

## SECTION 329500

### GREEN ROOF ASSEMBLY

#### **PART 1 GENERAL**

##### 1.1 SUMMARY

- A. Section specifies all labor, materials, transportation, equipment and services necessary to assemble a complete green roof assembly, as provided by Roofmeadow and as shown on the Drawings and as described herein. This system shall be installed in conjunction with a compatible roof waterproofing system.
- B. Related requirements specified elsewhere include:
  - 1. Waterproofing – Section xxxxxxx.

##### 1.2 REFERENCES

- A. Referenced standards and abbreviations. (Where applicable, use the most recent available standard.)
  - 1. System Provider's specifications and recommendations
  - 2. American Standard Testing Method Standards – abbreviated as "ASTM"
  - 3. ASTM E2396: Standard Testing Method for Saturated Water Permeability of Granular Drainage Media [Falling-Head Method] for Green Roof Systems
  - 4. ASTM E2399: Standard Testing Method for Maximum Media Density for Dead Load Analysis
  - 5. ASTM D5199: Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
  - 6. ASTM D4833: Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
  - 7. ASTM D5261: Standard Test Method for Measuring Mass per Unit Area of Geotextiles
  - 8. ASTM E2397: Standard Practice for Determination of Dead Loads and Live Loads Associated with Green Roof Systems
  - 9. ASTM C131: Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
  - 10. ASTM C88: Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
  - 11. ASTM C29M: Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
  - 12. ASTM C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
  - 13. ASTM D3776: Standard Test Methods for Mass per Unit Area (Weight) of Fabric
  - 14. ASTM D4632: Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
  - 15. ASTM D4491: Standard Test Methods for Water Permeability of Geotextiles by Permittivity
  - 16. ASTM D422: Standard Test Method for Particle-Size Analysis of Soils
  - 17. ASTM D5035: Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
  - 18. ASTM D1777: Standard Test Method for Thickness of Textile Materials
  - 19. ASTM D4716: Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
  - 20. ASTM D3786: Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method

21. ASTM D1621: Standard Test Method for Compressive Properties of Rigid Cellular Plastics
22. ASTM C40: Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
23. ASTM C140: Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
24. ASTM C67: Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
25. UL Inc.: Class a Classification for use in Ballasted Systems
26. Methods of Soil Analysis, American Society of Agronomy (1996) - abbreviated as "MSA"
27. Test Methods for the Examination of Composting and Compost (latest) – abbreviated as "TMECC"
28. Recommended Chemical Soil Testing Procedures, North Central Region Publication #221 – abbreviated as "RCSTP"
29. USDA Handbook #60 – abbreviated as "USDA"
30. Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V. [The Landscaping and Landscape Development Research Society], methods to be based on the latest English edition – Abbreviated as "FLL"
31. SPRI VR-1: Procedure for Investigating Resistance Root Penetration on Vegetated Roofs

### 1.3 DEFINITIONS

- A. **Drain Access Chamber:** Open-ended box or cylinder that covers drains and/or scuppers. The chamber must be designed to admit water freely at the base. It must also have a removable lid to prevent debris from entering the chamber. The choice of chamber type will depend on the type of deck drain or scupper in use. See 1.5 Submittals.
- B. **Drain Conduit:** Perforated or slotted conduit installed in the drainage layer that is used to intercept and drain away percolating rainfall during design storm events.
- C. **Drainage Layer:** A granular mineral material, synthetic sheet drain, or moisture management mat used to: 1) promote aerated conditions in the overlying growth media layer, and 2) manage rainfall runoff and convey it to the roof drains. Granular drainage layers also will augment the root volume for the plants.
- D. **Drawings:** Plans, sections and details included in the contract documents of which this Specification is a part.
- E. **Growth Media:** An engineered soil-like material designed to retain moisture, manage plant nutrients, and support vigorous growth of the foliage.
- F. **EFVM® (Electric Field Vector Mapping®):** A leak location technique that relies on the electrical conductivity of the cover material (moist media) and electrical insulating properties of the waterproofing membrane. The compatibility of EFVM® with a specific waterproofing system must be established in advance by the EFVM® service provider.
- G. **Manning formula for conveyance** (ft<sup>3</sup>/s):  $K = (1.49 \times A \times R^{(2/3)})/n$ ;  
A=area (ft<sup>2</sup>), R=hydraulic radius (ft), n=Manning's roughness coefficient (dimensionless).
- H. **Root-Barrier:** A thermoplastic membrane designed to prevent root penetration of the underlying waterproofing and to retain moisture in the root zone.
- I. **System Provider:** Company that provides or certifies all materials required for installation of the green roof assembly, furnishes on-site coordination and inspection, and

offers long-term support and warranty protections for the completed green roof assembly. This company shall be Roofmeadow.

- J. **Waterproofing Provider:** Company that provides or certifies all materials required for installation of the building waterproofing, furnishes on-site coordination and inspection, and offers long-term support and warranty protections for the completed waterproofing, including flashings, counter-flashings, coping, and deck drains.

#### 1.4 SYSTEM DESCRIPTION

- A. Design Requirements:
1. The green roof assembly shall be a single course system, consisting of a \_\_\_ inch growth media layer installed over a moisture management mat.
  2. The basis of design is the Roofmeadow Type I green roof assembly.
  3. This assembly is compatible with base capillary irrigation.
  4. This assembly is suitable for roofs with pitches ranging from 1/8:12 (0.6 degrees) to 2:12 (9.5 degrees). Assemblies installed on pitches steeper than 2:12 (9.5 degrees) will require supplemental slope stabilizing measures. (Consult System Provider for a slope stabilization system design that is suitable for the pitch and the roof architecture.)
  5. This assembly is compatible with pedestrian access and integration with patio and walkway elements.
- B. Performance Requirements: Green roof assembly shall:
1. Support a perennial vegetated ground cover.
  2. Provide efficient drainage of moisture that is in excess of that required for the vigorous growth of the installed vegetation.
  3. Protect roof waterproofing materials from damage caused by exposure to ultraviolet radiation, physical abuse, and rapid temperature fluctuations.
  4. Retain \_\_\_ inch of moisture at Maximum Water Capacity, in accordance with the referenced FLL or ASTM E-2397 standards.
  5. The wet dead weight of this system shall not exceed \_\_\_ pounds per square foot. (ASTM E-2397).
  6. Continue to perform as designed for the duration of the warranty period, without a requirement to: 1) replace materials or components or 2) amend or refresh the media.

#### 1.5 SUBMITTALS

- A. Product Data:
1. System Provider's technical literature showing compliance of all components with specified requirements. Documents shall be clearly marked to indicate all technical information which specifies full compliance with requirements of this section and Contract Documents.
  2. Certified laboratory report demonstrating compliance of the proposed media with this Specification.
- B. Shop Drawings: (provided prior to contract initiation)
1. A profile schematic showing thickness of all materials.
  2. Final layout for the internal drain conduit.
  3. Final irrigation plan approval by the Architect.
  4. Details of installation, showing conditions at terminations, transitions, drains, scuppers, and penetrations (if different from or supplemental to the Drawings).
  5. Fabrication detail or System Provider's information for drain access chambers. *(To use standard drain access chambers, deck drains and scuppers must conform to System Provider's requirements. Contact System Provider for more information.)*

C. Samples:

<u>Item No.</u>	<u>Quantity</u>	<u>Size</u>	<u>Description</u>
S1	1	4"x4"	Synthetic sheet components, including fabrics, sheet drains, reinforcing materials, and wind protection materials.
S2	1	12"	Perforated Conduit.
S3	1	6 oz	Growth Media for initial approval of the Architect.
S4		20 lbs	Washed Stone, for approval by the Architect

D. Statement of existing conditions that must be both achieved and present to begin installation of the green roof assembly.

E. Computational summary predicting the runoff properties of the green roof assembly for one or more design rainfall events specified by the Owner. *(Optional, for projects that are part of a site stormwater management program; not available for some regions of the country.)*

F. System Certification signed by the System Provider, certifying that:

1. The submitted green roof assembly complies with the specified system requirements. (See 1.4 System Description.)
2. The waterproofing system is fully compatible with the green roof assembly.
3. The submitted green roof assembly is eligible for the specified warranty required by the System Provider. *(If a single-source warranty is preferred, consult System Provider for options.)*
4. The proposed use is appropriate for each product.
5. The System Provider has reviewed and approved the details for the associated waterproofing system, including deck drains, flashings, penetrations, and copings.

G. Waterproofing Certification: Signed by the Waterproofing Provider, certifying that:

1. The proposed green roof assembly is fully compatible with the waterproofing assembly.
2. The finished waterproofing shall be tested under the direction of the Waterproofing Provider, as approved by System Provider, and shall be certified as watertight prior to installation of the green roof assembly.
3. The waterproofing assembly being supplied shall be separately warranted by the Waterproofing Provider, independent of any other warranties offered by the System Provider. *(If a single-source warranty is preferred, consult System Provider for options.)*

H. Maintenance Program: Shall clearly describe the procedures for maintaining the green roof assembly, including a maintenance schedule for the first 24 months. The schedule must include a minimum of six documented maintenance visits.

I. Affidavit: Signed by the System Provider, stating that the green roof assembly installation contractor ("Green Roof Installer") is certified by the System Provider to install the assembly.

J. Final Plant List: For approval by the Architect.

K. Completed Dead Load Worksheet (ASTM E2397).

1.6 DELIVERY, HANDLING, STORAGE

- A. Sedum cuttings shall be shipped to the site in cartons. The shipping time shall not exceed 24 hours. Upon receipt, the cartons should be opened immediately (do not moisten). If installation of the cuttings will be delayed until the following day, empty the contents of the cartons and spread the cuttings onto a moistened non-woven fabric or felt. The cutting should be stored in a shaded but sunlit area, sheltered from the wind.
- B. Plants shall be delivered in labeled flats and pots. They shall be stored in a shaded, but sunlit area and watered once every 36 hours until they are installed. One label representing each plant variety shall be preserved and included with the project documents.
- C. Pre-grown Sedum mats shall be delivered in rolls. They shall be stored in a shaded area for no longer than 24 hours and lightly watered during this time period as needed. A listing of each plant variety in the pre-grown Sedum mats shall be preserved and included with the project documents.
- D. Bulk earth materials shall be laid down on a tarp and covered with a tarp to minimize contamination, protect them from weed seed infiltration and maintain them in a dry condition.
- E. Synthetic components shall be accompanied by identifying labels. They shall be stored out of direct sunlight.
- F. Pavers and masonry materials shall be palletized, shrink-wrapped, and stored in a safe and secure location.
- G. Provide a description of how the completed waterproofing shall be protected between the time it is certified by the Waterproofing Provider as watertight and the time that installation of the green roof assembly can begin. The description shall include:
  - 1. Method for ballasting the finished waterproofing
  - 2. Procedures for protecting the finished waterproofing from physical damage
  - 3. Procedures for controlling access to the finished waterproofing

## 1.7 QUALITY ASSURANCE

- A. Warranty *(If a single source warranty is preferred, contact System Provider for options.)*
  - 1. A \_\_\_-year Standard Warranty shall be provided by the System Provider at the point of substantial completion. The terms of this warranty shall incorporate the following:
    - a. This warranty shall guaranty 80% foliage coverage after a period of 24 months so long as the green roof assembly is maintained according to the System Provider's requirements. Bare areas shall be reseeded as necessary.
    - b. Subject to the Workmanship Warranty requirements in 1.7.A.4, this warranty shall cover the cost of removing the green roof assembly, exposing and repairing the membrane, and restoring the green roof assembly, provided:
      - i. The System Provider approves the method and technician for leak location.
      - ii. A representative of the System Provider is present to observe the removal of the green roof assembly.
      - iii. The leak is attributable to physical damage caused by activities of the Green Roof Installer or representatives of the System Provider.
    - c. Subject to the Workmanship Warranty requirements in 1.7.A.4., this warranty also shall include provisions to repair or replace specified materials or Work that has failed within the warranty period. System

failures covered by the warranty shall include, but are not limited to, the following:

- i. Failure of the green roof assembly to support a robust ground cover
  - ii. Loss of soil permeability
  - iii. Development of anaerobic conditions in the profile
  - iv. Loss of drainage capacity
  - v. Development of soil pathogens
  - vi. Deleterious changes in pH
  - vii. Slope related instability of the green roof assembly
  - viii. Wind or water erosion of the green roof assembly
2. The warranty may exclude irrigation components. The Green Roof Installer shall deliver separately to the Owner the manufacturer's standard warranties for irrigation equipment. The warranty for driplines must be at least 5 years in duration
  3. The cost for the first two years of maintenance shall be included in the installation price and paid in advance to the Green Roof Installer.
  4. A two-year Workmanship Warranty shall be provided by the Green Roof Installer to the Owner and shall cover:
    - a. Workmanship and maintenance-related activities and components that shall be redone or removed and replaced at no cost to the Owner if, within the first twenty-four months after substantial completion, they are determined to be defective or not in accordance with contract documents.
    - b. The cost of removing the green roof assembly, exposing and repairing the membrane, and restoring the green roof assembly, provided:
      - i. The System Provider approves the method and technician for leak location.
      - ii. A representative of the System Provider is present to observe the removal of the green roof assembly.
      - iii. The leak is attributable to physical damage caused by activities of the Green Roof Installer.
- B. The work of this section shall be performed by a contractor that specializes in green roof installation work and that is licensed by the System Provider to install green roof assemblies. This company shall document the successful completion of at least 5 previous extensive roof projects.
- C. Temporary surface spray irrigation will be required during the first full growing season. The design and implementation of temporary irrigation is the responsibility of the Green Roof Installer. A suitable source of water supply shall be provided by the Owner. The irrigation dosing requirements to facilitate plant establishment shall be determined by the Green Roof Installer.
- D. Integration: All scope items related directly or indirectly to the green roof assembly shall be provided by one contractor. Tasks in addition to those specifically mentioned in this Specification may include the installation of:
  1. Patio and railing systems
  2. Paths and walkways
  3. Irrigation
  4. Stone
- E. System Provider's Field Supervision: The System Provider shall furnish a quality control specialist to observe critical aspects of the installation.
- F. Laboratory: Tests shall be conducted by an independent laboratory with the experience and capability to conduct the tests indicated. These may include, but are not limited to:
  1. A & L Great Lakes Laboratories, Inc. 3504 Conestoga Drive, Fort Wayne, IN 46808-4413 [260-483-4759]

2. *For specified FLL and ASTM test procedures:* Agricultural Analytical Services Laboratory, Penn State University, Tower Road, University Park, PA 16802 [814-863-0841]
  3. *For specified FLL and ASTM test procedures:* Turf Diagnostics & Design, 613 E. 1<sup>st</sup>, Linwood, KS 66052 [913-723-3700] www.turfdiag.com
- G. Coordination with Waterproofing Provider: Before commencement of the waterproofing installation, the Roofing Applicator and Green Roof Installer shall meet with the Owner's representative to discuss project sequence and methods for protecting and controlling access to the work (including ballasting of the completed waterproofing) and to review shop drawings to establish compliance with the specifications. At this time, the parties to this meeting shall specifically determine how the waterproofing will be protected between the time it is certified by the Waterproofing Provider as watertight and the time that installation of the green roof assembly can begin.

## 1.8 CONTRACT CLOSEOUT

- A. Signed warranty documents
- B. Maintenance Program

## PART 2 MATERIALS

### 2.1 ACCEPTABLE MATERIALS

- A. Materials in this section have been certified as suitable for this application and compatible by Roofmeadow.

### 2.2 ROOT BARRIER

- A. The Root Barrier subsystem consists of a 30-mil polyvinyl chloride, polypropylene, polyethylene or thermoplastic polyolefin membrane. Copper hydroxide-based root barriers or root barriers that incorporate root-inhibiting chemicals are not permitted. *(The appropriate root-barrier subsystem shall be chosen with regard to the waterproofing membrane and configuration.)*

### 2.3 PROTECTION LAYER

- A. Single-Sided Composite Drainage Net reinforcement underlayment consisting of a core constructed from two bonded, overlapping HDPE strands and with a 6 oz/sy non-woven fabric bonded to one side. This layer shall satisfy the following specifications:
  1. Thickness, core only (ASTM-D5199) ≥ 200 mil
  2. CBR Puncture Resistance of composite (ASTM-D6241) ≥ 1000 lb
- B. Protection Fabric that is an 8-ounce per square yard polypropylene or polyester non-woven needled fabric.
  1. Density (ASTM-D3776) ≥ 8 oz/yd<sup>2</sup>
  2. Puncture Resistance (ASTM D-4833) ≥ 105 lbs

### 2.4 DRAINAGE LAYER

- A. Perforated Conduit *(Select one.)*
  1. Triangular Perforated Conduit satisfying the following specifications:
    - a. Height ≤ 2.25 in
    - b. Open area (sides and top) ≥ 10 %
    - c. Slot or perforation size 1/16 - 1/8 in

- d. Hydraulic conveyance (K)  $\geq 0.02 \text{ ft}^3/\text{sec}$
  2. Rectangular perforated conduit, satisfying the following specifications:
    - a. Height  $\leq 2.25 \text{ in}$
    - b. Open area (sides and top)  $\geq 12 \%$
    - c. Hydraulic conveyance (K)  $\geq 1.4 \text{ ft}^3/\text{sec}$
  
- B. Geosynthetic Sheet Drain with adhered polypropylene non-woven separation fabric and a three-dimensional formed polyethylene core. The synthetic composite system shall satisfy the following specifications:
  1. System Thickness (ASTM D-1777)  $\geq 0.38 \text{ in}$
  2. Transmissivity, (ASTM D-4716)  $\geq 15 \text{ gal}/\text{min}/\text{ft}$   
(confining pressure of 1,000 psf, volumetric flow rate measured at 1.0 gradient)
  3. Compressive strength (ASTM D-1621)  $\geq 1,000 \text{ lb}/\text{ft}^2$
  4. Fabric:
    - a. Permittivity (ASTM-D4491)  $\geq 1.4 \text{ sec}^{-1}$
    - b. Puncture Resistance (ASTM-D4833)  $\geq 55 \text{ lb}$
    - c. Mullen Burst Strength (ASTM-D3786)  $\geq 160 \text{ lb}/\text{in}^2$
    - d. Grab Tensile (ASTM D-4632)  $\geq 90 \text{ lb}$
  
- C. Moisture Management Mat (*Select One*)
  1. Moisture Management Mat Option A composed of recycled closed-cell polyethylene foam with bonded separation fabric. The sheet includes bi-directional water channels on the underside to promote drainage.
    - a. Thickness  $\geq 1 \text{ in}$
    - b. Transmissivity (ASTM-D4716)  $0.002\text{--}0.08 \text{ m}^2/\text{s}$   
(confining pressure of 50 psf, volumetric flow rate measured at 0.02)
    - c. Compression Yield Strength (10% strain)  $\geq 250 \text{ lb}/\text{ft}^2$
    - d. Static Puncture Resistance (EN-ISO-12236)  $\geq 415 \text{ lb}$
    - e. Tensile Strength (EN-ISO-10319)  $\geq 180 \text{ lb}/\text{ft}^2$
  2. Moisture Management Mat Option B composed of a blend of polypropylene and acrylic. The mat incorporates water channels on the underside to promote drainage.
    - a. Density  $\geq 20 \text{ oz}/\text{yd}^2$
    - b. Transmissivity (ASTM-D4716)  $5\text{--}10 \text{ gal}/\text{min}/\text{ft}$   
(confining pressure of 150 psf, volumetric flow rate measured at 1.0 gradient)
    - c. Puncture Resistance  $\geq 120 \text{ lbs}$
  3. Moisture Management Mat Option C with adhered polypropylene non-woven separation fabric. The sheet is a three-dimensional mesh formed from tangled filaments. The composite system shall satisfy the following specifications:
    - a. System Thickness (ASTM D-1777)  $\leq 0.3 \text{ in}$
    - b. Transmissivity, (ASTM D-4716)  $\geq 10 \text{ gal}/\text{min}/\text{ft}$   
(confining pressure of 500 psf, volumetric flow rate measured at 1.0 gradient)
    - c. Fabric:
      - i. Permittivity (ASTM-D4491)  $\geq 2 \text{ sec}^{-1}$
      - ii. Puncture Resistance (ASTM-D4833)  $\geq 35 \text{ lb}$
      - iii. Grab Tensile (ASTM D-4632)  $\geq 120 \text{ lb}$
  
- D. Separation Fabric with root-permeable needled non-woven polypropylene or polyester separation fabric, satisfying the following specifications:
  1. Unit Weight (ASTM-D3766)  $\leq 6.25 \text{ oz}/\text{yd}^2$
  2. Permittivity (ASTM-D4491)  $\geq 1.5 \text{ sec}^{-1}$
  3. Puncture Resistance (ASTM-D4833)  $\geq 55 \text{ lb}$



- |                                       |                          |
|---------------------------------------|--------------------------|
| 4. Mullen Burst Strength (ASTM-D3786) | ≥ 160 lb/in <sup>2</sup> |
| 5. Grab Tensile (ASTM D-4632)         | ≤ 120 lb                 |

## 2.5 GROWTH MEDIA

- A. M1 Extensive Growth Media that is a mixture of mineral and organic components and that satisfies the following specifications:
- |   |                                 |
|---|---------------------------------|
| 1. Air Filled Porosity at Maximum Water Capacity (ASTM-E2399)   | ≥ 10%                           |
| 2. Maximum Water Capacity (FLL or ASTM-E2399)   | ≥ 20% (vol)                     |
| 3. Density at Maximum Water Capacity (ASTM-E2399)   | ≤ 70 lb/ft <sup>3</sup>         |
| 4. Water Permeability (ASTM-E2399-05)   | 1-5 in/min                      |
| 5. Alkalinity, Ca CO <sub>3</sub> equivalents (MSA)   | ≤ 2.5%                          |
| 6. Total Organic Matter, loss on ignition method (ASTM-F1647)   | 4-10% (dry wt.)                 |
| 7. pH (RCSTP)   | 6.5 – 8.0                       |
| 8. Soluble Salts (DPTA saturated paste extraction)  | ≤ 6 mmhos/cm (RCSTP)            |
| 9. Organic Supplements (compost, peat moss, etc.) (combined respiration rate (TMECC 05.08, B))  | ≤ 2 mg CO <sub>2</sub> /g TOM/d |
| 10. Cation exchange capacity (MSA)  | ≥ 10 meq/100g                   |
| 11. Grain-size distribution of the mineral fraction (ASTM-D422)   |                                 |
| a. Clay fraction (2 micron)   | ≤ 3%                            |
| b. Pct. Passing US#200 sieve (i.e., silt fraction)  | ≤ 7%                            |
| c. Pct. Passing US#60 sieve   | ≤ 10%                           |
| d. Pct. Passing US#18 sieve   | ≤ 35%                           |
| e. Pct. Passing 1/8-inch sieve  | 20 - 70%                        |
| f. Pct. Passing 3/8-inch sieve  | 70 -100%                        |
| 12. Total Nitrogen, TKN (MSA)   | 25-100 ppm                      |
| 13. Phosphorus, P <sub>2</sub> O <sub>5</sub> (Mehlich III)   | 20-200 ppm                      |
| 14. Potassium, K <sub>2</sub> O (Mehlich III)   | 150 ppm                         |
| 15. Other macro- and micro-nutrients shall be incorporated in the formulation in initial proportions suitable for support the specified planting. |                                 |
- B. Thoroughly blend at a batch facility. Moisten, as required, to prevent separation and excessive 'dusting' during installation.
- C. Quality control samples shall be collected for each 100 CY provided to the job. These samples shall be sealed in 2 gallon water-tight containers and held by the contractor for inspection by the Owner's representative.

## 2.6 PLANTS

- A. Sedum Cuttings
1. Freshly cut Sedum. Harvested Sedum shall not be flowering.
  2. Ship so that the cuttings are enclosed for no more than 30 hours.
- B. Plugs
1. *3 in deep, 72-cell plugs*, propagated in sterile nursery medium, according to the plant provider's recommendations.
  2. "Harden off" plugs prior to planting by gradually eliminating irrigation over a period of one week.
- C. Pre-Grown Sedum Mats shall contain Sedum varieties as specified by the System Provider and approved by the Architect. The media shall satisfy performance

requirements for Roofmeadow® Type M2 growth media. The mats shall be 90% covered when delivered to the project, satisfying the following specifications:

1. Thickness 0.75-1.25 in
2. Size 4 ft x 6.25 ft rolls
3. Foundation fabric
  - a. Wide Width Tensile (DIN 10319)  $\geq 1.1$  kN/m [CD] (dry)
  - b. Permittivity (ASTM-D4491)  $\geq 1.5$  sec<sup>-1</sup>

## 2.7 WIND PROTECTION

### A. Temporary Wind Scour Protection

1. Temporary Wind Blanket composed of biodegradable coir.
  - a. This product should be used when plants will be established from cuttings or plugs.
  - b. This blanket shall be secured using a method approved by the System Provider.
  - c. The wind scour blanket shall satisfy the following specification:
    - i. Tensile Strength (ASTM D-5035)  $\geq 100$  lb/ft
    - ii. Unit Weight (dry)  $\geq 8$  oz/sy
2. Tackifier Emulsion for use when establishing plants from plugs or pots. Consult System Provider for application rate. Typically Tackifier Emulsion must be re-applied as needed during the establishment period in order to secure media surface.
3. Hydro-Mulch for use after distributing the seed and/or cuttings. Seal the surface of the media using a wood-fiber Hydro-Mulch with Tackifier Emulsion. Consult the System Provider for binder specifications and coverage rates. Hydro-Mulch shall satisfy the following specifications:
  - a. Percent Wood Fiber  $\geq 70$
  - b. Rate of Application 175 lbs (dry) per 1,000 sf
  - c. Mixture Composition 30 lbs per 50 gal H<sub>2</sub>O

### B. Permanent Wind Scour Protection

1. Permanent Wind Blanket consisting of a PVC-coated geogrid manufactured with high molecular weight/high tenacity polyester yarn.
  - a. Permanent wind scour blanket shall be used within 5 feet of any leading edge.
  - b. This blanket shall be secured with a method approved by The System Provider. The permanent wind scour blanket shall satisfy the following specifications:
    - i. Aperture Width 0.5 – 1.0
    - ii. Tensile strength (ASTM D-6637)  $\geq 500$  lbs/ft
    - iii. Mass/Unit Area (ASTM D-5261)  $\geq 4.0$  oz/yd<sup>2</sup>
2. Stone that is non-carbonate washed, crushed or rounded river stone satisfying the grading requirements of AASHTO #3.
3. Turf Paver composed of concrete with rectangular apertures, satisfying the following specifications:
  - a. Width  $\geq 15$  in
  - b. Thickness  $\geq 3$  in
  - c. Weight 20-24 lb/ft<sup>2</sup>
  - d. Open Space  $\geq 40$  %
  - e. Aperture size  $\geq 12$  in<sup>2</sup>

### C. Tie Anchor

1. Nylon Tie Anchor that is a 14-in long Nylon 'zip' tie, satisfying the following specifications:
  - a. Length  $\geq 14$  in

- b. Breaking tensile strength ≥ 50 lb
  - 2. Stainless Steel Tie Anchor that is a stainless steel rope cable with copper ferrule connectors, satisfying the following specifications:
    - a. Breaking strength ≥ 250 lb
    - b. Diameter ≤ 1/16 in

## 2.8 BOUNDARY UNITS

- A. Aluminum Edge that is a cantilever-type (i.e., 'L-shaped') border unit fabricated from solid \_\_\_\_ gauge aluminum. (*Gauge depends on application; the base can be scalloped to allow the edge to be shaped to curves with radii of 3 inches.*) Aluminum edge units shall satisfy the following specifications:
  - 1. Height (*Unit height depends on system depth*) \_\_\_\_ inches
  - 2. Base width (*Unit base depends on system depth*) \_\_\_\_ inches
- B. Stainless Steel Edge that is a cantilever-type (i.e., 'L-shaped') border unit fabricated from solid \_\_\_\_ gauge stainless steel. (*Gauge depends on application; the base can be scalloped to allow the edge to be shaped to curves with radii of 3 inches.*) Edge units shall satisfy the following specifications:
  - 1. Height (*Unit height depends on system depth*) \_\_\_\_ inches
  - 2. Base width (*Unit base depends on system depth*) \_\_\_\_ inches
- C. Eave Baskets are used to contain gravel at the margin in eave areas. These units are designed to resist the down-slope forces of green roof assembly materials and are required for roofs with pitches in excess of 2-inches per foot. Eave baskets are 'U-shaped' border units fabricated from 1/8-inch thick perforated [aluminum] [stainless steel] sheet.
- D. Concrete Curbs are precast concrete provided by Hanover Architectural Products, Inc. or equivalent. Color and texture should be selected by the architect from the manufacturer's standard range. Precast concrete curb shall have dimensions as specified and satisfy the following specifications:
  - 1. Compressive Strength ≥ 4,000 psi
  - 2. Water Absorption ≤ 5%

## 2.9 PAVING SYSTEM

- A. Pavers
  - 1. Concrete Pavers shall be Hanover Architectural Products, Inc. Concrete Patio Pavers, or equivalent. Color shall be selected from manufacture's standards, and pavers shall satisfy the following specifications:
    - a. Size 24" x 24" x 2" (nominal)
    - b. Weight ≤ 25 lb/ft<sup>2</sup>
    - c. Absorption (ASTM C-140) ≤ 5%
    - d. Color as approved by Architect
  - 2. Companion Paver System shall be utilized to install pavers without the use of pedestals. Pavers are seated in a granular bedding material and contained with edging.
    - a. Reinforcing Grid is a structural reinforcing mesh constructed from two bonded, overlapping HDPE strands to form a diamond-shaped net. The mesh shall satisfy the following specifications:
      - i. Thickness (ASTM-D5199) ≥ 0.20 in
      - ii. Tensile Strength (ASTM –D5035) ≥ 0.40 lb/in
      - iii. Transmissivity ≥ 9 gal/min/ft
    - b. Granular Bedding Material shall be a lightweight mineral material satisfying the following specifications:

- i. Density at Maximum Water Capacity (ASTM-E2399-05) ≤ 60 lb/ft<sup>3</sup>
  - ii. Water Permeability (ASTM E2396-05) ≥ 25 in/min
  - iii. Total Organic Matter by loss on ignition (ASTM-F1647) ≤ 1%
  - iv. Abrasion Resistance (ASTM-C131-96) ≤ 25% loss
  - v. Soundness (ASTM-C88 or T103 or T103-91) ≤ 5% loss
  - vi. Porosity (ASTM-C29) ≥ 20%
  - vii. Alkalinity, CaCO<sub>3</sub> equivalents (ASTM-F1647) ≤ 1 %
  - viii. Grain-Size Distribution (ASTM-C136)
    - Pct. Passing US#18 sieve ≤ 1%
    - Pct. Passing 1/4-inch sieve ≤ 30%
    - Pct. Passing 3/8-inch sieve ≥ 80%
- c. Paver Setting Bed shall be sound stone screenings complying with ASTM D448 for Size No. 10.
- d. Concrete Pavers (see above)
- e. Paver Edging (see below) that is secured to reinforcing grid using nylon tie anchors
3. Pedestal Paver System (standard) provides the ability to achieve level plaza deck surfaces. The pedestals allow water to flow under the paver to the drain, while holding the pavers level.
4. Pedestal Paver System (high wind) consists of a three-piece paver bracket that is placed directly on a standard paver pedestal. This system is designed to prevent horizontal and vertical movement of the roof paver. Color shall be selected from manufactures standards.
5. Paver Edging
- a. Plastic Paver Edging is designed to conform to curves with radii as small as 8 feet and shall satisfy the following specifications:
    - i. Vertical wall height ≥ 1-7/8 in
    - ii. Base width ≥ 3 in
  - b. Aluminum Paver Edging is designed to conform to curves with radii as small as 12 feet and shall satisfy the following specifications:
    - i. Vertical wall height ≥ 1-5/8 in
    - ii. Base width ≥ 1-5/8 in
    - iii. Thickness ≥ 1/16 in

2.10 DRAIN ACCESS CHAMBERS (*select one, as appropriate*)

- A. PVC Drain Inspection Chamber is a round chamber available in heights of 10, 15, 20, and 30 cm. The diameter is 17 inches nominal. The chambers have no bottom panels; a vent on the removable lid, and knock-outs on the side panels for insertion of drain conduit. Conduit is used to enhance flow into or out of the chamber. Chambers shall be installed over all drains (in vegetated roof areas) and surrounded by an 18-inch stone margin.
- B. ABS Inspection Chamber is a square, variable height chamber with a removable lid. The width is 15-inches. The chambers have vents but no bottom panels; they have knock-outs on the side panels for insertion of drain conduit. Conduit is used to enhance flow into or out of the chamber. Chambers shall be installed over all drains (in vegetated roof areas) and surrounded by an 18-inch stone margin.

- C. Aluminum Inspection Chamber is available in both square and round shapes and in variable heights and widths. They have removable lids. The chambers have vents but no bottom panels; they have knock-outs on the side panels for insertion of drain conduit. Conduit is used to enhance flow into or out of the chamber. Chambers shall be installed over all drains (in vegetated roof areas) and surrounded by an 18-inch stone margin.
- D. Scupper Access Chamber is a square unit fabricated from polyethylene, with stainless steel fittings. The unit has a hinged lid to allow easy access for inspection. The width is 12-inches nominal. The chambers have vents but no bottom panels; they have knock-outs on the side panels for insertion of drain conduit. Conduit is used to enhance flow into or out of the chamber. Chambers shall be installed over all drains (in vegetated roof areas) and surrounded by an 18-inch stone margin.

## 2.11 IRRIGATION SYSTEM *(for irrigated projects only)*

- A. Capillary Fabric that is a composite fabric, satisfying the following specifications:
  - 1. Capillary Rise ≥ 6 in  
(vertical distance from static water level will wick moisture, as measured using a two-inch strip of fabric suspended in a water bath for 12 hours)
  - 2. Moisture retention (ASTM E2397) ≥ 0.16 in (0.10 gal/ft<sup>2</sup>)
  - 3. Density (ASTM D5261) ≥ 18 oz/yd<sup>2</sup>
  - 4. Puncture Resistance (ASTM D4833) ≥ 70 lb
- B. Capillary Irrigation components shall be assembled on top of the Capillary Fabric according to the Drawings.
  - 1. The Point of Connection (POC) shall be furnished by the General Contractor. The operating requirements at the POC shall be 20 gpm at 60 psi, measured after the Tee.
    - a. Backflow preventer
    - b. Manual 1-inch gate valve shut-off
    - c. Threaded 1-inch copper or PVC supply, with Tee to hose bib
  - 2. At each POC, the installing contractor shall provide and install:
    - a. Master automatic 1-inch globe valve, Rain Bird 100-PEB, or equivalent
    - b. 3/4-inch Netafim™ pressure regulator, PRV07HF45I, or equivalent
    - c. 1-inch Netafim Techfilter™, TF109XX-XXX, or equivalent
  - 3. Irrigation Drip Line: Netafim Techline™ pressure compensated drip line. The water delivery rate shall be 0.4 gph/ft.
  - 4. 1-inch diameter header pipe shall be 200 psi SDR21 PVC
  - 5. Auxiliary Equipment:
    - a. 1-inch remote control zone valve
    - b. Netafim™ air release valves (TLAVRV), or equivalent
    - c. Netafim™ flush valves (TLFV-1), or equivalent
    - d. Pressure indicator w. flag
    - e. Valve and junction boxes as required at all head

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. Install each component of the green roof assembly in accordance with the System Provider's published instructions and Contract Documents.
  - 1. Roofmeadow Type I green roof

### 3.2 INSPECT WATERPROOFING

- A. System Provider shall examine the completed waterproofing system, with the Roofing Applicator present, for compliance with Drawings, installation tolerances, and other conditions affecting performance.
  - 1. For submission to the General Contractor and the Roofing Applicator, System Provider shall prepare a written report identifying the specific conditions that may be detrimental to the performance of the work.
  - 2. Proceed only after unsatisfactory conditions have been corrected.
- B. One-hundred percent of all waterproofing seams shall have been tested by the waterproofing installer using one of the following procedures:
  - 1. Electrical Field Vector Mapping® (technician and methodology must be approved by the System Provider).
  - 2. Watertightness testing after at least 24 hours of flooding.
- C. The Owner shall delineate material and equipment laydown areas on the roof. The Owner shall also specify the maximum aggregate load permitted within each laydown area.

### 3.3 PREPARE SURFACE

- A. The surface of the waterproofing system shall be swept and washed.
- B. Until the Protection Layer or Moisture Management Mat is installed, traffic over the working area shall be strictly controlled and limited to essential personnel, only.
- C. Heavily traveled areas (e.g., corridors for transporting media to the working areas) must be protected in a manner approved by the waterproofing installer.
- D. Suitably protect laydown areas using ½-inch plywood or particle board over 1-inch sheets of expanded polystyrene (EPS), or similar sheathing material, and non-woven polypropylene fabric, or similar. Non-woven fabric shall be placed between EPS and waterproofing/roofing materials.

### 3.4 INSTALL ROOT BARRIER *(when waterproofing membrane necessitates)*

- A. Roll out Root Barrier above the completed waterproofing. The layout should minimize the aggregate seam length. Overlap adjoining sheets by a minimum of 2 inches. Allow slack to accommodate contraction during cold weather.
- B. Weld seams using hot-air welding equipment (Leister, or equivalent) according to the recommendations of the System Provider in order to create a watertight surface. One-hundred percent of all seams shall be tested by hand scribe.
- C. The completions at terminations shall be according to the recommendations of the System Provider.

### 3.5 INSTALL PERFORATED CONDUIT

- A. Assemble the Perforated Conduit according to the layout provided by the System Provider such that Perforated Conduit is placed on top of appropriately sized strips of Separation Fabric and in accordance with the recommendations of the System Provider.
- B. Cover the assembled Perforated Conduit with Separation Fabric.
- C. The Perforated Conduit will be completely concealed below the top of the Growth Media when properly installed.

3.6 INSTALL CAPILLARY FABRIC *(irrigated projects only)*

- A. Roll out the Capillary Fabric in irrigated areas.
- B. Overlap seams a minimum of 6 inches.

3.7 INSTALL IRRIGATION SYSTEM *(irrigated projects only)*

- A. Lay out Irrigation Drip Lines on top of the Capillary Fabric according to the recommendations of the System Provider.

3.8 TEST IRRIGATION SYSTEM *(irrigated projects only)*

- A. Connect the drip zones to the water supply.
- B. Inspect the Capillary Fabric for uniform distribution of moisture.
- C. As necessary, reposition the Irrigation Drip Lines to achieve uniform moisture distribution and retest.
- D. Prepare an as-built plan of the irrigation layout, showing the locations of all irrigation elements.

3.9 INSTALL PROTECTON LAYER

- A. Install 8 oz. Protection Fabric in vegetated areas *(under Moisture Management Mat Option C only)*.
  - 1. Roll out the Protection Fabric in the vegetated areas.
  - 2. Overlap seams a minimum of 6 inches.
  - 3. Install two layers of 8 oz. Protection Fabric at parapets, curbs, and penetrations.
  - 4. Extend the Protection Fabric at least 6 inches up parapets, curbs, and penetrations.
- B. Install Single Sided Composite Drainage Net in paver areas.
  - 1. Roll out the Single-Sided Composite Drainage Net in paver areas.
  - 2. Overlap seams a minimum of 6 inches.
  - 3. Extend the Single-Sided Composite Drainage Net at least 6 inches up parapets, curbs, and penetrations.

3.10 INSTALL MOISTURE MANAGEMENT MAT

- A. Install Moisture Management Mat Option A
  - 1. Lay out the panels of Management Mat Option A; butt adjacent panels at the seams.
  - 2. Place two layers of Management Mat Option A panels under the alignments for pavers.
  - 3. Cover immediately with Separation Fabric.
  - 4. Hold in place using water-filled bags, or equivalent. If work is discontinued overnight, stabilize using water-filled ballast bags or equivalent.
- B. Install Moisture Management Mat Option B
  - 1. Roll out the Moisture Management Mat Option B mat; overlap seams a minimum of 6 inches.
  - 2. Hold in place using water-filled bags, or equivalent. If work is discontinued overnight, stabilize using water-filled ballast bags or equivalent.
- C. Install Moisture Management Mat Option C

1. Roll out the Moisture Management Mat Option C; butt adjacent at the seams.
2. Cover seams with Separation Fabric.
3. Hold in place using water-filled bags, or equivalent. If work is discontinued overnight, stabilize using water-filled ballast bags or equivalent.

### 3.11 INSTALL PERMANENT WIND SCOUR PROTECTION SYSTEM

- A. Install Permanent Wind Scour Protection System at parapets 36 inches or lower.
- B. At parapets, place a 6 foot-wide strip of Permanent Wind Blanket on top of Moisture Management Mat according to instructions of the System Provider.
- C. Place Boundary Units
  1. Place Geosynthetic Sheet Drain as an underlayment for the Boundary Units.
  2. Place Boundary Units and cover with Separation Fabric.
- D. Place Stone or Turf Pavers between the Boundary Unit and the parapet.
- E. Temporarily fold the Permanent Wind Blanket back over the parapet.
- F. Fold the Permanent Wind Blanket back over the completed Growth Media surface.

### 3.12 INSTALL BOUNDARY UNITS

- A. Place Geosynthetic Sheet Drain as an underlayment for the Boundary Units. Cover Boundary Units and Geosynthetic Sheet Drain with Separation Fabric to prevent intrusion of media.
- B. Assemble Boundary Units where identified in the Specification.
- C. Immediately place Stone, Turf Pavers, or Growth Media.

### 3.13 INSTALL DRAIN ACCESS CHAMBERS

- A. Assemble Drain Access Chambers on top of 2-foot wide strips of Geosynthetic Sheet Drain. Cover Geosynthetic Sheet Drain with Separation Fabric to prevent intrusion of media.
- B. Immediately place an 18-inch wide margin of Stone to stabilize the Drain Access Chambers.
- C. Separate Stone from the Growth Media according to the recommendations of the System Provider.

### 3.14 INSTALL PAVER SYSTEM *(if required in the Drawings)*

- A. Install Companion Paver System
  1. Fill Granular Bedding Material to within 3- inches of the finished surface. Compact using a 4-foot wide lawn roller with a total load of not less than 200 lbs and not more than 300 lbs.
  2. Place Separation Fabric and Reinforcing Grid.
  3. Fasten Paver Edging to the Reinforcing Grid with Nylon Tie Anchors according to System Provider's recommendations.
  4. Place ½ - 1 inch of Paver Setting Bed.
  5. Fit Concrete Pavers snugly against the Paver Edging and settle with mallets.



- B. Install Pedestal Paver System (standard)
  - 1. Install pedestals on the Moisture Management Mat or Protection Layer.
  - 2. Level as necessary.
  - 3. Place Concrete Pavers.
- C. Install Pedestal Paver System (high wind)
  - 1. Install pedestals on the Moisture Management Mat or Protection Layer.
  - 2. Level as necessary.
  - 3. Place Concrete Pavers.
  - 4. Secure pavers with fastening clamp.

### 3.15 INSTALL GROWTH MEDIA

- A. Place the Growth Media. The Growth Media shall be dispensed at the roof level in a manner that will not suddenly increase the load to the roof. It shall be immediately spread to the specified thickness, plus ten percent, after moderate compaction. Unless otherwise approved, compaction shall be using a 4-foot wide lawn roller with a total load of not less than 200 lbs and not more than 300 lbs.
- B. Thoroughly soak with water using a sprinkler or hand sprayer.

### 3.16 PLANT VEGETATION

- A. Pre-grown Sedum Mats. (Consult the System Provider for information about type and availability of pre-vegetated mats.)
  - 1. Unroll the Pre-grown Sedum Mats on the roof and layout on top of Growth Media.
  - 2. Soak.
  - 3. Continue temporary irrigation, using sprayers, for 4 weeks.
- B. Cuttings /Seed
  - 1. The planting mixture should include species that will generate a continuous ground cover. Maximum mature plant heights shall be less than 24 inches. Large drifts of single species should be avoided.
  - 2. All extensive planting schemes in temperate climates must incorporate non-deciduous or semi-deciduous Sedum species. These should be established from fresh Cuttings. The plant mixture should include a minimum of four species of Sedum in approximately equal quantities. Cuttings should be distributed over the surface of the Media at a minimum rate of 40 lbs/1000 square feet. Planting using Sedum cuttings can be undertaken in most temperate climates from April 1 through May 1 and from September 15 through October 30. When installed outside this window, regular watering may be required until the plants are established. System Provide must approve specific planting dates relative to local weather conditions.
  - 3. Seed mixtures (optional) should include a minimum of five perennial varieties. Turf forming grasses should be avoided. Consult with the System Provider for recommendations concerning the incorporation of grasses in planting mixtures. For seeding rates and seasonal restrictions consult the seed provider. Apply seed according to System Provider's instructions.
  - 4. If more than 24 hours has elapsed since installing and soaking the Growth Media, thoroughly re-soak Growth Media prior to commencing the broadcast distribution of seed or Cuttings.
  - 5. Immediately cover with the Temporary Wind Blanket. Secure Temporary Wind Blanket with Nylon Tie Anchors.
  - 6. Install Hydro-Mulch according to System Provider's recommendations. Re-apply as needed during the establishment period to prevent erosion of Growth Media.

7. As required, soak the prepared seed bed at the completion of planting operations.
8. Depending on the season that plants are established and plants included, periodic watering may be required during the first growing season.

C. Plugs

1. Plant installation may occur April-October.
2. Plants should be established from 72-cell 3-inch deep plugs (unless indicated in the drawings) propagated in sterile nursery medium, according to the plant provider's recommendations. The recommended minimum planting rate is two plants per square foot.
3. Thoroughly soak the Growth Media prior to commencing planting.
4. Cover with the Temporary Wind Blanket. Secure Temporary Wind Blanket with Nylon Tie Anchors. As required, make cuts in Temporary Wind Blanket to insert the Plugs.
5. Install Plugs. Plugs should be set into the Growth Media to their full depth and the Growth Media pressed firmly around the installed Plug. At the end of each day, soak those areas that have been newly planted.
6. Apply Tackifier Emulsion according to System Provider's recommendations.
7. Do not mulch.

3.17 PROVIDE 2-YEAR MAINTENANCE SERVICE

- A. The Green Roof Installer shall provide a two-year maintenance service. This service will include:
1. Hand weeding and/or chemical weeding and fertilization, as required to maintain the health and vigor of the plants.
  2. Plant replacement as needed to achieve the required 80% coverage rate two years following substantial completion.
  3. Temporary spray irrigation during the first growing season. All temporary irrigation equipment shall be removed at the conclusion of the maintenance service period.

END OF SECTION

**NOTICE**

**No warranty expressed or implied is offered for any work based on the information provided herein, unless**

- 1) Roofmeadow is provide supervisory role in the construction of the green roof assembly, and**
- 2) Installation and maintenance of the green roof assembly is provided by a contractor that is trained and licensed by Roofmeadow.**

**Roofmeadow will not assume any responsibility for the inclusion of this material in specifications or documents published by others.**