

PART 1: GENERAL

1.1 Description:

- A. Provide all labor, materials, equipment and supervision to install a vegetated wall/slope system in accordance with these specifications and in reasonable close conformity with the dimensions shown on the plans or as specified by the Owner or Owner's Engineer.
- B. Work shall consist of furnishing and installing appurtenant materials required for the construction of the vegetated system shown on the construction plans.

1.2 Related Sections:

- A. Coordinate related work specified in other parts of the contract documents, including but not limited to the following:
 - 1) Section 02200 - Site Preparation
 - 2) Section 02300 - Earthwork
 - 3) Section 02900 - Planting

1.3 Reference Standards

- A. Engineering design
 - 1) AASHTO, "Standard Specification for Highway Bridges," 17th edition, 2002.
 - 2) AASHTO, "AASHTO LRFD Bridge Design Specifications", fifth edition, 2010.
- B. Soils
 - 1) ASTM D 422 Standard Test Method for Particle-Size Analysis of Soils
 - 2) ASTM D 698 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lb/ft³ (600 kN-m/m³))
 - 3) ASTM D 1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
 - 4) ASTM D 2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
 - 5) ASTM D 6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
 - 6) ASTM D 4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
 - 7) ASTM D 6913 Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

1.4 Design Requirements

- A. Design Method
 - 1) All designs shall conform to the minimum safety factors in this Specification. Design submittals not meeting this design criteria or technical/administrative criteria specified will be rejected in their entirety until complete compliance is achieved.
 - 2) Design of reinforced soil slopes shall be in accordance with design guidelines presented in the AASHTO Bridge Manual.

B. Design Parameters

- 1) The design of the SRW system shall be based on the following soil parameters provided by the Owner.

<u>Soil</u>	<u>w'</u>	<u>c'</u>	<u>Unit Wt.</u>
Reinforced Backfill	___ ° (min)	___ psf (kPa)	___ pcf (kN/m3)
Retained Backfill	___ °	___ psf (kPa)	___ pcf (kN/m3)
Foundation Backfill	___ °	___ psf (kPa)	___ pcf (kN/m3)

1.5 Submittal

- A. Material Submittals: The Contractor shall submit manufacturer's certifications, 30 days prior to the start of work, stating that the vegetated units and associated components including , geosynthetic reinforcement, reinforced backfill, and gravel fill meet the requirements of Part 2.0 of this specification. The Contractor shall provide a list of successful projects with references showing that the installer for the segmental retaining wall is qualified and has a record of successful performance.
- B. Installation Instructions: Manufacturer's printed installation instructions. Include methods for maintaining installed products.

1.6 Quality Assurance

- A. Manufacturer's Field Representative Qualifications: Experienced in the installation of the specified products.
- B. Installer Qualifications: Experienced in performing work of this section who has specialized in installation of work similar to that required for this project.
- C. Pre-installation Meeting: Convene a meeting a minimum of two weeks prior to start of vegetated system. Verify project requirements, manufacturer's installation instructions and coordination with other work. Require attendance of parties directly affecting work of this section, including the contractor, engineer, installer, and manufacturer's representative.

1.7 Delivery, Storage and Handling

- A. The Contractor shall inspect the materials upon delivery to assure that proper type and grade of material has been received.
- B. The Contractor shall store and handle materials in accordance with manufacturer's recommendations and in a manner to prevent deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping or other causes.
- C. The Contractor shall protect the materials from damage. Damaged material shall not be incorporated into the segmental retaining wall.

1.8 Definitions

- A. Retained Soil
1) Compacted, imported or in-situ soil behind reinforced zone of the retaining wall.
- B. Reinforced Soil
1) Compacted fill placed in the area behind that face units with internal geogrid reinforcing.

PART 2: Products

2.1 Approved Vegetated Slope/Wall Systems

- A. Suppliers of vegetated system material components shall have demonstrated experience in the supply of similar size and types of vegetated retaining walls on previous projects and shall be approved by the Owner's Engineer. Each supplier must be approved two weeks prior to bid opening. Systems currently approved for this work are:
 - a) Envirolok Vegetated Environmental Solutions
 - 2) Geosynthetic Reinforcements
 - a) Strata Systems
 - b) T.C. Mirafi
 - c) _____

2.2 Envirolok units

- A. The Envirolok unit is composed of 100% polypropylene must be weather resistant to minus 30 degrees Celsius and is 100% recyclable. Two connection pins shall be supplied per unit, interconnecting the units vertically and horizontally.
- B. The Envirolok Unit is for use in all slope system applications including applications using P.E.T. (polyester) geogrids or HDPE (high density polyethylene) for geogrid reinforced wall and slope applications.
- C. Envirolok Bags are made from a specifically designed tan colored Non-Woven geotextile that will not rot or mildew, is non-biodegradable and is resistant to damage from insects and rodents. The Envirolok bags provide a filtering functionality, are water permeable and root friendly. Vegetated Bags have met all applicable ASTM standards for geotextile testing.
- D. Envirolok units shall be manufactured from polypropylene resins. Facing panel polymers shall be greater than 70% U.V. stabilized after 1000 hours testing (ASTM 4355).
- E. Units are manufactured using an ultra violet resistant (UVR) bonded anti-wick polyester threat.
- F. Unit color shall be earth color (light brown or tan) to reduce heat absorption from sunlight to promote greater germination without heat damage.

2.3 Connection Pin

- A. Connection pin devices shall be polymeric and shall penetrate the units a minimum of 2 inches to form a positive connection.
- B. Connection pins shall penetrate the geogrid reinforcing connecting the reinforcing to the vegetated facing system.
- C. Connecting pins shall have a 35% open geometry to allow root penetration through the locking pin.

2.4 Cinching and Twining

- A. Cinching and twining strips shall be high tenacity, multifilament polyester geogrid strips as supplied by the manufacturer.

2.5 Infill Soil/ Reinforced Backfill

- A. The reinforced backfill shall be free of debris, and consist of one of the following inorganic USCS soil types: SW, SP, SM, SC, meeting the following gradation as determined in accordance with ASTM D 422.

Sieve Size	Percent Passing
1 in.	100
No. 4	100 - 20
No. 40	0 - 60
No. 200	0 - 35

- B. Cohesionless, coarse-grained soils (sand), are preferred; finer soils with low-plasticity (i.e., PI of the finer fraction is less than 20) may be used provided they are approved by the Owner.
- C. The maximum size should be limited to 1-in. for geosynthetic reinforced soil unless tests have been performed to evaluate potential strength reduction in the geosynthetic due to installation damage.

2.6 Soil Reinforcement

- A. Geosynthetic reinforcement formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock or earth and function as reinforcement. Soil reinforcement shall be specifically manufactured for use in reinforcing soil materials.
- B. Geosynthetic Reinforcements shall consist of high tenacity PET geogrids, HDPE geogrids, or geotextiles manufactured for soil reinforcement applications. The type, strength and placement location of the reinforcing geosynthetic shall be as shown on the plans. The design properties of the reinforcement shall be determined according to the procedures outlines in this specification and the NCMA Design Manual for Segmental Retaining Walls (3rd Edition, 2009) Detailed test data shall be submitted to the Owner's Engineer for approval at least 30 days prior to construction.

2.7 Unit Bag Fill Material

- A. Bag fill material should be selected with the desired vegetation and specific application in mind. Criteria for bag fill soils should be specified by the Designer, suggestions include:
- B. Walls, slopes and above High Waterline Applications
- 1) Freely draining native soils and granular materials clean of all debris, roots, branches, stones in excess of 2" (50 mm) diameter and other deleterious materials. Remove soil contaminated with calcium chloride, toxic materials and petroleum products.
 - 2) Recommended mix shall include 70-80% Sand and 20-30% Topsoil.
 - 3) Properties should include (by volume)
 - a) Approximate Top Soil Content: 20-30% (for an engineered structure)
 - b) Topsoil shall be a sandy-loam to clay loam based soil. It shall be of uniform composition, screened and free of stones greater than 2" (50 mm), lumps, plants, and their roots, debris and other extraneous matter over one inch in diameter.
 - c) Soil should be tested prior to screening and stock piling to ensure it is free from containments that would inhibit plant growth or harm water quality.
 - d) Approximate Sand Content: 70-80%
 - e) Granular Content: smaller than 50 mm larger than 2 mm 60 - 70%
 - f) Granular Content larger than 0.05 mm smaller than 2mm 10 -15%

- g) Use of Compost (Organic) Content: Use of Compost is not recommended for standard applications, unless approved by Project Engineer or Manufacturer. Percentage content shall not exceed 10%.
- h) Clay and Silts 0 - 5%
- i) Percolations shall be such that no standing water is visible 60 minutes after at least 10 minutes of moderate to heavy rain or irrigation.
- j) Top Soil materials should be a locally available or from commercially provided sources.
- k) Mix all Top Soil materials evenly throughout the bag fill material.
- l) Do not deliver or store soils in frozen, wet, or muddy conditions.
- m) Protect soils and mixes from absorbing excess water and from erosion at all times.
- n) Do not store materials unprotected from large rainfall events.
- o) Fill per bag is approximately 1.25 cu ft. (.0354 m³)
- p) Other criteria may be required in Project Specific Engineered Drawings. Refer to Contract Documents.
- q) Clay soils shall not be used for bag fill.

C. Below Waterline Applications

- 1) Clean Granular material; 3/4 in (20mm) gravel minimum particle size 2mm.

2.8 Vegetated Materials

- A. Vegetation shall be applied through hydro-seeding, hand application and/or planting methods.
- B. Live Vegetation / Vegetation Mix shall [can] be applied during the construction of the structure or after completion of construction.
 - 1) Hydro-seeding can be applied after completion of the structure.
- C. Hydro-seeding can be applied after completion of the structure or in phases as approved by the Owner.
- D. Vegetation should be selected with consideration of the environment - weather, climate, exposure, etc. A vegetation specialist may assist in the selection of plant materials.
- E. Depending on the location and climate, an irrigation system may need to be incorporated within the Vegetated System.
 - 1) A low pressure drip irrigation system may be located between selected rows should be used (if required)
- F. Vegetation methods Include, but are not limited to:
 - 1) Slurry Mix (Hand Seeding Application)
 - 2) Hydro-seeding
 - 3) Live Planting
 - 4) Live Staking
 - 5) Brush Layering
 - 6) Native Vegetated Mat
 - 7) A mix of Hydro-seeding and Planting or Native Vegetated Mat is recommended for rapid establishment and consistent coverage.

2.9 Materials NOT Allowed for Vegetated Wall / Slope Solutions

- A. Systems or components that would provide entrapment to mammals.
- B. System or components that will oxidize.
- C. Systems with exposed surfaces or pieces that could cause injury to people or animals climbing or traversing the vegetated wall / slope system.
- D. Systems that do not allow for 100% percent vegetation on exposed surfaces.

PART 3: Execution

3.1 General

- A. Construction and construction tolerances shall be in accordance with the plans or specifications. Grades shall be within 3 inches of the grades shown on the plans, or as specified.
- B. Before beginning installation, verify site conditions are as indicated on the drawings. Notify the Owner if site conditions are not acceptable. Do not begin preparation or installation until unacceptable conditions have been corrected.

3.2 Construction Observation

- A. The Owner or Owner's Engineer should verify the materials supplied by the contractor meet all the requirements of the specification. This includes all submittals and proper installation of the system.
- B. The Contractor should have demonstrated experience with the installation of the Envirolok system. Installation training is recommended for all contractors and can be acquired through Envirolok or Envirolok Distributor.
- C. The Contractor's field construction supervisor shall have demonstrated experience and be qualified to direct all work at the site.

3.3 Site Preparation

- A. Clear and grub existing area.
- B. Test native soils for suitability as bag fill material (if site soil is used as filler) and backfill material. (reference sections 2.5 and 2.7)
- C. If unit bags are filled on site, prepare a suitable "work area" ideally located near the site that allows for stockpiling.

3.4 Preparation of Vegetated Units

- A. Ensure the bag fill material is suitably mixed with any required additives prior to beginning the filling process. Fill materials are shown in section 2.
- B. Fill the bags completely, to a consistent weight, density, and size, allowing adequate geotextile material for secure closure of the bag.
 - 1) Placed and compacted units should have approximately one square of face area.
- C. Bag closure methods include but are not limited to methods such as zip-ties, stapling or sewing. Bags shall be sewn utilizing UV-resistant Bonded Polyester thread as approved by the manufacturer.
- D. Vegetated units shall be stored in a covered area and shall be kept dry.

3.5 Excavation

- A. Contractor shall excavate to the lines and grades shown on the project grading plans and SRW plan and profile drawing. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted infill material, or as directed by the Owner/Engineer, at the Contractor's expense.

3.6 Foundation Preparation

- A. Following excavation for the leveling pad and the reinforced soil zone, foundation soil shall be examined by the Owner's Engineer to assure the actual foundation soil strength meets or exceeds the assumed design bearing strength. Soils not meeting the required strength shall be removed and replaced with soil meeting the design criteria, as directed by the Owner's Engineer.

3.7 Drainage

- A. Refer to Engineering Drawings and Specifications for drainage structures, and comply with requirements.

3.8 Installation

- A. Refer to Engineering Drawings and Specifications for construction.
- B. Install the base course of filled Vegetated bags as per design drawings. Compact the units to ensure the connection pin penetrate the bags. Place the initial row of bags perpendicular to the direction of slope with snorkels facing inward. In more decorative applications, or if specified by Engineer, initial row may be placed so that the bag seam is horizontal and faces inwards towards backfill material. Start installation at the lowest point.
- C. Install drainage system if required.
- D. Place and compact backfill every course of bags.
- E. Place bags so that the seam is horizontal and faces inwards towards backfill material. Place Vegetated units to straddle each juncture of soil bags as shown in the engineered drawings. Compact every row to ensure the connection pins on the unit interlock penetrate the bags.
 - 1) Connection pins interlock three units to form a totally connected slope/wall structure.
- F. Maintain the specified batter or slope as rows of Vegetated units are placed.
- G. Place Coping Layer (Top Row of bags) perpendicular to the direction of slope with snorkels facing inward, unless otherwise approved by Engineer.

3.9 Backfill

- A. Backfill shall be placed in maximum 8 inch (200mm) uncompacted lift thickness and compacted to 95 percent Standard Proctor density as determined in accordance with ASTM D 698. The in-place moisture content shall not exceed the optimum moisture content as determined in accordance with ASTM D 698 and shall be no lower than 3 percentage points below optimum moisture content.
- B. Backfill shall be placed, spread, and compacted in such a manner that minimizes the development of slack or loss of tension in the geogrid reinforcement layer. Preferred placement is from the units back toward the tail of reinforcement to increase tension.
- C. Only hand operated compaction equipment shall be operated within 3 feet (1m) of the back of the Vegetated units.
- D. Tracked equipment shall not be operated directly on the reinforcing. A minimum thickness of 6 inches (150mm) of fill is required prior to operating tracked equipment over the reinforcing.
- E. Rubber tired equipment may be operated on the geogrid reinforcing if care is taken, avoiding sudden braking and sharp turns.
- F. At the end of each day's operation the Contractor shall grade the backfill away from the wall area and direct runoff away from the wall area. The Contractor shall not allow surface runoff from adjacent areas to enter the wall construction area.

3.10 Geogrid Installation

- A. Geogrid reinforcing shall be cut and laid at the proper elevations as shown on the construction drawings or as directed by the Engineer.
- B. Correct orientation (generally the roll direction) of the geogrid shall be verified by the Contractor with the strength direction placed perpendicular to the wall face.
- C. Geogrid reinforcing shall be attached to the Vegetated system by placing the geogrid to the front face of the Vegetated unit above the installed course. Install the connecting pins through geogrid and into the Vegetated units. The next course of units shall be placed, and compacted locking the reinforcement in place.
- D. Geogrid shall be pulled taut removing any slack in the layer while fill is placed over the reinforcing. Care shall be taken to not operate equipment directly on the reinforcing to minimize potential for damage.

3.11 Vegetating

- A. Finish in accordance with the supplier recommendations.

- B. Vegetation can be applied through seeding or planting methods. Vegetation/ vegetation mix to be applied to the structure within two weeks of Vegetated System placement.
- C. Bags shall be watered prior to installing any vegetation. Soak bags thoroughly using low pressure water source.
- D. Seeding:
 - 1) Hydro-seeding is the preferred method of seeding. Apply hydro seeded material to the wall or slope face of the Vegetated structure to achieve complete coverage of the exposed bag face.
 - 2) Use a seed mixture which responds to the specific site environmental conditions such as shoreline, roadside, interior grasslands. The mixture should contain a variety of easily germinated, hardy, drought resistant vegetation proven for the area and exposure.
- E. Live Planting:
 - 1) Planting with locally available native plants, ornamental or plants proven to be sustainable in the area may also be used to re-vegetate the structure.
 - 2) The root ball can be positioned snugly under the Vegetated bags. Depending on the chosen plants and site location, a 10gm slow release fertilizer tablet sitting on top of the root ball may be required. Refer to construction documents for plant list, spacing and placement instructions.
 - 3) Plants shall be placed between bags only. DO NOT Puncture bags or place plant material inside the bag.
 - 4) Plant Size Recommendations: Plants shall be 2.5" square pots or smaller. For best establishment results and to lessen undulation of bags, 2"x5" deep plugs are recommended.
- F. Live Staking:
 - 1) Live-staking with locally available native materials such as willows may be used to re-vegetate the structure. Live staking is achieved by placing between units to be in contact with soil behind the units. Timing of construction must be coordinated to ensure the survivability of live stakes for successful vegetation.
 - 2) Plants shall be placed between bags at vertical and horizontal joints. DO NOT Puncture bags or place plant material inside the bag.
- G. Brush Layering:
 - 1) Brush layering is achieved by placing the plant between the bags with the root ball behind the Vegetated System. This method is may be recommended with applications in water.
 - 2) Plants shall be placed between bags at vertical and horizontal joints. DO NOT Puncture bags or place plant material inside the bag.
- H. Native Vegetative Mat (NVM)
 - 1) NVM is a pre-grown mat utilizing native grasses and forbes available in a variety of custom mixes with locally available species. NVM should be used for sites requiring rapid establishment.
 - 2) NVM Specifications
 - a) NVM shall be produced from a native seed matrix, free from any noxious or invasive species.
 - b) The mat shall be comprised of a soilless media and integrated core.
 - c) Soilless Media shall be comprised of Agrecol Mat Blend 9002 and free of any admixture of soil, slag, clay stones or any other extraneous matter. PH values may range between a minimum of 5.4 and a maximum of 7.0
 - d) Integrated core shall be 100% biodegradable coir mat of woven coir fibers evenly machine twisted and spun at 20.5 to 25.5 oz/ sy. Biodegradable longevity shall be 3-6 years.

- e) Native Mat Thickness shall include a root zone depth of 1" ±.20.
- f) Standard roll size shall be 40" wide x 132" long.
- 3) Installation & Care
 - a) Place a 1" layer of topsoil over the Envirolok units. Be sure to fill voids at seams and between courses of bags.
 - b) Mat should be anchored in place with sod staples, wooden stakes or rebar stakes, depending on site conditions.
 - c) Water or irrigate every few days for the first two weeks upon installation. Continue watering or irrigating to the equivalent of ½" every four days for 4-6 weeks.
 - d) Monitor waterings to ensure proper moisture and establishment.
- 3.12 Field Review
 - A. Field Review at regular intervals to ensure satisfactory germination and/or coverage of the Vegetated bags.
 - B. At six months, if adequate coverage of the Vegetated system has not occurred it is recommended that reseedling or remedial planting be performed.
- 3.13 Field Quality Control
 - A. Field Quality Assurance - The Owner shall engage inspection and testing services, including independent laboratories, to provide quality assurance and testing services during construction. As a minimum, quality assurance testing should include foundation soil inspection, inspection for the need for any additional drainage, soil and backfill testing, verification of design parameters, and observation of construction for general compliance with design drawings and specifications. This does not relieve the Contractor from securing the necessary construction quality control testing during construction.
 - B. Field Quality Control - The Contractor's quality control testing and construction inspection services shall only be performed by independent, qualified and experienced technicians and engineers. The Contractor's quality control testing, as a minimum, shall include:
 - 1) Field density testing
 - 2) Sub grade: one test for every 2500 square feet (230 sm) of sub grade.
 - C. Reinforced Backfill: one test for every 2500 square feet (230 sm) per lift with a minimum of one test for every other lift.
 - D. Retained and Foundation Soil: per Section 02200 (Site Preparation).
 - E. Laboratory Moisture Density - minimum one test per soil type.
 - F. Gradation Analysis
 - 1) Unit Fill: one test per 500 CY (400 cm)
 - 2) Backfill: one test per 1000 CY (800 cm)
- 3.14 Vegetation Maintenance
 - A. Field Review at regular intervals to ensure that vegetation is in a healthy and vigorous growing condition for a period of not less than three years from substantial completion.
 - B. It is recommended that a low-volume, temporary drip irrigation system be installed that applies not less than one inch water per week during the active growing season throughout the warranty period, with supplemental watering as needed to prevent desiccation of any vegetation.
 - 1) Provide system that provides not less than one inch water per week for a period of not less than 90 (ninety) days from substantial completion. In the event that substantial completion occurs after 30 October, continue irrigation the following spring to insure establishment.
 - C. Promotion of growth; Weeding of exotic vegetation shall be by cutting back

- growth to discourage re-seeding or establishment. Water and perform other operations necessary to promote vigorous growth and as approved by [Owner] [Engineer] and consistent with approved Integrated Pest Management Plan.
- D. Inspect vegetation at least weekly during the active growing season and perform needed maintenance promptly. Herbicides and pesticides are not recommended; use organic/natural matter for pest and disease control. Do not fertilize wildflowers, sedges or grasses.
 - E. At end of maintenance period, request End of Maintenance Period Inspection by [Owner] [Engineer].
 - 1) Final acceptance of wildflowers, sedges and grasses will be based upon a satisfactory establishment of vegetation. Establishment of groundcover and grass is 95 percent ground cover of established species. Replant areas which do not have a satisfactory establishment of wildflowers, sedges and grasses. Final acceptance of vegetation will be based upon satisfactory health and vigor of plants.
 - F. When work is found to be unsatisfactory, maintenance period will be extended at no additional cost to Owner until work has been completed, inspected and accepted by [Owner] [Engineer].
 - G. Warrant living planting materials for a period of three years after date of Substantial Completion, against defects including death and unsatisfactory growth, except for defects resulting from abuse, vandalism or events beyond the control of the installer for the duration of the warranty period.
 - 1) Remove and replace dead vegetation immediately unless required to plant in the succeeding planting season.
 - 2) Replace planting materials that are more than 25 percent dead or in an unhealthy condition as determined by the [Owner] [Engineer] at end of the warranty period.