This is a guidance document with sample specification language intended to be inserted into project specifications on this subject as appropriate to the agency's environmental goals. Certain provisions, where indicated, are required for U.S. federal agency projects. Sample specification language is numbered to clearly distinguish it from advisory or discussion material. Each sample is preceded by identification of the typical location in a specification section where it would appear using the SectionFormat™ of the Construction Specifications Institute; the six digit section number cited is per CSI Masterformat™ 2004 and the five digit section number cited parenthetically is per CSI Masterformat™ 1995.

SECTION 07 33 63 (SECTION 02930) – VEGETATED ROOF COVERING

SPECIFIER NOTE:

resource management: Green roofing systems offer an excellent opportunity to incorporate renewable resources into the built environment. Some systems are available with drainage layers manufactured from recycled plastic.
Green Roofs for Healthy Cities, a non-profit provides information related to the economic, social, and environmental benefits of green roof infrastructure across North America; refer to http://www.greenroofs.org/

toxicity/IEQ: Green roofing systems have the capacity to improve environmental quality. Plants process carbon dioxide (carbon sinking). They can process certain types of toxins through their leaves and roots. Green roofing systems can provide biofiltration of rainwater.

performance: Modern systems have evolved from traditional building techniques and include membranes and drainage layers appropriate to modern building needs. Warranted garden roof systems have been used in Europe for decades.
Green roofing systems, when properly detailed and installed, can provide excellent thermal and acoustic insulation. Refer to the U.S. EPA options for “What Can Be Done” in respect to the Heat Island Effect, http://www.epa.gov/heatisland/index.htm

The plants contribute to carbon sinking and can provide wildlife corridors, urban agriculture, and recreational areas. By using water in situ, they also help minimize stormwater runoff and improve local hydrologic cycle functions. Care must be taken to design for anticipated live and dead loads.

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Vegetation for roof covering.
2. Growth media for roof covering.
3. Accessories and components as necessary for a complete installation of the vegetated roof covering.

B. Related Sections:
1. Section 07 55 63 (07530): Membrane Roofing for Green Roofing Systems.

1.2 DEFINITIONS

A. Definitions pertaining to sustainable development: As defined in ASTM E2114.

B. 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.

C. Growth Media Layer: An engineered soil-like material designed to retain moisture, manage plant nutrients, and support vigorous growth of the foliage.

D. Manning formula for conveyance (ft^3/s): $K = (1.49 \times A \times R^{(2/3)})/n$;
A=area (ft^2), R=hydraulic radius (ft), n=Manning's roughness coefficient (dimensionless).

E. System Installer: Entity approved by System Provider to install vegetated roof covering system.

F. System Provider: Entity that provides all materials required for installation of the vegetated roof covering system.

G. Roofing Membrane Provider: Entity that provides all materials required for installation of the waterproofing/roofing system below the vegetated roof covering. Refer to Section 07 55 63 (07530).

1.3 SYSTEM DESCRIPTION

SPECIFIER NOTE:
Green roofs can be extensive or intensive.
Extensive Green Roof -- Low maintenance landscaping consisting of shallow soil depths (< 6 inches (150mm) with plant varieties restricted to primarily succulent plants, herbs and some grasses capable of withstanding harsh growing conditions. Extensive assemblies are typically un-irrigated and are constructed to achieve specific benefits.
Intensive Green Roof -- Landscaping requiring regular maintenance, consisting of deeper soil depths (> 10 inches (250mm) with a wider variety of plant species possible including turf grass, meadow perennials, shrubs and small trees. Intensive green roofs are typically irrigated and can furnish significant aesthetic and habitat value.
Following is an example of an extensive installation with 2.5 to 4.0 inches of media and an under drain component.

A. Design Requirements:
1. The vegetated cover shall be a single-media system, consisting of a **[2.5 to 4.0] [xxxx]** inch growth media layer installed over a layer designed to promote drainage and distribute moisture.

SPECIFIER NOTE:
The density of media correlates to the cost of the media. As a guide, typical growing media weighs about 74 pounds per cubic foot.

2. The weight of this system at Maximum Water Capacity as per ASTM E2399 and with rainfall runoff occurring, shall be less than or equal to **[18] [xxxx]** pounds per square foot.
3. The system dead load, measured according to ASTM D2397, when added to the weight of the roofing membrane system, shall not exceed the maximum allowable dead load for the roof.

B. Performance Requirements: Vegetated roof covering system 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;

SPECIFIER NOTE:

Maximum Water Capacity is a design consideration that will depend on the depth of the media and the type of media selected. As a guide, typical growing media offers 35% water retention by volume.

4. Retain **[1] [xxxx]** inches of moisture at Maximum Water Capacity, in accordance with ASTM E2398.

1.4 SUBMITTALS

A. Product Data: Unless otherwise indicated, submit the following for each type of product provided under work of this Section:

1. Product data for material and components of vegetated roof covering indicating compliance with specified requirements.

SPECIFIER NOTE:
Specifying local materials may help minimize transportation impacts; however it may not have a significant impact on reducing the overall embodied energy of a building material because of efficiencies of scale in some modes of transportation.
Green building rating systems frequently include credit for local materials. Transportation impacts include: fossil fuel consumption, air pollution, and labor.
USGBC-LEED™ v3 includes credits for materials extracted/harvested and manufactured within a 500 mile radius from the project site. Green Globes US also provides points for materials that are locally manufactured.

2. Local/Regional Materials:
   a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
   b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
   c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
   d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

SPECIFIER NOTE:
The Food, Conservation, and Energy Act of 2008 (also known as the 2008 U.S. Farm Bill) largely continues programs of the Farm Security and Rural Investment Act of 2002 (2002 Farm Bill) http://www.usda.gov/farmbill/ Section 9002 requires each Federal Agency to develop a procurement program which will assure that items composed of biobased products will be purchased to the maximum extent practicable and which is consistent with applicable provisions of Federal procurement law. USDA designates biobased products for preferred Federal procurement and recommends biobased content levels for each designated product.
USGBC-LEED™ v3, for example, includes credits for use of rapidly renewable materials, which USGBC describes as plants harvested within a ten-year cycle.
Green Globes – US, provides credit for integration of materials from renewable sources that have been selected based on life-cycle assessment.

3. Biobased materials:
   a. Indicate type of biobased material in product.
   b. Indicate the percentage of biobased content per unit of product.
   c. Indicate relative dollar value of biobased content product to total dollar value of product included in project.

B. Shop Drawings: Submit Shop Drawings showing:

1. Details of installation with conditions at terminations, transitions, and penetrations;
2. Layout for the internal drain conduit;

3. A profile schematic, in 1/2 scale, showing thickness of all materials;
4. Fabrication details or System Provider's information for drain access chambers.
   a. Coordinate with Roofing Membrane Provider details for roof drains, scuppers and overflows, including accurate dimensions and geometric configurations. Verify that standard drain access chambers, deck drains and scuppers conform to System Provider's written recommendations.

C. Samples: Submit samples as follows:
1. 6-ounce sample of growth medias for initial approval.
2. **[2] [20] [xxxx]** pound sample of the growth media as delivered for each 100 cubic yards for verification.

D. Plant list: Identify species, size, and source for each type of plant. Indicate planting method, planting density, and quantity conditions for care during the establishment period. Where selected species are not indigenous, describe reasons for preference.

E. Certifications:
1. System Provider's statement indicating that:
   a. Proposed use is appropriate for each product, material and component.
   b. System Provider has reviewed and approved the details for the associated Roofing Membrane system, including deck drains, flashings, penetrations, and coping.
   c. System Installer is approved by System Provider.
   d. Proposed system is eligible for the specified warranty required of the System Provider.

F. Closeout Submittals:
1. Warranty.
2. Maintenance Agreement.

1.5 QUALITY ASSURANCE

SPECIFIER NOTE: Single Source Responsibility for the full system – membrane and vegetated roof covering - may not be available from roofing suppliers. However, most membrane suppliers will work with approved vegetated roof covering system suppliers. This is important in order to maintain the warranty of the membrane.

A. Single-Source Responsibility: Installation of the vegetated roof covering system components and vegetation, shall be **[provided by] [coordinated by]** a single-source. Components include but are not limited to:
1. Drain layer underlayment.
2. Growth Media.
3. Drainage panels.
4. Border units.
5. Separation fabric.
6. Drain and scupper access chambers.
7. Protection layer.
8. Paths and walkways.
9. Vegetation.

B. Roofing Inspection: As specified in Section 07 55 63 (07530) and as follows:
1. The **[Owner] [System Provider]** shall furnish a quality control specialist to observe critical aspects of the installation and testing of the work.

C. Pre-Construction Meeting: After award of Contract and prior to the commencement of the Work of this Section, schedule and conduct meeting to discuss the Work of this

Section and to coordinate with related Work. Coordinate with pre-construction meeting specified in Section 07 55 63 (07530). Convene pre-construction meeting to comply with requirements of Division 01 (1) and as follows:

1. Notify all attendees at least two weeks prior to the conference.
2. Require attendance of parties directly affecting Work of this Section, including, but not limited to:
   a. Owner,
   b. Contractor,
   c. Architect,
   d. System Provider,
   e. System Installer,
   f. Roofing Membrane Provider,
   g. Roofing Membrane Installer, and
   h. Mechanical and Plumbing Installers.
3. Review methods and procedures related to installation and operation of Work of this Section, including coordination with related Work.
4. Document proceedings, including corrective measures or actions required, and furnish copy of record to each participant.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate the Work with installation of associated roofing, waterproofing, flashings, and roof accessories specified under other sections as the Work of this Section proceeds.

B. Sequence the Work with attention to preventing deterioration of installed roofing by minimizing the use of newly constructed roof deck for storage, walking surface, and equipment.

1.7 WARRANTY

A. Green Roof System Components: Provide a warranty signed by System Provider against failure of components in vegetated roof covering system, except vegetation. Warranty shall include repair of flaws which impair the functioning of the green roof system, provided the flaws originate from errors in design, material defects, improper assembly, incompatibility between components, or deterioration. Failure of components shall include:
   1. Loss or dislocation of media due to wind scour (during the establishment period).
   2. Persistent ponding of water after rainfalls.
   3. Anaerobic conditions developed in the media due to inadequate drainage.
   4. Cracking or deterioration of drain access chambers and border units, clogging of roof drains or scuppers.
   5. Cracking or exfoliation of concrete pavers.

B. Green Roof System Vegetation: Provide a warranty signed by System Installer against failure of vegetation in vegetated roof covering system, including but not limited to failure of the plants to thrive due to compression or decomposition of the media. Warranty shall provide for the following:
   1. Overseeding of plant cover after 12 months if the surface coverage rate is less than 60 percent. If overseeding is required, the deficient grids shall be manually re-seeded and stabilized. Cover rates shall be estimated separately for each 400 square-foot grid of the vegetated surface.
   2. Overseeding of plant cover after the 24-month establishment period as necessary to provide a minimum plant cover of 80 percent. Cover rates shall be estimated separately for each 400 square-foot grid of the vegetated surface.
   3. Emendation of media, if required to provide a viable growing medium for the vegetation.

C. Warranties shall include cost of labor and materials to inspect, repair, remove, and replace components in vegetated roof covering system without financial limit.
   1. Warranties shall include removing and replacing vegetated roof covering to access and repair waterproofing/roofing below vegetated roof covering.

D. Warranty Period:
   1. Green Roof System Components: 15 years.
   2. Green Roof System Vegetation: 2 years.

1.8 MAINTENANCE

A. System Installer shall execute with Owner a 2-year establishment period maintenance contract for plantings.

B. Maintenance shall include cultivation, weeding, disease and insect pest control. Procedures shall be consistent with good horticultural practice necessary to ensure vigorous, healthy growth of plant material.
   1. Provide hand weeding and organic fertilization, as required to maintain the health and vigor of the plants.
   2. Clean up: During course of maintenance, excess and waste materials shall be promptly removed at end of each workday.

C. Maintenance schedule of activities:
   1. Schedule: Include minimum 6 maintenance visits to project in 24 month period.
   2. Provide schedule to Owner that details planned maintenance activities including names of subcontractors.

D. Maintenance reports:
   1. Provide reports to Owner summarizing activities, observations, necessary corrections and recommended changes to maintenance routine, if any.

PART 2 – PRODUCTS

SPECIFIER NOTE:
EO 13423 includes requirements for Federal Agencies to use “sustainable environmental practices, including acquisition of biobased, environmentally preferable, energy-efficient, water-efficient, and recycled-content products”

Specifically, under the Sustainable Building requirements per Guiding Principle #5 Reduce Environmental Impact of Materials, EO13423 directs Federal agencies to “use products meeting or exceeding EPA's recycled content recommendations” for EPA-designated products and for other products to “use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 10% (based on cost) of the total value of the materials in the project.”

Executive Order 13514; *Federal Leadership in Environmental, Energy, and Economic Performance*; was signed on October 5, 2009. http://www.ofee.gov/execorders.asp It expands upon the environmental performance requirements of EO 13423.
http://www1.eere.energy.gov/femp/regulations/printable_versions/eo13423.html

EO 13514 sets numerous federal requirements in several areas, including sustainable buildings and communities. Federal agencies must implement high performance sustainable federal building design, construction, operation and management, maintenance, and deconstruction, including:
- Ensuring all new Federal buildings, entering the design phase in 2020 or later, are designed to achieve zero net energy by 2030.

- Ensuring all new construction, major renovations, or repair or alteration of Federal buildings comply with the Guiding Principles of Federal Leadership in High Performance and Sustainable Buildings http://www1.eere.energy.gov/femp/pdfs/mouhighperfsustainfedfacs.pdf
- Ensuring at least 15% of existing agency buildings and leases (above 5,000 gross square feet) meet the Guiding Principles by fiscal year 2015 and that the agency makes annual progress towards 100% compliance across its building inventory.

Additionally, for USDA-designated biobased products, Federal agencies must use products meeting or exceeding USDA's biobased content recommendations; and for other products, biobased products made from rapidly renewable resources and certified sustainable wood products.

2.1 GREEN ROOFING SYSTEM COMPONENTS

A. Synthetic drain layer underlayment: Mat or Geocomposite drainage layer with minimum performance characteristics as follows:

SPECIFIER NOTE:
Effective transmissivity equals the underlayment transmissivity plus the hydraulic conveyance of internal conduit that may be supplied to augment flow. Effective transmissivity is a design parameter that must be adjusted for climate, roof size, geometry and pitch. The value provided is only a guideline.

Underlayment Transmissivity (gpm/ft), measured at i=1 and confining pressure ≥20 psf according to ASTM D4716
Conduit Conveyance (gal/min/ft), measured as $K = 669 \times A \times R^{(2/3)} / (L \times n)$;
A=conduit area (ft^2), R=hydraulic radius (ft), n=Manning's roughness coefficient (dimensionless), L=conduit spacing (ft).

Effective Transmissivity, referred to i=1	≥ 20 gal/min/ft
Permittivity as per ASTM D4491	≥ $1.5 sec^{-1}$
Puncture Resistance, as per ASTM D4833	≥ 200 lb

B. Growth Media Layer: Mixture of mineral and organic components with minimum performance characteristics as follows:

Non-Capillary Pore Space at Field Capacity, 0.333 bar as per TMECC 03.01 A	≥ 15% (vol)
Maximum Water Capacity as per ASTM E2399	≥ 35% (vol)
Saturated Hydraulic Conductivity as per ASTM 2399	≥ 0.05 in/min
Alkalinity, $CaCO_3$ equivalents, as per MSA	≤ 2.5%
Total Organic Matter, by loss on ignition method as per MSA	4 - 8% (dry wt.);
pH as per RCSTP	6.5 – 8.0
Soluble Salts, DPTA saturated media extraction as per RCSTP	≤ 6 mmhos/cm
Cation exchange capacity as per MSA	≥ 8 meq/100g
Grain-size distribution of the mineral fraction as per ASTM-D422	
Clay fraction (2 micron)	≤2
Pct. Passing US#200 sieve (i.e., silt fraction)	≤ 10%
Pct. Passing US#60 sieve	≤ 15%
Pct. Passing US#18 sieve	10 - 40%
Pct. Passing 1/8-inch sieve	20-70%
Pct. Passing 3/8-inch sieve	75 -100%

Organic supplements (compost, peat, etc.): Provide as follows. Other macro- and micro-nutrients may be incorporated in the formulation in initial proportions suitable for support the specified planting. Thoroughly blend at a batch facility. Moisten, as required, to prevent separation and excessive 'dusting' during installation.

Combined respiration rate as per TMECC 05.08, B	≤ 1 mg CO^2/gTOM/d
Total Nitrogen, TKN as per MSA	25-100 ppm
Phosphorus, P_2O_5 as per RCSTP	20-200 ppm
Potassium, K_2O as per RCSTP	≥ 150 ppm

C. Drainage Panel: For use under border units and drain chambers, to promote free flow across boundaries. Polyethylene or Polystyrene panels with minimum performance characteristics as follows:

Compressive strength	≥ 5,200 lb/ft^2
Transmissivity, as per ASTM D4716	≥ 15 gal/min/ft

D. Border Units:
1. Edge Elements: Aluminum, plastic, stainless steel, or enamel-coated galvanized steel cantilever edge units. Size and shape as indicated on drawings.
2. Scupper Fences: Aluminum, plastic, stainless steel, or enamel-coated galvanized steel cantilevered fences Used in lieu of scupper chambers. Size and shape as indicated on drawings.

E. Separation fabric: For use to prevent media loss at seams, boundaries and openings. Non-woven polypropylene or polyester fabric with minimum performance characteristics as follows:

Permittivity as per ASTM-D4491	≥1.5 sec-1
Weight as per ASTM –D5261	≥ 6 oz/yd2
Puncture Resistance as per ASTM-D4833	≥ 130 lb
Mullen Burst Strength as per ASTM-D3786	≥ 350 lb/in2
Grab Tensile as per ASTM D-4632	≥ 150 lb

F. Drain and Scupper Access Chambers: Provide chambers with lids for inspection of drains and scuppers. The chambers shall have perforations on the sides and be mounted on drain panel. Chambers may be fabricated from plastic, aluminum, stainless steel, fiber-reinforced cement, or enamel coated galvanized steel

G. Protection Layer: Provide as required for protection of the roofing membrane in critical areas and as follows:

Thickness, core only as per ASTM-D5199	≥ 200 mil
Puncture Resistance of each fabric as per ASTM D-4833	≥ 110 lbs

H. Paths and Walkways: Concrete Pavers; swept or textured finish; with minimum performance characteristics as follows:

Thickness	≥ 1.75 in
Size	2 ft x 2 ft (nominal)
Weight	≥ 23 lb/ft^2
Compressive Strength	≥ 7,500 psi
Flexural Strength	≥ 2,000 lb
Water Absorbtion	≤ 5%

2.2 VEGETATION

A. Plants: Provide plants in accordance with ASTM E2400 and as follows:

SPECIFIER NOTE:

In extensive green roof design, it is almost never possible to include a majority of indigenous plants. Currently, plant lists for un-irrigated extensive green roofs in non-temperate climates are experimental. Until reliable regional plant lists are available, it is important to allow the green roof System Provider to recommend plants.

1. Provide vegetation consistent with a xeriscaping approach that minimizes or eliminates irrigation requirements.
2. The use of indigenous plant species is encouraged. However, this value is secondary to providing a plant community that can provide a dense groundcover capable of withstanding climatic conditions, holding the growth medium in place, and minimizing weed pressure.
3. The plant list shall include a minimum of 5 species with a record of success in similar installations and conditions.
4. Plants selected for extensive green roofs shall be low-growing, with maximum heights of 18 inches.

PART 3 − EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions under which roofing will be applied, with System Installer and Roofing Membrane Installer present, for compliance with requirements
   1. Correct any deficiencies to the satisfaction of the System Installer.
   2. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare Surface:
   1. Clean surface of the Roofing Membrane as recommended by Roofing Membrane Provider/Installer and by System Provider.

B. Protect Roofing Membrane:
   1. Until the drainage media course is installed, traffic over the working area shall be strictly controlled and limited to essential personnel only.
   2. Protect heavily traveled areas, including but not limited to corridors for transporting media to the working areas, as recommended by the Roofing Membrane Provider.
   3. Protect laydown areas using ½-inch plywood or particle board over 1-inch sheets of expanded polystyrene (EPS), or similar sheathing material.

C. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction.

3.3 INSTALLATION

A. Install vegetated roof covering system according to System Provider's written instructions, applicable regulations, approved shop drawings, and as specified.

B. Install drain layer underlayment:
   1. Lay out the mat smoothly, with joints abutting tightly, at all areas to receive vegetated roof cover.
   2. Cover joints between adjacent panels with separation fabric, allowing an overlap on either side of minimum 6 inches.

C. Install drain access chambers and border units:

1. Assemble border units directly on top of the drainage panel. Cover the edge elements and sheet drain with separation fabric to prevent intrusion of media.
2. Layout drain access boxes. Wrap drain access chambers with separation fabric to prevent intrusion of media.

D. Install Walkways:
1. Install a second layer of drainage panel at areas to receive walkways.
2. Locate as shown in the drawings.
3. Edge the walkways with separation fabric.

E. Place Growth Media:
1. Place the growth media layer at the roof level in a manner that will not suddenly increase the load to the roof. Immediately after placement, spread to the specified thickness, plus 10 percent after compaction with lawn roller delivering 100 lbs/linear foot.
2. Thoroughly soak with water using a sprinkler or hand sprayer.

3.4 PLANT VEGETATION

A. If more than 72 hours have elapsed since the media was last watered, soak the media again prior to installation of plant vegetation.

B. Install plants as per the approved Plant List. Distribute cuttings evenly across the surface of the media at a rate of **[30 lb/1,000 square feet] [xxxx].** Distribute the seed mixture at rate as indicated by the System Provider. Cuttings shall be applied **[August 15-October 1 and April 15-June 1] [xxxx]** unless otherwise approved by Owner.

END OF SECTION