope Seed Mixture, in one application, to surfaces as part of the seeding process, in a manner that ensures proper soil surface coverage.

3.7 MECHANICALLY-BONDED FIBER MATRIX

A. Apply the M-BFM, seed, and fertilizer in a manner approved by the ENGINEER.

B. Apply M-BFM for erosion protection at a rate of 3,000 lbs/acre.

C. Spray M-BFM in a manner that ensures proper soil surface coverage.

D. Apply M-BFM to surfaces as part of the seeding process in two stages:
   1. Apply first coat of 1,500 lbs/acremulch with seed mixture.
   2. Apply second coat of 1,500 lbs/acre mulch, fertilizer with tackifier.

E. The Mechanically-Bonded Fiber Matrix mixture shall be referred to the “Slope Seed Mixture” for this project. The Slope Seed Mixture shall be applied to slopes at or steeper than 7.5H:1V, unless directed otherwise by the ENGINEER.

3.8 WOOD CHIPS

A. Place wood chips in a manner which minimizes compaction.

B. Place wood chips 6 inches thick unless otherwise directed by the ENGINEER.

3.9 PROTECTION AND MAINTENANCE

A. Immediately re-seed areas which show bare spots prior to demobilization using appropriate erosion control techniques (i.e. mulch, M-BFM, etc.).

B. Protect seeded areas against traffic or other uses.

C. Maintain all seeded areas in good condition until satisfactory uniform growth is established. Maintenance may include watering, re-seeding, and re-fertilizing.

D. Satisfactory uniform growth will be defined as follows:
   1. No bare spots larger than 3 square feet.
   2. No more than 10 percent of any continuous area with bare spots exceeding 0.5 square feet.
   3. No weed growth covering areas greater than one square foot.

E. All seeded areas shall be guaranteed by the CONTRACTOR for not less than one full year from time of final completion.

END OF SECTION 31 90 00

SECTION 33 42 00 – CON/SPAN STORMWATER CONVEYANCE

1. DESCRIPTION

1.1. TYPE - This work shall consist of furnishing and constructing a CON/SPAN® O-SERIES® bridge system in accordance with these specifications and in reasonably close conformity with the lines, grades, design and dimensions shown on the plans or as established by the Engineer. In situations where two or more specifications apply to this work, the most stringent requirements shall govern.

1.2. DESIGNATION - Precast reinforced concrete CON/SPAN® O-SERIES bridge units manufactured in accordance with this specification shall be designated by span and rise. Precast reinforced concrete wingwalls and headwalls manufactured in accordance with this specification shall be designated by length, height, and deflection angle. Precast Reinforced Concrete Express™ foundation units manufactured in accordance with this specification shall be designated by length, height and width.

1.3. ALTERNATES - Precast reinforced concrete CON/SPAN® O-SERIES Bridge System as supplied by CONTECH Engineered Solutions is the basis of this design. Proposed alternates must be of equal or greater span and must provide the documentation listed below at least 20 days prior to bid. Any approved alternate shall be designated via addenda 10 days prior to bid. Alternates will not be evaluated after the bid.

- Bridge drawings including a plan view showing total bridge length and end treatment wall length and angles, upstream and downstream end elevations showing precast span, clear span, precast rise, clear rise, headwall height and wall thickness dimensions of bridge members and bridge end treatments.

- Product specific foundation design detailing foundation width, thickness, required reinforcement and concrete compressive strength.

- Design calculations for precast concrete elements and foundations sealed by a registered professional engineer in the State of Vermont. The Professional engineer signing the shop drawings and calculations MUST have at least 5 years of experience designing Soil Interactive structures utilizing a PUBLIC domain software.

- Hydraulic analysis demonstrating no increase in headwater elevation, tailwater elevation or velocity. Contact engineer for acceptable hydraulic software list.

2. DESIGN

2.1. SPECIFICATIONS - The precast elements are designed in accordance with the “AASHTO LRFD Bridge Specification” 4th Edition, adopted by the American Association of State Highway and Transportation Officials, 2002.

A minimum of one foot of cover above the crown of the bridge units is required in the installed condition. (Unless noted otherwise on the shop drawings and designed accordingly.)

3. MATERIALS

3.1. CONCRETE - The concrete for the precast elements shall be air-entrained when installed in areas subject to freeze-thaw conditions, composed of Portland cement, fine and coarse aggregates, admixtures and water. Air-entrained concrete shall contain 6 ± 2 percent air. The air-entraining admixture shall conform to AASHT0 M154. The minimum concrete compressive strength shall be as shown on the shop drawings.

3.1.1. Portland Cement - Shall conform to the requirements of ASTM Specifications C150-Type I, Type II, or Type lll cement.

3.1.2. Coarse Aggregate - Shall consist of stone having a maximum size of 1 inch. Aggregate shall meet requirements for ASTM C33.

3.1.3. Water Reducing Admixture - The manufacturer may submit, for approval by the Engineer, a water-reducing admixture for the purpose of increasing workability and reducing the water requirement for the concrete.

3.1.4. Calcium Chloride - The addition to the mix of calcium chloride or admixtures containing calcium chloride will not be permitted.

3.1.5. Mixture - The aggregates, cement and water shall be proportioned and mixed in a batch mixer to produce a homogeneous concrete meeting the strength requirements of this specification. The proportion of Portland cement in the mixture shall not be less than 564 pounds (6 sacks) per cubic yard of concrete.

3.2. STEEL REINFORCEMENT

3.2.1. The minimum steel yield strength shall be 60,000 psi, unless otherwise noted on the shop drawings.

3.2.2. All reinforcing steel for the precast elements shall be fabricated and placed in accordance with the detailed shop drawings submitted by the manufacturer.

3.2.3. Reinforcement shall consist of welded wire fabric conforming to ASTM Specification A 185 or A 497, or deformed billet steel bars conforming to ASTM Specification A 615, Grade 60. Longitudinal distribution reinforcement may consist of welded wire fabric or deformed billet-steel bars.

3.3. STEEL HARDWARE

3.3.1. Bolts and threaded rods for wingwall connections shall conform to ASTM A 307. Nuts shall conform to AASHTO M292 (ASTM A194) Grade 2H. All bolts, threaded rods and nuts used in wingwall connections shall be mechanically zinc coated in accordance with ASTM B695 Class 50.

3.3.2. Structural Steel for wingwall connection plates and plate washers shall conform to AASHTO M 270 (ASTM A 709) Grade 36 and shall be hot dip galvanized as per AASHTO M111 (ASTM A123).

3.3.3. Inserts for wingwalls shall be 1" diameter Two-Bolt Preset Wingwall Anchors as manufactured by Dayton Superior Concrete Accessories, Miamisburg, Ohio, (800) 745-3700 and shall be mechanically zinc coated in accordance with ASTM B695 Class 50.

3.3.4. Ferrule Loop Inserts shall be F-64 Ferrule Loop Inserts as manufactured by Dayton Superior Concrete Accessories, Miamisburg, Ohio, (800) 745-3700.

3.3.5. Hook Bolts used in attached headwall connections shall be ASTM A307.

3.3.6. Inserts for detached headwall connections shall be AISI Type 304 stainless steel, F-58 Expanded Coil inserts as manufactured by Dayton Superior Concrete Accessories, Miamisburg, Ohio, (800) 745-3700. Coil rods and nuts used in headwall connections shall be AISI Type 304 stainless steel. Washers used in headwall connections shall be either AISI Type 304 stainless steel plate washers or AASHTO M270 (ASTM A709) Grade 36 plate washers hot dip galvanized as per AASHTO M111 (ASTM A123).

3.3.7. Reinforcing bar splices shall be made using the Dowel Bar Splicer System as manufactured by Dayton Superior Concrete Accessories, Miamisburg, Ohio, (800) 745-3700, and shall consist of the Dowel Bar Splicer (DB-SAE) and Dowel-In (DI).

4. MANUFACTURE OF PRECAST ELEMENTS - Subject to the provisions of Section 5, below, the precast element dimension and reinforcement details shall be as prescribed in the plan and shop drawings provided by the manufacturer.

4.1. FORMS - The forms used in manufacture shall be sufficiently rigid and accurate to maintain the required precast element dimensions within the permissible variations given in Section 5 of these specifications. All casting surfaces shall be of a smooth material.

4.2. PLACEMENT OF REINFORCEMENT

4.2.1. Placement of Reinforcement in Precast Bridge Units - The cover of concrete over the outside circumferential reinforcement shall be 2 inches minimum. The cover of concrete over the inside circumferential reinforcement shall be 1 1/2 inches minimum, unless otherwise noted on the shop drawings. The clear distance of the end circumferential wires shall not be less than one inch nor more than two inches from the ends of each section. Reinforcement shall be assembled utilizing single or multiple layers of welded wire fabric (not to exceed 3 layers), supplemented with a single layer of deformed billet-steel bars, when necessary. Welded wire fabric shall be composed of circumferential and longitudinal wires meeting the spacing requirements of 4.3, below, and shall contain sufficient longitudinal

wires extending through the bridge unit to maintain the shape and position of the reinforcement. Longitudinal distribution reinforcement may be welded wire fabric or deformed billet-steel bars and shall meet the spacing requirements of 4.3, below. The ends of the longitudinal distribution reinforcement shall be not more than 3 inches and not less than 1 1/2 inches from the ends of the bridge unit.

4.2.2. Bending of Reinforcement for Precast Bridge Units – The outside and inside circumferential reinforcing steel for the corners of the bridge shall be bent to such an angle that is approximately equal to the configuration of the bridge's outside corner.

4.2.3. Placement of Reinforcement for Precast Wingwalls and Headwalls - The cover of concrete over the longitudinal and transverse reinforcement shall be 2 inches minimum. The clear distance from the end of each precast element to the end of reinforcing steel shall not be less than ½ inch nor more than 3 inches. Reinforcement shall be assembled utilizing a single layer of welded wire fabric, or a single layer of deformed billet-steel bars. Welded wire fabric shall be composed of transverse and longitudinal wires meeting the spacing requirements of 4.3, below, and shall contain sufficient longitudinal wires extending through the element to maintain the shape and position of the reinforcement. Longitudinal reinforcement may be welded wire fabric or deformed billet-steel bars and shall meet the spacing requirements of 4.3, below.

4.2.4. Placement of Reinforcement for Precast Foundation Units – The cover of concrete over the bottom reinforcement shall be 3 inches minimum. The cover of concrete for all other reinforcement shall be 2 inches minimum. The clear distance from the end of each precast element to the end of reinforcing steel shall not be less than 2 inches nor more than 3 inches. Reinforcement shall be assembled utilizing a single layer of welded wire fabric or a single layer of deformed billet-steel bars. Welded wire fabric shall be composed of transverse and longitudinal wires meeting the spacing requirements of 4.3, below, and shall contain sufficient longitudinal wires extending through the element to maintain the shape and position of the reinforcement. Longitudinal reinforcement may be welded wire fabric or deformed billet-steel bars and shall meet the spacing requirements of 4.3, below.

4.3. LAPS, WELDS, AND SPACING

4.3.1. Laps, Welds, and Spacing for Precast Bridge Units - Tension splices in the circumferential reinforcement shall be made by lapping. Laps may be tack welded together for assembly purposes. For smooth welded wire fabric, the overlap shall meet the requirements of AASHTO 8.30.2 and 8.32.6. For deformed welded wire fabric, the overlap shall meet the requirements of AASHTO 8.30.1 and 8.32.5. The overlap of welded wire fabric shall be measured between the outer-most longitudinal wires of

each fabric sheet. For deformed billet-steel bars, the overlap shall meet the requirements of AASHTO 8.25. For splices other than tension splices, the overlap shall be a minimum of 12" for welded wire fabric or deformed billet-steel bars. The spacing center to center of the circumferential wires in a wire fabric sheet shall be not less than 2 inches nor more than 4 inches. The spacing center to center of the longitudinal wires shall not be more than 8 inches. The spacing center to center of the longitudinal distribution steel for either line of reinforcing in the top slab shall be not more than 1 foot 4 inches.

4.3.2. Laps, Welds, and Spacing for Precast Wingwalls, Headwalls and Foundations - Splices in the reinforcement shall be made by lapping. Laps may be tack welded together for assembly purposes. For smooth welded wire fabric, the overlap shall meet the requirements of AASHTO 8.30.2 and 8.32.6. For deformed welded wire fabric, the overlap shall meet the requirements of AASHTO 8.30.1 and 8.32.5. For deformed billet-steel bars, the overlap shall meet the requirements of AASHTO 8.25. The spacing center-to-center of the wires in a wire fabric sheet shall be not less than 2 inches nor more than 8 inches.

4.4. CURING - The precast concrete elements shall be cured for a sufficient length of time so that the concrete will develop the specified compressive strength in 28 days or less. Any one of the following methods of curing or combinations thereof shall be used:

4.4.1. Steam Curing - The precast elements may be low-pressure steam cured by a system that will maintain a moist atmosphere.

4.4.2. Water Curing - The precast elements may be water cured by any method that will keep the sections moist.

4.4.3. Membrane Curing - A sealing membrane conforming to the requirements of ASTM Specification C309 may be applied and shall be left intact until the required concrete compressive strength is attained. The concrete temperature at the time of application shall be within +/- 10 degrees F of the atmospheric temperature. All surfaces shall be kept moist prior to the application of the compounds and shall be damp when the compound is applied.

4.5. STORAGE, HANDLING & DELIVERY

4.5.1. Storage

Precast concrete bridge elements shall be lifted and stored in “as-cast” position.

Precast concrete headwall and wingwall units are cast, stored and shipped in a flat position.

The precast elements shall be stored in such a manner to prevent cracking or damage. Store elements using timber supports as appropriate. The units shall not be moved until the concrete compressive strength has reached a minimum of 2500 psi, and they shall not be stored in an upright position.

4.5.2. Handling

Handling devices shall be permitted in each precast element for the purpose of handling and setting.

Spreader beams may be required for the lifting of precast concrete bridge elements to preclude damage from bending or torsion forces.

4.5.3. Delivery

Precast concrete elements must not be shipped until the concrete has attained the specified design compressive strength, or as directed by the design Engineer.

Precast concrete elements may be unloaded and placed on the ground at the site until installed. Store elements using timber supports as appropriate.

4.6. QUALITY ASSURANCE - The Precaster shall demonstrate adherence to the standards set forth in the NPCA Quality Control Manual. The Precaster shall meet either Section 4.6.1 or 4.6.2

4.6.1. Certification: The Precaster shall be certified by the Precast/Prestressed Concrete Institute Plant Certification Program or the National Precast Concrete Association's Plant Certification Program prior to and during production of the products covered by this specification.

4.6.2. Qualifications, Testing and Inspection

4.6.2.1. The Precaster shall have been in the business of producing precast concrete products similar to those specified for a minimum of three years. He shall maintain a permanent quality control department or retain an independent testing agency on a continuing basis. The agency shall issue a report, certified by a licensed engineer, detailing the ability of the Precaster to produce quality products consistent with industry standards.

4.6.2.2. The Precaster shall show that the following tests are performed in accordance with the ASTM standards indicated. Tests shall be performed as indicated in Section 6 of these specifications.

4.6.2.2.1. Air Content: C231 or C173

4.6.2.2.2. Compressive Strength: C31, C39, C497

4.6.2.3. The Precaster shall provide documentation demonstrating compliance with this section to CONTECH® Engineered Solutions at regular intervals or upon request.

4.6.2.4. The Owner may place an inspector in the plant when the products covered by this specification are being manufactured.

4.6.3. Documentation - The Precaster shall submit Precast Production Reports to CONTECH® Engineered Solutions as required.

5. PERMISSIBLE VARIATIONS

5.1. BRIDGE UNITS

5.1.1. Internal Dimensions - The internal dimension shall vary not more than 1% from the design dimensions nor more than 1-1/2 inches whichever is less.

5.1.2. Slab and Wall Thickness - The slab and wall thickness shall not be less than that shown in the design by more than 1/4 inch. A thickness more than that required in the design shall not be cause for rejection.

5.1.3. Length of Opposite Surfaces - Variations in laying lengths of two opposite surfaces of the bridge unit shall not be more than 1/2 inch in any section, except where beveled ends for laying of curves are specified by the purchaser.

5.1.4. Length of Section - The underrun in length of a section shall not be more than 1/2 inch in any bridge unit.

5.1.5. Position of Reinforcement - The maximum variation in position of the reinforcement shall be ± 1/2 inch. In no case shall the cover over the reinforcement be less than 1 1/2 inches for the outside circumferential steel or be less than 1 inch for the inside circumferential steel as measured to the external or internal surface of the bridge. These tolerances or cover requirements do not apply to mating surfaces of the joints.

5.1.6. Area of Reinforcement - The areas of steel reinforcement shall be the design steel areas as shown in the manufacturer's shop drawings. Steel areas greater than those required shall not be cause for rejection. The permissible variation in diameter of any reinforcement shall conform to the tolerances prescribed in the ASTM Specification for that type of reinforcement.

5.2. WINGWALLS & HEADWALLS

5.2.1. Wall Thickness - The wall thickness shall not vary from that shown in the design by more than 1/2 inch.

5.2.2. Length/ Height of Wall sections - The length and height of the wall shall not vary from that shown in the design by more than 1/2 inch.

5.2.3. Position of Reinforcement - The maximum variation in the position of the reinforcement shall be ± 1/2 inch. In no case shall the cover over the reinforcement be less than 1 1/2 inches.

5.2.4. Size of Reinforcement - The permissible variation in diameter of any reinforcing shall conform to the tolerances prescribed in the ASTM Specification for that type of reinforcing. Steel area greater than that required shall not be cause for rejection.

5.3. FOUNDATION UNITS

5.3.1. Wall Thickness - The wall thickness shall not vary from that shown in the design by more than 1/2 inch.

5.3.2. Length/ Height/Width of Foundation sections - The length, height and width of the foundation units shall not vary from that shown in the design by more than 1/2 inch.

5.3.3. Position of Reinforcement - The maximum variation in the position of the reinforcement shall be ± 1/2 inch. In no case shall the cover over the reinforcement be less than 1 1/2 inches.

5.3.4. Size of Reinforcement - The permissible variation in diameter of any reinforcing shall conform to the tolerances prescribed in the ASTM Specification for that type of reinforcing. Steel area greater than that required shall not be cause for rejection.

6. TESTING/ INSPECTION

6.1. TESTING

6.1.1. Type of Test Specimen - Concrete compressive strength shall be determined from compression tests made on cylinders or cores. For cylinder testing, a minimum of 4 cylinders shall be taken for each bridge element. Each element shall be considered separately for the purpose of testing and acceptance.

6.1.2. Compression Testing - Cylinders shall be made and tested as prescribed by the ASTM C 39 Specification. Cylinders shall be cured in the same environment as the bridge elements. Cores shall be obtained and tested for compressive strength in accordance with the provisions of the ASTM C42 specification.

6.1.3. Acceptability of Cylinder Tests - When the average compressive strength of all cylinders tested is equal to or greater than the design compressive strength, and not more than 10% of the cylinders tested have a compressive strength less than the design concrete strength, and no cylinder tested has a compressive strength less than 80% of the design compressive strength, then the element shall be accepted. When the compressive strength of the cylinders tested does not conform to these acceptance criteria, the acceptability of the element may be determined as described in section 6.1.4, below.

6.1.4. Acceptability of Core Tests - The compressive strength of the concrete in a bridge element is acceptable when the average core test strength is equal to or greater than the design concrete strength. When the compressive strength of a core tested is less than the design concrete strength, the precast element from which that core was taken may be re-cored. When the compressive strength of the re-core is equal to or greater than the design concrete strength, the compressive strength of the concrete in that bridge element is acceptable.

6.1.4.1. When the compressive strength of any recore is less than the design concrete strength, the precast element from which that core was taken shall be rejected.

6.1.4.2. Plugging Core Holes - The core holes shall be plugged and sealed by the manufacturer in a manner such

that the elements will meet all of the test requirements of this specification. Precast elements so sealed shall be considered satisfactory for use.

6.1.4.3. Test Equipment - Every manufacturer furnishing precast elements under this specification shall furnish all facilities and personnel necessary to carry out the test required.

6.2. INSPECTION - The quality of materials, the process of manufacture, and the finished precast elements shall be subject to inspection by the purchaser.

7. JOINTS - The bridge units shall be produced with flat butt ends. The ends of the bridge units shall be such that when the sections are laid together they will make a continuous line with a smooth interior free of appreciable irregularities, all compatible with the permissible variations in section 5, above. The joint width between adjacent precast units shall not exceed 3/4 inches.

8. WORKMANSHIP/ FINISH - The bridge units, wingwalls, headwalls and foundation units shall be substantially free of fractures. The ends of the bridge units shall be normal to the walls and centerline of the bridge section, within the limits of the variations given in section 5, above, except where beveled ends are specified. The faces of the wingwalls and headwalls shall be parallel to each other, within the limits of variations given in section 5, above. The surface of the precast elements shall be a smooth steel form or troweled surface. Trapped air pockets causing surface defects shall be considered as part of a smooth, steel form finish.

9. REPAIRS - Precast elements may be repaired, if necessary, because of imperfections in manufacture or handling damage and will be acceptable if, in the opinion of the purchaser, the repairs are sound, properly finished and cured, and the repaired section conforms to the requirements of this specification.

10. REJECTION - The precast elements shall be subject to rejection on account of any of the specification requirements. Individual precast elements may be rejected because of any of the following:

    10.1. Fractures or cracks passing through the wall, except for a single end crack that does not exceed one half the thickness of the wall.

    10.2. Defects that indicate proportioning, mixing, and molding not in compliance with section 4 of these specifications.

    10.3. Honeycombed or open texture.

    10.4. Damaged ends, where such damage would prevent making a satisfactory joint.

11. MARKING - Each bridge unit shall be clearly marked by waterproof paint. The following shall be shown on the inside of the vertical leg of the bridge section:
    Bridge Span X Bridge Rise
    Date of Manufacture
    Name or trademark of the manufacturer

12. INSTALLATION PREPARATION - To ensure correct installation of the precast concrete bridge system, care and caution must be exercised in forming the support areas for bridge units, headwall, and wingwall elements. Exercising special care will facilitate the rapid installation of the precast components.

    12.1. FOOTINGS

    Do not over excavate foundations unless directed by site soil engineer to remove unsuitable soil.

    The site soils engineer shall certify that the bearing capacity meets or exceeds the footing design requirements, prior to the contractor pouring of the footings.

    The bridge units and wingwalls shall be installed on either precast or cast-in-place concrete footings. The size and elevation of the footings shall be as designed by the Engineer. A keyway shall be formed in the top surface of the bridge footing as specified on the plans. No keyway is required in the wingwall footings, unless otherwise specified on the plans.

    The footings shall be given a smooth float finish and shall reach a compressive strength of 2,000 psi before placement of the bridge and wingwall elements. Backfilling shall not begin until the footing has reached the full design compressive strength.

    The footing surface shall be constructed in accordance with grades shown on the plans. When tested with a 10-foot straight edge, the surface shall not vary more than 1/4 inch in 10 feet.

    If a precast concrete footing is used, the contractor shall prepare a 4-inch thick base layer of compacted granular material the full width of the footing prior to placing the precast footing.

    The foundations for precast concrete bridge elements and wingwalls must be connected by reinforcement to form one monolithic body. Expansion joints shall not be used.

    The contractor shall be responsible for the construction of the foundations per the plans and specifications.

13. INSTALLATION

    13.1. GENERAL - The installation of the precast concrete elements shall be as explained in the publication *CON/SPAN Bridge Systems Installation Handbook*.

        13.1.1. Lifting - It is the responsibility of the contractor to ensure that a crane of the correct lifting capacity is available to handle the precast concrete units. This can be accomplished by using the weights given for the precast concrete components and by determining the lifting reach for each crane unit. Site conditions must be checked well in advance of shipping to ensure proper crane location and to avoid any lifting restrictions. The lift anchors or holes provided in each unit are the only means to be used to lift the elements. The precast concrete elements must not be supported or raised by other means than those given in the

manuals and drawings without written approval from CONTECH® Engineered Solutions.

13.1.2. Construction equipment weight restrictions: In no case shall equipment operating in excess of the design load (HL-93) be permitted over the bridge units unless approved by CONTECH® Engineered Solutions.

13.1.2.1. In the immediate area of the bridge units, the following restrictions for the use of heavy construction machinery during backfilling operations apply:

- No construction equipment shall cross the bare precast concrete bridge unit.
- After the compacted fill level has reached a minimum of 4 inches over the crown of the bridge, construction equipment with a weight of less than 10 tons may cross the bridge.
- After the compacted fill level has reached a minimum of 1 foot over the crown of the bridge, construction equipment with a weight of less than 30 tons may cross the bridge.
- After the compacted fill level has reached the design cover, or 2 feet minimum, over the crown of the precast concrete bridge, construction equipment within the design load limits for the road may cross the precast concrete bridge.

13.2. LEVELING PAD/ SHIMS - The bridge units and wingwalls shall be set on hardboard shims conforming to ASTM D1037 or plastic shims (Dayton Superior P-80, P-81 or approved equal) measuring 5" x 5", minimum, unless shown otherwise on the plans. A minimum gap of 1/2 inch shall be provided between the footing and the bottom of the bridge's vertical legs or the bottom of the wingwall. Also, a supply of 1/4 inch, 1/2 inch & 1/8 inch thick hardboard or plastic shims for various shimming purposes shall be on site.

13.3. PLACEMENT OF BRIDGE UNITS

The bridge units shall be placed as shown on the Engineer's plan drawings. Special care shall be taken in setting the elements to the true line and grade. The joint width between adjacent precast units shall not exceed 3/4 inches.

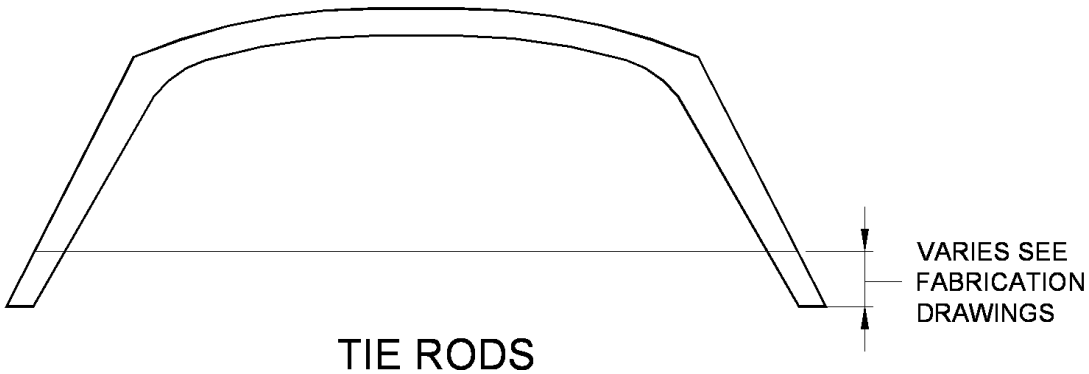
13.4. It is the contractor’s responsibility to maintain the structure span during all phases of installation. Due to the arch shape, bridge elements will tend to spread under self-weight. It is imperative that any lateral spreading of the bridge elements be avoided during and after their placement. Generally, horizontal tie rods are shipped in the larger bridge elements to assist in preventing this spreading. Tie rods shall not be removed until bridge units are grouted, and grout has cured. It is recommended that temporary hardwood blocks be used in conjunction with the cable/tie rods to maintain span. If, however, due to site restrictions, these cable ties/tie rods must be

removed prior to placement of the bridge elements, the contractor must notify CONTECH (manufacturer) and request a suggested installation procedure.

In addition, if the cable ties/tie rods must be removed prior to setting arch units, the following quality control procedure must be followed:

1) Find “measured span” upon arch unit’s delivery to site, prior to lifting from truck and removing cable ties/tie rods. “Measured span” shall be the average of (3) span measurements along the lay length of the arch unit.
2) After setting of bridge unit on the foundation, verify the span. This “installed span measurement” shall not exceed the maximum of
   A) The nominal span + ½” OR
   B) The “measured span”.

If the “installed span measurement” exceeds this amount, the arch unit shall be lifted and re-set until the “installed span measurement” meets the limits.



TIE RODS

13.5. PLACEMENT OF WINGWALLS, HEADWALLS & FOUNDATION UNITS

The wingwalls, headwalls and foundations shall be placed as shown on the plan drawings. Special care shall be taken in setting the elements to the true line and grade.

13.6. WATERPROOFING/ JOINT PROTECTION AND SUBSURFACE DRAINAGE

13.6.1. External Protection of Joints - The butt joint made by two adjoining bridge units shall be covered with a 7/8" x 1 3/8" preformed bituminous joint sealant and a minimum of a 9-inch wide joint wrap. The surface shall be free of dirt before applying the joint material. A primer compatible with the joint wrap to be used shall be applied for a minimum width of nine inches on each side of the joint. The external wrap shall be either EZ-WRAP RUBBER by PRESS-SEAL GASKET CORPORATION, SEAL WRAP by MAR MAC MANUFACTURING CO. INC. or approved equal. The joint shall be covered continuously from the bottom of one bridge section leg, across the top of the bridge and to the opposite bridge section leg.

Any laps that result in the joint wrap shall be a minimum of six inches long with the overlap running downhill.

13.6.2. In addition to the joints between bridge units, the joint between the end bridge unit and the headwall shall also be sealed as described above. If precast wingwalls are used, the joint between the end bridge unit and the wingwall shall be sealed with a 2'-0" strip of filter fabric. Also, if lift holes are formed in the bridge units, they shall be primed and covered with a 9" x 9" square of joint wrap.

13.6.3. During the backfilling operation, care shall be taken to keep the joint wrap in its proper location over the joint.

13.6.4. Subsoil drainage shall be as directed by the engineer.

13.7. GROUTING

13.7.1. Grouting shall not be performed when temperatures are expected to go below 35° for a period of 72 hours.

Fill the bridge-foundation keyway with cement grout (Portland cement and water or cement mortar composed of Portland cement, sand and water) with a minimum 28-day compressive strength of 3000 psi. Vibrate as required to ensure that the entire key around the bridge element is completely filled. If bridge elements have been set with temporary ties (cables, bars, etc.) grout must attain a minimum compressive strength of 1500 psi before ties may be removed.

13.7.2. All grout shall have a maximum aggregate size of ¼ inch.

13.7.3. Lifting and erection anchor recesses shall be filled with grout.

13.8. BACKFILL

13.8.1. Do not perform backfilling during wet or freezing weather.

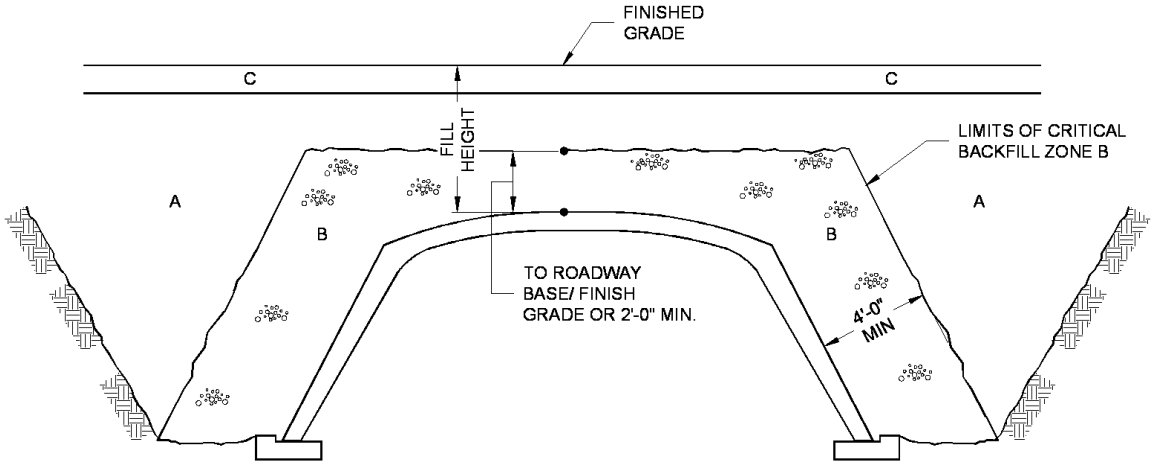
13.8.2. No backfill shall be placed against any structural elements until they have been approved by the Engineer.

13.8.3. Backfill shall be considered as all replaced excavation and new embankment adjacent to the precast concrete elements. The project construction and material specifications, which include the specifications for excavation for structures and roadway excavation and embankment construction, shall apply except as modified in this section.

13.8.4. Backfill Zones

- In-situ soil
- Zone A: constructed embankment or overfill.
- Zone B: fill that is directly associated with precast concrete bridge installation.
- Zone C: road structure.

13.8.5. Required Backfill Properties



SPAN	FILL HEIGHT	ACCEPTABLE MATERIAL INSIDE ZONE B
≤ 24'-0"	≥ 12'-0"	A1, A3
≤ 24'-0"	< 12'-0"	A1, A2, A3, A4
> 24'-0"	all	A1, A3

13.8.5.1. In-situ soil

Natural ground is to be sufficiently stable to allow effective support to the precast concrete bridge units. As a guide, the existing natural ground should be of similar quality and density to Zone B material for minimum lateral dimension of one bridge span outside of the bridge footing.

13.8.5.2. Zone A

Zone A requires fill material with specifications and compacting procedures equal to that for normal road embankments.

13.8.5.3. Zone B

Generally, soils shall be reasonably free of organic matter, and, near concrete surfaces, free of stones larger than 3 inches in diameter. See charts for detailed descriptions of acceptable soils.

Acceptable Soils for use in Zone B Backfill

Typical USCS Materials	AASHTO Group	AASHTO Subgroup	Percent passing US Sieve No.			Character of Fraction passing No. 40 Sieve		Soil Description
			#10	#40	#200	Liquid Limit	Plasticity Index	
GW, GP, SP	A-1	A-1a	50 max	30 max	15 max		6 max	Largely gravel but can include sand and fines
GM, SW, SP, SM		A-1b		50 max	25 max		6 max	Gravelly sand or graded sand, may include fines
GM, SM, ML, SP, GP	A-2	A-2-4			35 max	40 max	10 max	Sands, gravels with low-plasticity silt fines
SC, GC, GM		A-2-5			35 max	41 min	10 max	Sands, gravels with plastic silt fines
SP, SM, SW	A-3			51 min	10 max		non-plastic	Fine sands
ML, SM, SC	A-4				36 min	40 max	10 max	Low-compressibility silts

13.8.5.4. Zone C

Zone C is the road section of gravel, asphalt or concrete built in compliance with local engineering practices.

13.8.5.5. Geotechnical engineer shall review gradations of all interfacing materials and, if necessary, recommend geotextile filter fabric (provided by contractor).

13.8.6. Placing and Compacting Backfill

Dumping for backfilling is not allowed any nearer than 3 ft from the bridge leg.

The fill must be placed and compacted in layers not exceeding 8 inches. The maximum difference in the surface levels of the fill on opposite sides of the bridge must not exceed 2 feet.

The fill behind wingwalls must be placed at the same time as that of the bridge fill. It must be placed in progressively placed horizontal layers not exceeding 8 inches per layer.

The backfill of Zone B shall be compacted to a minimum density of 95% of the Standard Proctor, as required by AASHTO T-99.

Soil within 1 foot of concrete surfaces shall be hand-compacted. Elsewhere, use of rollers is acceptable. If vibrating roller-compactors are used, they shall not be started or stopped within Zone B and the vibration frequency should be at least 30 revolutions per second.

The backfill material and compacting behind wingwalls shall satisfy the criteria for the bridge backfill, Zone B.

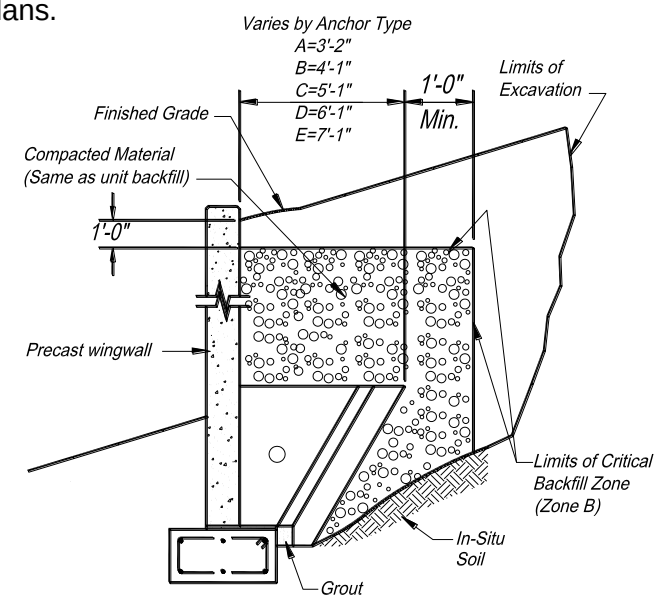
Backfill against a waterproofed surface shall be placed carefully to avoid damage to the waterproofing material.

13.8.7. Bridge Units

For fill heights over 12 feet (as measured from top crown of bridge to finished grade), no backfilling may begin until a backfill compaction testing plan has been coordinated with and approved by CONTECH® Engineered Solutions.

13.8.8. Wingwalls

Backfill in front of wingwalls shall be carried to ground lines shown in the plans.



13.8.9. Monitoring

The contractor shall check settlements and horizontal displacement of foundation to ensure that they are within the allowable limit provided by the engineer. These measurements should give an indication of the settlements and deformations along the length of the foundations.

The first measurement should take place after the erection of all precast bridge system elements, a second after completion of backfilling, and a third before opening of the bridge to traffic. Further measurements may be made according to local conditions.

END OF SECTION 33 42 00

