

US EPA ARCHIVE DOCUMENT

# Jackson Square Redevelopment Initiative Sustainability Pilot

## Recommendations for Green Roof Planning

FINAL

May 14, 2009



**Prepared for:**

U.S. Environmental Protection Agency  
Office of Solid Waste and Emergency Response  
Office of Brownfields and Land Revitalization  
Washington, DC 20460

**Prepared by:**

Vita Nuova LLC  
Newtown, CT 06482  
[www.vitanuova.net](http://www.vitanuova.net)

SRA International, Inc. (Contract No. EP-W-07-023)  
3434 Washington Boulevard  
Arlington, VA 22201

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FINAL REPORT

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## Recommendations for Green Roof Planning

### Project intent

Vita Nuova LLC, subcontractor to SRA, an Environmental Protection Agency (EPA) contractor, is assigned the task of assessing green roof planning options for Urban Edge's Jackson Square Redevelopment Initiative. Urban Edge is a community development corporation based in Roxbury, MA. Vita Nuova LLC has prepared this for the Jackson Square Redevelopment Initiative. This report is intended to assist the grantor and grantee in selecting the most appropriate green roof technologies for the proposed brownfields redevelopment on 14.5 acres in the City of Boston. Vita Nuova has considered a large range of general and site-specific concerns in evaluating and recommending the use of green roofs, including environmental and energy impacts, stormwater management, meeting regulatory requirements, and addressing programming needs and access. This report is not intended to exhaustively review all green roof products and vendors, nor provide a complete life-cycle assessment of green roof technologies. It is assumed, for the purposes of this report, that green roofs will be constructed at Jackson Square and that specific rooftop programming and design will be chosen after understanding the relative costs and benefits of available green roof products. Therefore, Vita Nuova seeks to provide Urban Edge with a basis for making sound vendor and product choices, establishing appropriate roof construction designs and anticipating adequate green roof coverage to meet the range of needs of the project.

Vita Nuova has developed this report to address the site-specific needs of the Jackson Square Initiative, as well as serve as a template for evaluating green roof opportunities at other Sustainability Pilot sites. Vita Nuova has sought to address the needs of both users, providing the developer with the tools needed to make appropriate design decisions and providing EPA with a document that may have non-site-specific uses. This analysis represents the final report for the agreed upon Statement of Work (**Appendix A**).

### EPA brownfields program

EPA's Brownfields Program enables local communities to assess, clean up and revitalize key community properties through collaboration between relevant stakeholders. EPA's Brownfields Sustainability Pilots are intended to facilitate and encourage sustainable redevelopment of brownfields sites through technical assistance on sustainability practices. EPA defines brownfields sites as real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant.

### Environmental conditions

The Jackson Square Redevelopment Initiative area is divided into a number of sites that each had a variety of historic uses. In the 1880s, 225 Centre Street was used for private residences, a blacksmith and gas tank storage. By the early 1900s, the site was home to a machine shop, as well

as a paint shop and, in the mid-1900s, the site contained a filling station and auto repair shop. In 1980, the remaining buildings were demolished and the site became a parking area for the MBTA and it continues to function as a parking lot today. Another site, 1540-1544 Columbus Avenue/Highland Avenue, was used in the early 1900s as a stable and subsequently as a plumbing warehouse, as well as an automobile dealership, repair shop and garage for the City of Boston Department of Public Works. Since the 1970s, part of the site has been used as a minimum-security correctional facility. The areas of the site that contained the automobile dealership and repair shop have been vacant since 1996. The Public Works garage is currently in use and includes a salt storage shed.

Using EPA-funds, the Boston Department of Neighborhood Development conducted Phase I and Phase II Environmental Site Assessments (ESA) on the Columbus Avenue and Centre Street sites. The ESAs revealed that while there was some historic record of an underground storage tank (UST) on the Centre Street site, one was not detected. Soil sampling for this site indicated that there were no reportable conditions outside of the former filling station. Gasoline impacts were reported in the former filling station area.

ESAs on the Columbus Avenue site reported that petroleum contamination was found onsite when an UST and oil/ water separator were removed. As of 2003, a heating oil UST is currently located underneath the building slab. Soil sampling reveals impacts from lead, arsenic and petroleum related contaminants.<sup>1</sup>

In March 2006 subsurface investigation was completed on three specific areas of the Jackson Square Redevelopment Initiative. Investigation of the first site, MBTA Parcel 35, revealed the presence of five to 12 inches of fill cover, which contained ash and cinders. In the northeast corner of the site, the location of the former gas station, there were reportable concentrations of petroleum hydrocarbons (EPH and VPH) and naphthalene. Onsite remediation is required for the former gas station area, but the remediated soil can remain onsite. Fill in the remainder of the site does not require remediation.

Investigation of the second site, located on Columbus Avenue, included three borings and four test pits. These investigations showed that the site contains two and a half to 12 inches of Urban Fill throughout. Further chemical analysis of the soil revealed elevated levels of lead and arsenic above the reporting threshold. Groundwater testing at a monitoring well, located in the northeastern portion of the site, revealed Volatile Organic Compounds (VOC), VPH and EPH, although the levels are below reporting thresholds. In addition, a UST is located in the northwestern portion of the site.<sup>2</sup>

Investigation of the third site, denoted as MBTA Parcels 69-71 and 41 Armory, included nine borings and four test pits, with three of the borings related to groundwater monitoring. There are eight USTs located on parcel 69 with elevated levels of petroleum hydrocarbons in the surrounding soil and groundwater. Earlier testing had indicated the presence of PAH, lead, arsenic, non-aqueous phase liquid (NAPL) above the applicable thresholds. In addition, EPH was

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<sup>1</sup> QAPP, Limited Subsurface Investigation, Jackson Square, Roxbury, Massachusetts, GEI Consultants, June 2007.

<sup>2</sup> The 1540 Columbus Avenue parcel is listed under Release Tracking Number (RTN) 3-12084 for lead and arsenic releases and the 1542 Columbus Avenue parcel is listed under RTN3-21935.

found in amounts exceeding thresholds near a UST vault and the NAPL area. Lead was also found in the Urban Fill throughout the site, but below reportable thresholds.<sup>3</sup>

Parcel 70 contains approximately 12 to 18 inches of Urban Fill. Ground penetrating radar detected three irregularities.

There is 10 to 15 inches of Urban Fill throughout parcel 71 and ground penetrating radar revealed a potential UST. In addition, elevated levels of arsenic, lead, antimony, copper, and zinc required a 120-day reporting condition.

The final parcel, 41 Armory Street, contained approximately 10 to 15 inches of Urban Fill. The site is a former auto salvage yard and is a Tier II release site with a range of soil contaminants above applicable thresholds.<sup>4</sup>

### **Project review**

The Jackson Square Redevelopment Initiative involves a proposed plan to redevelop 14.5 acres of former industrial land in the Roxbury neighborhood of Boston. The plan includes the construction of 14 new buildings and restoration of one existing building. Construction documents, at the time of writing of this report, are not completed and may yet be influenced by the structural and material requirements of green roofs. The development is planned as a mixed use residential/commercial district with significant street-level programming and green space. The development's use of green roofs will reduce the scale of street-level stormwater infrastructure required to meet City and State guidelines, reduce the disturbance of contaminated soils and increase the total area that can be dedicated to outdoor programming.

The project will be developed in four construction phases. Table 1 lists the buildings designated for each phase, their total footprints and the maximum area possible for green roofs. Figure 1 shows the locations of each building within the entire development. Urban Edge has described several possible green roof programming interests, including tenant gardening, recreation, education, and stormwater management. Urban Edge is also interested in maximizing the secondary green roof effects of habitat creation, reduction of the urban heat island effect, reduced costs for climate control, roof material longevity, and aesthetic improvements. However, rooftop loading capacities, roof slopes, space availability, and cost limit the ability of green roof design to address each of these interests.

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<sup>3</sup> The three parcels are listed under RTN 3-3573 for a specific release of petroleum to the soil and groundwater at parcel 69.

<sup>4</sup> Environmental Protection Component, Epsilon Associates, Inc.

**FIGURE 1: Jackson Square Redevelopment Initiative, green roof planning and phasing.**

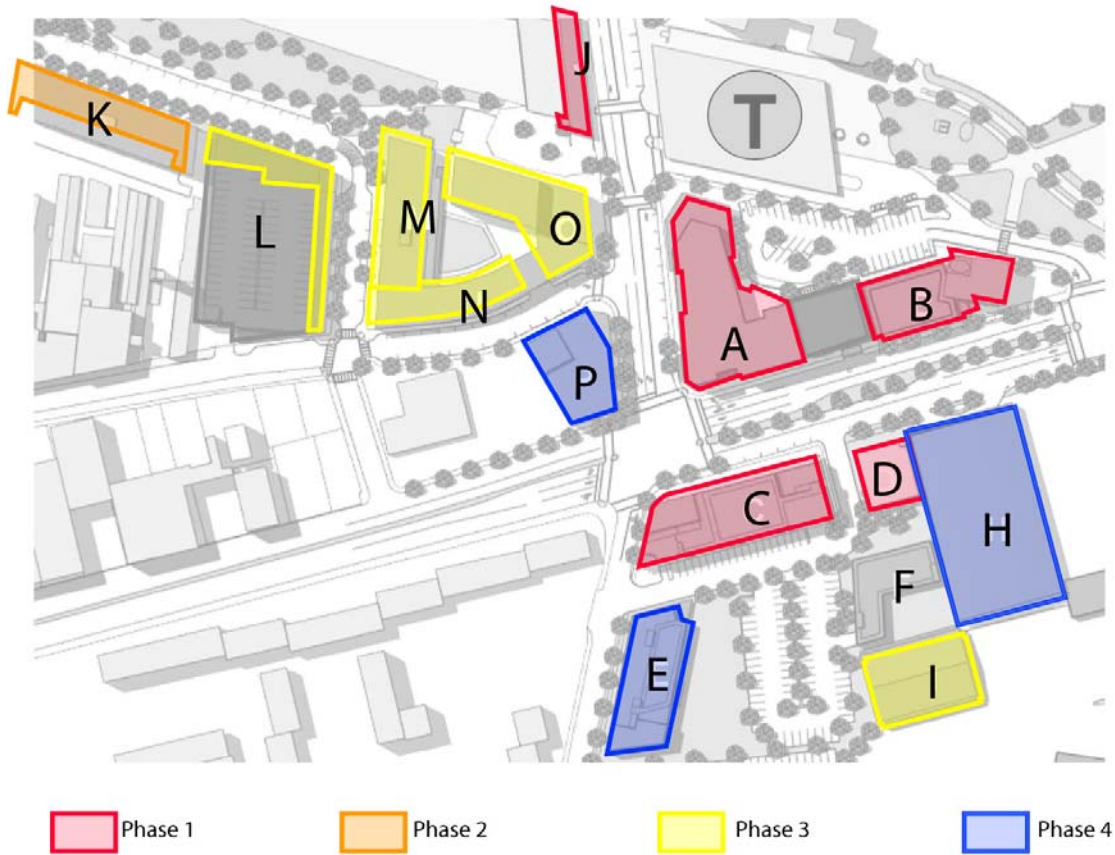


TABLE 1: PHASES, BUILDINGS, AND GREEN ROOF AREAS

Phase	Building ID	Building Name	Building Footprint (ft <sup>2</sup> )	Building Rooftop Available for Green Roof (ft <sup>2</sup> )	Area (ft <sup>2</sup> )	Percent Roof Area Extensive	Percent Roof Area Intensive	Notes
1	A	225 Centre Street	19,625	15,500	Upper Lower	70% 0%	0% 50%	50% active deck; no food production; ornamental native garden
	B	Youth and Family Center	12,580	12,580	Upper Lower	70% 0%	0% 50%	Opportunity for education/natural area/agriculture/nursery
	C	1562 Columbus Ave	15,180	15,180	Upper Middle Lower	70% 56% 0%	0% 14% 0%	Programming for intensive focus on agriculture Pavers for tenant access.
	D	Webb Office Building	4,551	4,551		70%	0%	
	F	DYS Facility	6,673	6,673		0%	0%	Existing building/Unknown bearing capacity
	J	MBTA Site	3,573	3,573		70%	0%	
<b>Total Phase 1 Areas (ft<sup>2</sup>)</b>			<b>62,182</b>	<b>58,057</b>		<b>25,050</b>	<b>6,891</b>	
2	K	50/70 Jackson Street	7,750	7,750		70%	0%	
<b>Total Phase 2 Areas (ft<sup>2</sup>)</b>			<b>7,750</b>	<b>7,750</b>		<b>5,425</b>	<b>0</b>	
3	I	PWD Facility Reconstruction	9,780	9,780		0%	0%	
	L	32 Jackson Street	29,964	6,705		100%	0%	Area around parking only
	M	15 Jackson Street	9,688	9,688		70%	0%	
	N	Amory Street	6,892	6,892		70%	0%	
	O	250 Centre Street	12,080	12,080	Upper Lower	70% 70%	0% 0%	
<b>Total Phase 3 Areas (ft<sup>2</sup>)</b>			<b>68,404</b>	<b>45,145</b>		<b>26,767</b>	<b>0</b>	
4	E	Ritchie Street	10,404	10,404	Upper Lower	70% 70%	0% 0%	
	H	Indoor Rec Center	28,894	28,894		70%	0%	Arched roof
	P	240 Centre Street-NStar Site	8,396	8,396	Upper Lower	70% 70%	0% 0%	
<b>Total Phase 4 Areas (ft<sup>2</sup>)</b>			<b>47,694</b>	<b>47,694</b>		<b>33,386</b>	<b>0</b>	
<b>TOTAL AREAS (ft<sup>2</sup>)</b>			<b>186,030</b>	<b>158,646</b>		<b>90,627</b>	<b>6,891</b>	

At the time of writing of this report, Phase I was in the design stage. The design stage is where decisions can be made regarding rooftop programming and the possibility of including intensive green roofs for tenant access and activities. Table 1 shows the beginning of the process of differentiating and designating green roof programming on a building-by-building basis, while also anticipating the green roof needs of the entire project. Where no programming decisions have been made, the green roof coverage was set at 70% extensive (shallow media) use. The table is intended as a tool for understanding and quantifying the use of green roofs throughout the process of planning and design of the project.

New construction planning can be modified or enhanced to anticipate the desired green roof programming needs. Distributed loading rates of 200 to 300 pounds per square foot far exceed the loads of most green roof products, but are commonly required by modern construction codes. Roofs with slopes of less than 2% provide ideal drainage and stability. In addition, a range of modern roofing materials will offer sufficient waterproofing and durability in the foundation requirements for the green roof. Retrofit conditions, however, offer greater restrictions in the type, benefit and use of green roofing. Maximum loading rates, slopes and waterproofing systems will be limited by the existing conditions of the roof and its underlying structure.

### **Project interest in green roofing**

Urban Edge used a number of factors when deciding to install green roofs over most of the planned buildings in the Jackson Square Redevelopment Initiative. Principally among the factors is compliance with Massachusetts Department of Environmental Protection (MADEP) stormwater management guidelines, which impose strictly defined stormwater quality and peak-flow discharge requirements on new construction activities of more than one acre. In order to meet these requirements, it will be necessary to install street-level and/or subsurface stormwater treatment and detention structures sized to mitigate precipitation falling on the site. Green roofs can be used to reduce (but not eliminate) the need for stormwater detention tanks and treatment on or in the ground. The project will redevelop a brownfield site, use less excavation/removal of contaminated fills through green roofs, decrease in emissions from hauling, reduce risk from potential exposure to contaminants, and increase cost efficiency.

Green roofs improve stormwater quality and reduce peak flowrates by providing detention and filtration of stormwater before discharge. Green roofs also provide some amount of retention through evapo-transpiration. The detention of stormwater delays the time that a volume of water is released to the conveyance system, thus reducing the likelihood of flooding from heavy rainfall in an overburdened sewer system. As Boston is largely served by combined sewers (both sanitary and stormwater in the same pipes), reducing peak flows would also reduce the volume and number of Combined Sewer Overflow (CSO) events. These events release untreated sanitary wastewater into receiving waters. Developed urban areas experience a high degree of “flashiness,” or a quick accumulation of stormwater reaching conveyance systems. This is due to the great increase in impermeable surfaces and reduction in opportunities for infiltration to groundwater. Stormwater quality in urban areas is also diminished by high rates of contamination from street runoff, limited filtration and high solids content. Green roofs, like natural systems, provide opportunities to slow the accumulation of rainfall, to filter rainfall through porous media and biologically active systems and to diminish the total burden on the stormwater conveyance system by retaining a volume of water within the media. The MADEP regulations are written to enhance these properties, and to set minimum standards for green roof performance. The regulations are discussed below in more detail.

Green roofs have been demonstrated to lower the cost of heating and cooling in buildings by providing a higher degree of insulation from heat transfer. In winter months, green roofs increase

the insulating ability of the roof through the presence of additional material. This increase depends on the thickness and type of green roof installed and the insulation value of the remaining roof structure. In northern states, building codes generally require substantial insulation values for new roof construction, which diminishes the relative additional effect of the green roof. In summer months, green roofs will reduce building cooling needs by increasing insulation, reducing solar gain, and increasing evapo-transpiration. In southern states, cooling costs can drop dramatically after the installation of a green roof. However, predicting the energy savings from the use of green roofs is difficult and unreliable, as these predictions are based on a number of site-specific conditions (building size and energy usage, roof insulation, materials, etc.) and climatic conditions (latitude, cloud cover, rainfall patterns, wind speeds, ambient temperature and humidity, etc.). Energy models that incorporate these variables are not very well-developed for green roof applications.

Roofing materials vary in their longevity, from 10 and 100 years. Modern commercial flat roofs typically endure 10 to 30 years of standard use under most conditions and with minimal maintenance. Green roof manufacturers claim green roofs increase the lifespan of the roof from between 200% and 300% when protected by a well-maintained and properly installed green roof.

Public access to rooftop areas can be achieved by integrating the design of green roof structures, pavement panels and other amenities and accessories. Actual access and use of the green roof will depend on the roof type, thickness and vegetative cover. Thicker planting media (8 inches - 18 inches) can sustain a variety of annual and perennial plants, including shrubs and even small trees, and can provide tenants with opportunities for vegetable and ornamental gardening. Recreational lawns can also be installed on roof surfaces, with adequate protection at the perimeter. Each of these applications must be considered individually to ensure that the roof provides sufficient structure, appropriate slope, adequate stormwater mitigation, proper plantings, sturdy green roof materials, and protection of the waterproofing system.

Additional benefits from installing green roofs come from the opportunities for creation of habitat for migratory birds, providing urban habitat niches that are safe from street hazards and human interruption. By targeting specific bird species, plant choices can be made which provide a forage source for the birds themselves or for their prey. These decisions depend largely on the developer's interests, local conditions and local habitat scarcity. Combating the urban heat island effect is another reason for creating a green roof. Traditional building materials absorb the sun's radiation and re-emit it as heat, making cities at least 7°F hotter than surrounding areas. On Chicago's City Hall, by contrast, which features a green roof, roof temperatures on a hot day are typically 25 to 80°F cooler than they are on traditionally roofed buildings nearby. Figure 2 illustrates the aerial extent of local "greening" that the development can achieve through this plan.

**FIGURE 2: Habitat opportunities and local “greening” through green roof installation at Jackson Square, Roxbury, MA.**



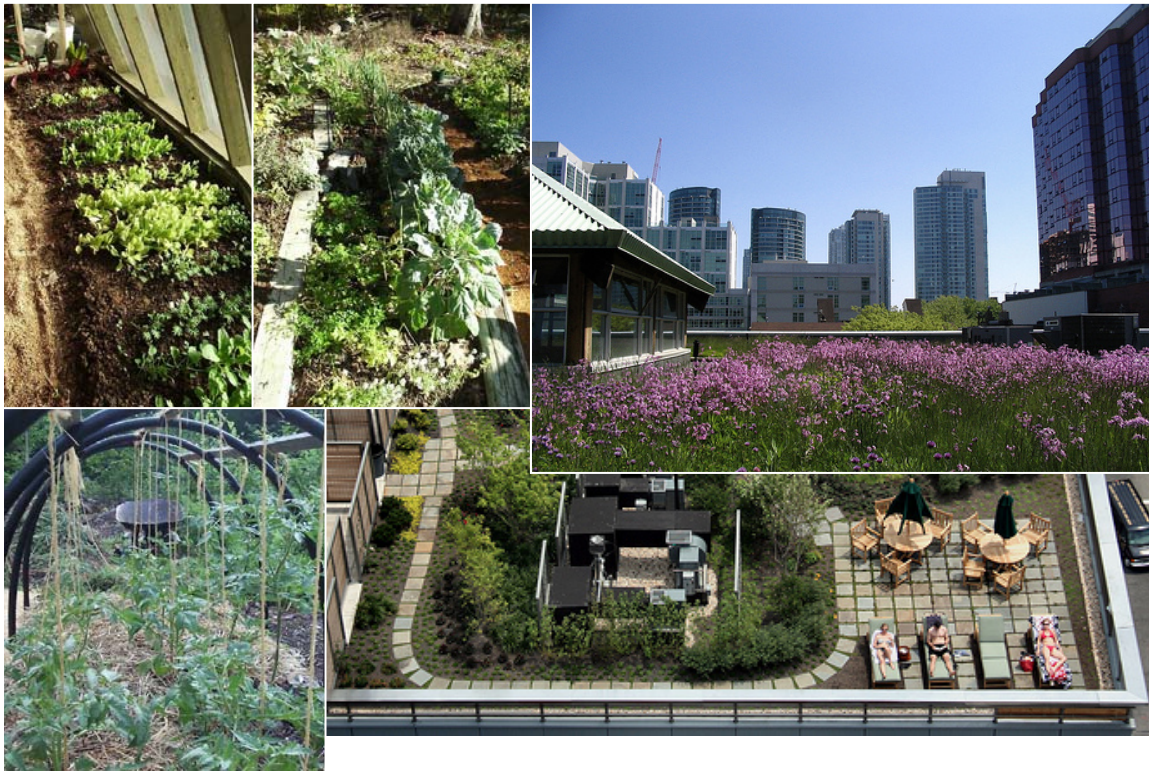
### **Extensive and intensive green roofs**

There are typically two types of green roofs: extensive or thin media and intensive or thicker media. Extensive green roof media meet the minimum needs of a small selection of hardy plants that can survive perennially and with no or minimum irrigation. The total thickness is between two and four inches. Most extensive green roofs will meet a building’s stormwater detention requirements when applied over at least two thirds of the total roof area, and will perform the additional functions of reducing climate control costs, extending the lifespan of the roof structure, and reducing the heat island effect. Extensive green roofs also have low loading densities (10 - 35 lb/ft<sup>2</sup>), lower material costs, low maintenance costs, and ease of application. For these reasons, extensive green roofs are generally the best choice in retrofitting existing roofs. A number of very different extensive products are available for easy application by relatively untrained roofers. Various products will arrive for installation with already established plantings. It is becoming increasingly common in the US for commercial roofers to offer extensive green roofing as part of a total roof package.

Plant choices for extensive roofs are usually limited to *sedums*, a hardy succulent groundcover that can endure both drought and flood conditions. *Sedum* species grown on green roofs can provide a variety of colors, but are generally non-native and do not reach the range of forms and

heights that many designers seek in a rooftop landscape. Extensive green roof values are also minimal. However, a properly installed and well-established extensive green roof can survive with almost no maintenance or irrigation and at a much lower initial cost than intensive green roofs.

**FIGURE 3: Examples of Intensive Green Roofs, including native flowers and food production.**



*Intensive uses include food production, herb gardens, native flowers, and ornamental gardens.*

Intensive green roofs offer a much greater variety of plant types and opportunities for landscaping and design. Intensive growing media typically range in thickness between 8 and 18 inches and have been installed at depths up to 36 inches where special growing conditions were required. With irrigation and maintenance, eight inches of growing media can support a range of habitat types, multiple landscape architecture options and public access. The only limiting factors on intensive green roof applications are roof bearing capacity and cost. Agricultural or gardening opportunities can be created with a minimum of 8 to 12 inches of media, when the deeper strata are protected from damage by gardening tools. Some typical installations include native plant gardens, shrubs and woody perennials, native or ornamental grasses, and ornamental flower beds.

Shallow-intensive green roofs can also be selected when there is interest in providing greater utility and public access to the roof. However, there is less viability for diverse plant communities. Grass lawns can be sustained in six to eight inches of growing media with proper media selection and irrigation, offering direct recreational access for tenants.

### Green roof implications with respect to stormwater regulations

Green roof benefits stand alone in their contributions to habitat enhancement, energy savings, roof longevity, and aesthetics. Yet their use is frequently driven by their ability to meet state and local regulations mandating limited stormwater discharges from new construction under a variety of storm conditions. Vita Nuova recommends sizing green roof installations to minimally meet the relevant regulations, then enhancing the design to meet the more specific needs of the development.

The Boston Water and Sewer Commission (BWSC) does not directly regulate stormwater management. The BWSC's only site plan requirements for stormwater are the following:

“10. It is required that the project proponent assesses the use of methods to contain stormwater on the site. BWSC will not approve connections to its storm system or combined system without an assessment of on-site retainage.

11. Drainage calculations for the runoff are needed including the storm frequency, time of concentration, peak rate of runoff, and total volume of water for all projects involving over 2,500 square feet of impervious surface.”<sup>5</sup>

BWSC also reserves the right to require that “[e]very person seeking to establish a new connection to the Commission’s wastewater or storm drainage system or to reconstruct, repair or modify an existing connection for a facility undergoing expansion may be required to prepare and implement a stormwater management plan .... The design of such facilities shall be subject to the approval of the Commission.”<sup>6</sup>

The BWSC defers to the MADEP regarding stormwater management requirements. Those regulations are described in the Massachusetts Stormwater Handbook which is available online at <http://www.mass.gov/dep/water/laws/policies.htm#storm>.

The handbook describes two principal stormwater control parameters that must be met, Standards 2 and 4. Standard 4 states that the *required water quality volume* must equal 0.5 inches of runoff times the total impervious area of the post-development site. The volume is to be detained, treated and 80% of the Total Suspended Solids (TSS) removed.<sup>7</sup> “If [a green roof is] sized to retain the required water quality volume, the area of the green roof may be deducted from the impervious surfaces used to calculate the required water quality volume for sizing other structural treatment practices.”<sup>8</sup> This is the parameter that Vita Nuova has sought to meet in sizing green roofs for Jackson Square. Increasing rooftop retention beyond the required volume would not necessarily result in a reduction of the water quality volume required for the remainder of the site. This would likely have to be addressed with additional stormwater best management practices (BMPs) on the ground.

The second parameter relates to post-development peak discharge rates. The discharge rates must not exceed pre-development peak discharge rates for the 2-year and 10-year 24-hour storms. In order to demonstrate compliance with Standard 2, the developer should develop a site-wide

<sup>5</sup> Sewer Data, Boston Water and Sewer Commission, [http://www.bwsc.org/tab\\_menus/6frameset5.htm](http://www.bwsc.org/tab_menus/6frameset5.htm).

<sup>6</sup> Sewer Regulations, Boston Water and Sewer Commission, [http://www.bwsc.org/tab\\_menus/6frameset5.htm](http://www.bwsc.org/tab_menus/6frameset5.htm).

<sup>7</sup> Massachusetts Stormwater Handbook, Volume 1, Chapter 1, page 9, <http://www.mass.gov/dep/water/laws/policies.htm#storm>.

<sup>8</sup> Massachusetts Stormwater Handbook, Volume 2, Chapter 2, page 112, <http://www.mass.gov/dep/water/laws/policies.htm#storm>.

hydrological model that predicts the relative change in peak flow discharge for the two storms. This should be done once the entire site's drainage, detention and stormwater treatment plan is complete. A further requirement states that the modeling of the 100-year 24-hour storm should not increase any off-site flooding.<sup>9</sup>

With this understanding, Urban Edge should seek to maximize the regulatory benefits of green roofs by meeting the requirements of Standard 4, the water quality driven requirements. The next step to reach MADEP compliance is to plan the additional ground-level stormwater infrastructure required to meet Standard 4. This should be combined with Low Impact Development (LID) features, such as vegetated swales, rain gardens, grassy areas, or other ground surface techniques for retaining water. Once these systems are planned and sized, Urban Edge should develop a site-wide hydrological model to demonstrate compliance with Standard 2, the water quantity driven requirements. If the requirements of Standard 2 are not met, a design option should offer increasing the green roof coverage or depth.

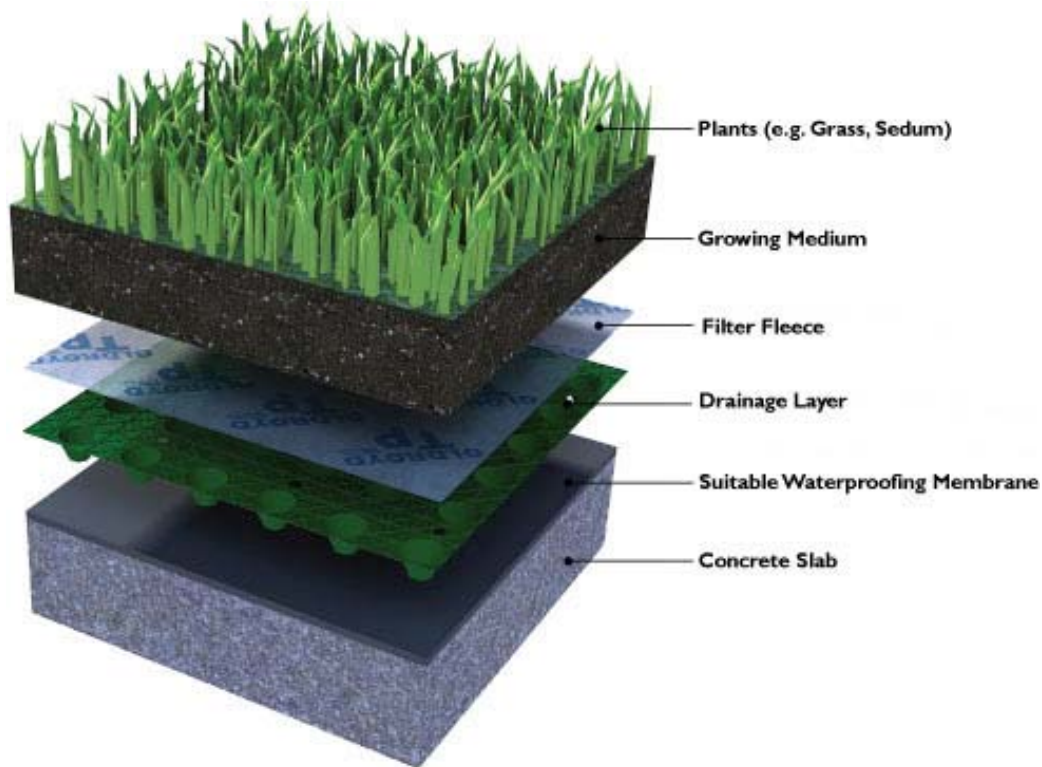
### **Components of green roofs**

Green roof systems can best be described as artificial layered planting beds that imitate natural soil conditions. In order to minimize loading on the roof structure below, the growing media are designed to be lightweight while maintaining sufficient moisture and nutrients to support plant communities. As the beds are installed over an impermeable roof surface, some form of sub-surface drainage must be provided to prevent ponding. While there are a great variety of ways to meet these needs, most green roof systems possess the same components (see Figure 4). In the US, green roofs are often sold and installed by roofers. For the purposes of this report, we have considered only those green roof components that are installed above the roof's waterproofing and insulation systems.

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<sup>9</sup> Massachusetts Stormwater Handbook, Volume 1, Chapter 1, page 5,  
<http://www.mass.gov/dep/water/laws/policies.htm#storm>.

**FIGURE 4: Generalized green roof system components.**<sup>10</sup>

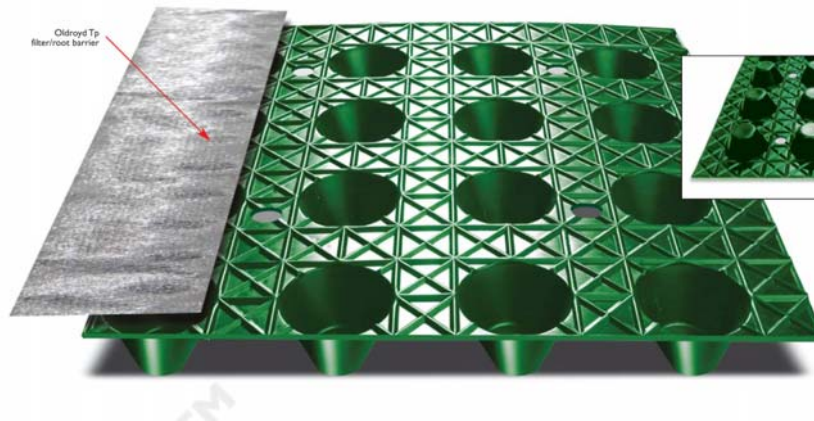


*Drainage layer*

The drainage layer sits directly above the waterproofed roof, often separated by a protective sheet to prevent abrasion and root intrusion. These layers are intended to remain partially dry when they are not actively draining. This allows air to flow into the pore spaces of the growing media and prevents anaerobic conditions and stagnation. In order to ensure the layers remain partially dry, the roof includes a layer of uniformly sized pea-gravel, typically made of expanded clay or shale, or a layer of molded plastic “egg cartons” (see Figure 5). Occasionally the molded plastic is designed to retain some water which is then available to the roots of the plants. When using pea-gravel, depending on the dimensions of the green roof and the degree and direction of the slope, it may be necessary to embed a drainage pipe grid system (see Figure 6). These pipes are then routed toward the building downspout, flow control device, or elsewhere for reuse. Some extensive green roof products meet their drainage needs by using a thick, porous mat of looped fibers bound to a filter fabric (see Figure 7). These can be inexpensive to install, especially when retrofitted over existing roof structures.

<sup>10</sup> Flat Green Roofs and Roof Gardens, Safeguard Europe Limited, [http://www.safeguardeurope.com/applications/green\\_roofs\\_flat.php](http://www.safeguardeurope.com/applications/green_roofs_flat.php).

**FIGURE 5: Example of preformed plastic drainage layer.<sup>11</sup>**



**FIGURE 6: Example of drainage pipe grid for pea-gravel drainage layer.<sup>12</sup>**



<sup>11</sup> Oldroyd Turf Roofs, Safeguard Europe Limited,  
[http://www.safeguardeurope.com/pdf\\_datasheets/oldroyd\\_turf\\_roofs.pdf](http://www.safeguardeurope.com/pdf_datasheets/oldroyd_turf_roofs.pdf).

<sup>12</sup> Green Roofs – Systems with Granular Drainage, Conservation Technology,  
[http://www.conservationtechnology.com/greenroof\\_systems\\_granular.html](http://www.conservationtechnology.com/greenroof_systems_granular.html).

**FIGURE 7: Example of fabric drainage mat.<sup>13</sup>**



*Filter fabric*

This layer is typically composed of a woven or non-woven geotextile fabric, and is intended to prevent fines from intruding into the growing medium and the drainage layer (see Figure 8).

**FIGURE 8: Filter fabric installed over plastic drainage layer.<sup>14</sup>**



*Growing medium*

The role of the growing medium is to imitate or replace the properties of natural topsoils while remaining lightweight and relatively free of fine particles. Key properties of the growing medium

<sup>13</sup> Going Green at Haverford – root barrier, Haverford College, <http://news.haverford.edu/blogs/goinggreen/tag/root-barrier/>.

<sup>14</sup> Green roof booklet, J-Drain, <http://www.j-drain.com/pdfs/Greenroof%20Booklet.pdf>.

include permeability, water retention and nutrient adsorption. In time, the medium grows soil bacteria and fungi, which drive the decomposition of organic matter, subsequently providing nutrients for the plant communities and supporting insects that attract foraging birds. Growing media must also be able to regulate pH, reflect sunlight, and endure conditions of high winds and exposure.

Two types of solutions have become popular growing media in the green roof market: non-woven fabric, fleece or coir mats and aggregate “soils.” While mats can be used over an aggregate “soil” in intensive applications, they are typically limited to extensive green roofs. Lightweight aggregates vary widely in composition, texture, density, appearance, and utility, and each vendor has their own proprietary mixture for different green roof applications and climates.

Fabric mats do not resemble natural soils in appearance or form. However, they provide the necessary substance for water retention and root growth. Fabric mats are limited in their maximum depth and are therefore generally used only in extensive green roof applications where two inches or less of growing medium is required. Additionally, they are typically overlain with either a pre-seeded or pre-vegetated mat which is established off-site prior to installation (see Figure 9). While the mats are easy to install, they require one to two years of set-up time before the roots become fully integrated into the growing medium and create a stable system. Until that time, these systems will usually require irrigation to assure success of the plantings. In addition, fabric media may not be walked upon regularly. With some materials, long-term viability is uncertain.

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**FIGURE 9: Example of pre-vegetated mat.<sup>15</sup>**



Lightweight aggregate media possess many of the same properties of soils without the density and fine particles. Many aggregates contain expanded clay, shale or slate, which can create the bulk and structure of the growing layer (see Figure 10). These expanded products are themselves porous and of uniform size distribution, creating a rigid skeleton of unlimited depth. A variety of organic and inorganic materials are added to the mix in order to provide the properties necessary to sustain plant growth (see Figures 11 and 12). The desired texture of the medium can be adjusted when there is interest in creating opportunities for gardening or specialized plant communities.

<sup>15</sup> These mats are established before delivery and subsequently placed over the installed growing medium, drainage layer and filter fabric. They will typically require two years to fully establish in the new growing medium. In this image, the growing medium is a thick fleece blanket. Xero Flor - Simply. Smarter. Green Roofs., Xero Flor America LLC, <http://www.xeroflora.com/system.html>.

**FIGURE 10: Example of light-weight growing medium (expanded slate, bark and compost).**<sup>16</sup>



**FIGURE 11: Growing media components.**<sup>17</sup>



<sup>16</sup> Green Roof Entry Arbor, Felder Rushing, [http://www.felderrushing.net/GreenRoofEntryArbor\\_000.htm](http://www.felderrushing.net/GreenRoofEntryArbor_000.htm).

<sup>17</sup> Precise mix will depend on climate, intended use, and vendor trademarks.  
G-Sky – Planning – Soil, G-Sky, [http://www.g-sky.com/Planning\\_Soil.aspx](http://www.g-sky.com/Planning_Soil.aspx).

**FIGURE 12: Example of light-weight growing medium (expanded clay aggregate or vermiculite and other light-weight, high water storage capacity components).<sup>18</sup>**



#### *Plant layer*

Extensive green roofs in the northern United States have principally been planted with *sedums*, a hardy, succulent groundcover that is able to endure very dry and very wet conditions. *Sedum* roofs are typically planted with several species which can grow in a range of colors and produce seasonal flowers. These plants reproduce well both vegetatively and sexually and are highly tolerant to the extreme conditions produced on rooftops. They are the ideal low-maintenance cover for shallow media green roofs, especially when providing irrigation is not possible, nor desirable. The primary disadvantage of *sedum* roofs is their fragility. As a result, this makes recreational access to the green roof possible only where paving or pathways are provided. Most *sedums* will be crushed under a person's foot. There are some 400 species of sedums catalogued, ranging from creeping annuals to waste-high perennial shrubs. Dozens of species have been tested on extensive green roofs.

Intensive green roofs provide much greater horticultural flexibility and variety. The typical medium depth (eight inches) can support shrubs and even some small trees, and deeper growing media, as much as 36 inches, can support a multitude of tree species. Plants are selected depending on aesthetic and programming interests, accounting for hardiness, light and temperature regimes. Intensive green roofs usually provide tenant access and are usually cultivated with attractive plants of varying heights, with landscaped pathways and public spaces. Mowed grass can also be sustained in shallow-intensive roofs (six to eight inches) creating recreational lawns and play spaces. Some care must be taken when choosing a growing medium

<sup>18</sup> These components include peat moss, composted sawdust and bark fines, coco peat, washed sand, recommended fertilizers and water retaining crystals. Green Roof Systems, Elmich, <http://www.elmich.com.au/greenroofsystems/specifications.php>.

and drainage layer; both must be structurally capable of supporting regular traffic. Irrigation systems are also required to maintain grass cover.

#### *Agricultural alternative*

Cultivation and public gardening can be created with a minimum of eight inches of granular medium and advanced planning to protect the roofing membrane from accidental damage. Experienced green roof vendors will be able to offer a growing medium mix that possesses the proper texture and chemical properties for producing both edible and ornamental plants. Intensive roofs are normally installed with irrigation systems and artificial soils do not contain a reservoir of undesirable seeds. As a result, rooftop gardening can easily become a successful and popular endeavor.

There are, however, caveats when programming productive gardening systems on rooftops. First, productive agricultural systems will impose a significant load to the roof structure that far exceeds most lightweight intensive green roof systems. Regularly introducing large quantities of compost to a lightweight soil aggregate will eventually increase its density and reduce the porosity and drainage rates. This conflicts with the ability of green roofs to provide stormwater retention and detention. A designer should hesitate to recommend intensive farming without a complete understanding of how the stormwater management functions of the green roof would be affected. Additionally, applying fertilizer or increasing the percentage of organic material, particularly humus, into the soil results in water quality consequences. Specifically, fertilizer increases nitrogen and phosphorous concentrations in the percolate. Rooftop farming is a viable option, but requires a fair amount of advanced planning to assure that structural and stormwater retention needs are met, and inadvertent nutrient loading downstream is avoided. (For further information on rooftop agriculture see <http://www.buildinggreen.com/articles/IssueTOC.cfm?Volume=18&Issue=2>.)

#### **Green roof accessories**

A number of specially designed accessories are available and marketed for green roof applications. Generally, these accessories become necessary only with intensive green roofs when there will be public access to the roof areas. The accessories are used to protect the roofing membrane or waterproofing system from inadvertent damage, maintain the edges of the green roof materials and provide safety or limited access to roof areas. Additional accessories include flow or discharge control weirs that regulate the rate at which detained water is released to the storm sewer systems, and irrigation systems which improve the diversity and viability of the plantings during dry periods.

Pavers are used to provide access and avoid damage to plant communities and the membrane system, and to limit or regulate traffic. These are generally made from light-weight aggregate concrete or recycled plastic. They come in colors that reflect the heat from sunlight. One of the primary ingredients in the lightweight growing media is expanded clay, slate or shale. These can break down or crumble under constant foot traffic. Pavers prolong the life of the growing media and provide stable flat patios for many types of programming.

Edge restraints are needed wherever the green roof edges are exposed at the roof's edge (if there is no parapet wall), along pathways or around mechanical systems. The edge restraints must retain the growing media and drainage core without requiring anchoring or penetration of the roofing membrane. As these features are generally visible, they are usually made from high quality materials (steel or aluminum) and provide a finished look to the planted edge. When there is sufficient advanced planning, as with new construction, many situations that might usually

require edge restraints can be avoided by using permanent structural barriers built into the roof design.

Irrigation systems vary widely, from pop-up sprinkler networks to subsurface drip irrigators with automatic sensors. Extensive systems will commonly require irrigation for the first two years in order to establish viable root systems. These systems can be installed temporarily and removed once they are no longer useful. Plant communities in intensive systems will require permanent and regular irrigation, especially during summer months. Automatic systems with timers and moisture sensors can reduce the need for frequent oversight and care.

Any full-service green roof vendor should be willing to recommend and/or install a range of products in order to improve the long-term viability of a green roof, as well as to enhance the user's experience. Many landscape architects have become increasingly familiar with green roofing design and should also have access to off-the-shelf products for green roofs.

### **Comparing green roof vendors**

Vita Nuova has selected three green roof vendors for detailed comparison. The comparison contrasts their services and products applications to the development at Jackson Square. A common difficulty in assessing the viability of green roofing comes from the complex criteria and variables that influence price estimating, as well as the range of products and product performances that exist in today's market. As the use of these technologies is relatively new in the US, many consumers (developers, architects, landscape architects, building owners/managers) are unfamiliar with the constraints and parameters involved in making proper product selections and are unaware of the range of design possibilities. Vendors are also frequently reluctant to offer product and installation pricing because of the site-specific conditions that influence those costs.

The market in the US is also complicated by the recent emergence of many green roof vendors that are linked to vendors or manufacturers of standard roofing materials. In these cases, isolating the cost of different components (roof membrane or waterproofing system, insulation, drainage system, green roof, irrigation system, etc.) can be very difficult. Designers and consumers have frequently complained that a vendor will try to under-price their green roof product in order to assure the sale of the conventional roof below. Furthermore, green roofing systems provided by conventional roofing contractors may not provide the same range of utility or flexibility in design. They also lack the expertise offered by a dedicated green roof vendor who is promoting several different green roof products.

For the purposes of this report, Vita Nuova selected three green roof vendors for detailed review. The vendors were chosen based on requests from Urban Edge, the types of green roof systems offered and willingness of the vendor to perform detailed cost estimates with no site visit, limited planning details and no assurance of return for their efforts. Vita Nuova also considered vendor locations and proximity to Boston, project history in the Boston area and expertise in related services. By request of one vendor, the company name will not be reported, and the vendor will be referred to by the alias "Green Roof Inc." The actual identity will be submitted to Urban Edge for their internal use, along with product specifications and additional pricing information.

Green Roof Inc. principally produces a modular tray system with granular growing media of either four or eight-inch depth. Trays are planted, kept in greenhouses and delivered for installation with established plant communities. Xero Flor America produces a pre-vegetated roll-out system that uses a fleece fabric growing medium. Xero Flor's products are principally for use in extensive green roof applications. Roofscapes, Inc. produces a range of build-in-place systems

for both intensive and extensive green roofs. Each of these products is applicable to Jackson Square.

*Physical product traits*

As mentioned above, this report considers the application of a viable planting medium, with plants and drainage, on flat rooftop surfaces with a waterproofing system or membrane. These surfaces have sufficient structural integrity to manage the saturated weight of the media and plants. Refer to Figure 4 for the component layers of the generalized system.

Some roof surfaces should be protected from the possible intrusion of plant roots by a root barrier, a flexible thermoplastic membrane. The need for this layer should be determined by the membrane or waterproofing system manufacturer. Green Roof Inc. recommends the use of a protective fabric over the membrane in order to prevent abrasion from the high-density polyethylene (HDPE) trays.

The first substantial layer of the green roof system serves to drain excess stormwater as it percolates through the planting medium, directing stormwater to the building drains, and thus preventing flooding or ponding. Green Roof Inc.'s drainage layer is integrated into the modular tray, the bottom of which is waffled and perforated with drain holes. Filter fabric is laid over the waffles to prevent the intrusion of fines. Xero Flor uses a drainage mat, a layer of flexible non-woven, entangled polymeric filaments with perforated geotextile filter-fabric bonded to one side. This mat is approximately ½-inch thick and is rolled into place. Roofscapes utilizes a number of drainage materials, the selection depends on the roof application. Their extensive system is installed with a 1-inch thick "moisture mat," composed of recycled closed-cell polyethylene foam with bonded separation fabric and water channels on the underside to promote drainage. Roofscapes's intensive system is built with a 3-inch layer of "pea gravel," uniformly-sized mineral granules, which are laid with a network of perforated pipes to promote better flow along longer slopes. The gravel is over-lain with a filter fabric to prevent intrusion of the finer grains from the growing medium above.

Green Roof Inc. and Roofscapes both utilize lightweight granular mixtures with both mineral and organic components, and grain size distributions that exclude the clay and silt fractions. The compositions of these "soils" are based on standards developed for green roof applications in Germany, and are proprietary products of the vendors. Xero Flor's growing medium consists of rolled-out sheets of a fleece fabric produced from a blend of recycled synthetic fibers. To meet the MADEP stormwater retention guidelines, two layers (one inch each) of fleece should be installed over at least two-thirds of the building footprint.

The plant layer utilized by Xero Flor consists of a textile-based vegetation carrier, made of lightweight fleece sown to entangled fibers, bonded to a geotextile fabric and filled with a planting substrate. The mat is precultivated with an even layer of low-profile *sedums*. Installation involves rolling the mats over the growing medium. Roofscapes offers a similar product, as well as a coir fiber mat that can be seeded or planted with plugs or cuttings and established on site. Green Roof Inc.'s extensive product is established with mature *sedums* from greenhouses prior to installation. The intensive green roof systems offered by Green Roof Inc. and Roofscapes can be seeded or planted with a wide range of plant species. The species can be selected by the designer or landscape architect. Green Roof Inc. will establish those plants in advance of installation. Table 2 summarizes the above information.

**TABLE 2: Green roof layer types from three vendors.**

Vendor	Extensive			Intensive		
	Type of Growing Medium	Type of Drainage System	Plant Offerings	Type of Growing Medium	Type of Drainage System	Plant Offerings
Green Roof Inc.	Granular	HDPE Trays	Sedums	Granular	HDPE Trays	Perennials, grasses and shrubs/No Active Cultivation
Xero Flor America	Fabric Mat	Fabric Mat	Sedums	Fabric	Fabric Mat	Sedums
Roofscapes, Inc.	Granular	Moisture Mat	Sedums	Granular	Pea Gravel	Shrubs, tall grass, large perennials

Modular systems have the advantage of rapid installation and allow later design changes. While Xero Flor’s system will develop into a fully integrated mat, Green Roof Inc.’s “trays” can be relocated at any time given changes in programming needs. The trays can also be moved to access sections of the roof structure for repair. Built-in-place systems generally involve large contiguous areas of the rooftop. Portions of the built-in-place systems can be pulled away for roof maintenance, but they will not relocate easily. For larger projects over new building construction, built-in-place systems are likely to be more cost effective. Figures 13 and 14 show examples of both types of systems.

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**FIGURE 13: Built-in-place installation showing pea-gravel drainage, filter fabric, and growing medium.<sup>19</sup>**



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<sup>19</sup> Building the many layers of the green roof, The Scott Arboretum's Garden Seeds, <http://blogs.scottarboretum.org/gardenseeds/2008/08/building-layers-green-roof/>.

**FIGURE 14: Example of modular drop-in-place system.<sup>20</sup>**



Off-site plant development can minimize the initial maintenance time spent on difficult to access roof areas and allow immediate greening of a roof after installation. The advantage of establishing plants on site lies principally in cost savings. Additionally, plugs are more costly than cuttings, which in turn are more costly than seeds. Irrigation and regular maintenance are required to assure that plants reach maturity. Green Roof Inc. and Xero Flor only offer products with plants that are established prior to installation. Roofscapes offers a prevegetated extensive mat in addition to non-vegetated systems for both extensive and intensive applications. This information, along with the saturated weights of each of the products, is summarized in Table 3.

<sup>20</sup> These trays are self-contained modules, delivered with established plantings and ready to install over the roof membrane and a protective fabric mat. Deeper trays can sustain a wider range of plant varieties. Green Grid Roofs, <http://www.greengridroofs.com/MEDIA/PICTS/ERL2.JPG>.

**TABLE 3: Green roof offerings from three vendors.**

Vendor	Extensive			Intensive		
	Saturated Weight Density (lb/ft <sup>2</sup> )	Modular (MOD) or Built-In-Place (BIP)	Plants Established On or Off-Site	Saturated Weight Density (lb/ft <sup>2</sup> )	Modular (MOD) or Built-In-Place (BIP)	Plants Established On or Off-Site
Green Roof Inc.	18-22	MOD	Off-Site	36-50	MOD	Off-Site
Xero Flor America	15-18	MOD	Off-Site	18-24	MOD	Off-Site
Roofscapes, Inc.	20-34	BIP	On-Site/Plugs or Cuttings (Off-site available)	55	BIP	On-Site/Plugs or Cuttings

*Product performance traits*

Differences in green roof product performance can be subtle and observable only in longer timeframes. If stormwater retention and effluent quality standards are the primary concern, meeting those standards with the lowest possible cost, least maintenance and longest product lifespan are the performance objectives. If there are other programming interests, such as the creation of public gathering spaces, recreational areas, plant nurseries, or gardening opportunities, then performance must be measured differently. Vita Nuova has made an effort to compare a small number of these traits, summarized below in Table 4.

**TABLE 4: Growing media depths from three vendors.**

Vendor	Extensive			Intensive	
	Total System Depth to meet MADEP Requirements* (inches)	Growing Medium Depth (inches)	Longevity (years)	Range of Medium Depths (inches)	Range of Uses
Green Roof Inc.	4	4	not provided by vendor	8	No Cultivation, No Foot Traffic
Xero Flor America	3.5	2	>70	3†	No Cultivation, Light Foot Traffic
Roofscapes, Inc.	3	2	50-75	6-12	Cultivation Possible, Light to Heavy Foot Traffic

\*70% area coverage, detaining 0.5 inches over total building footprint per storm.

†This is not an actual intensive system, but can be built in conjunction with additional granular growing media.

Each of the vendors makes similar claims regarding stormwater management performance. The extensive systems will be sufficient to meet the MADEP required water quality volume when applied over at least two-thirds of the building footprint. Table 4 illustrates the total system and growing medium depths required to meet this criterion. Intensive systems will retain larger

volumes of water and are therefore typically chosen to meet other performance criteria, which are not as easily measured.

Vendors also made similar claims of their products' longevities, expecting approximately 70 years of service before replacement due to clogging or material degradation. This is the typical life expectancy of a conventional roof when protected by a green roof. Green Roof Inc. was reluctant to assert a life expectancy, as their products are relatively new to the market.

Each green roof product is expected to sustain 80% plant coverage after the establishment period, or the first two years. Maintenance contracts and vendor warranties can assure this level of plant success.

*Service traits*

Maintenance contracts and extended warranties can be negotiated with each of the vendors but for varying costs and lengths of service. Other service offerings and types of assistance are summarized in Table 5.

**TABLE 5: Service offerings from three green roof vendors.**

Vendor	Provides Design Assistance	Provides Regulatory Assistance	Provides Installation Assistance	Offers Accessories (Pavers, Edging, Irrigation)	Maintenance Contract	Warranty Service
Green Roof Inc.	N	N	N	Y	0-10 years	1-10 years
Xero Flor America	N	N	N	N	0-5 years	2-5 years
Roofscapes, Inc.	Y	some	Y	Y	2-12 years	10-12 years

**Comparing cost estimates**

Each of the vendors provided estimates of initial capital costs, including a five phase installation of approximately 100,000 square feet of green roofing on buildings with six or fewer stories. Cost estimates were provided on a square foot basis and do not include accessories, such as edge restraints, pavers, railings, or irrigation systems. The vendors also provided estimates of the annual cost to purchase a service or maintenance contract. These costs are summarized in Table 6.

**TABLE 6: Green roof cost comparison from three vendors.**

Vendor	Extensive <sup>^</sup>		Intensive <sup>^</sup>	
	Initial Capital Cost per Square Foot (incl. installation)	Annual Service Contract Cost per Square Foot	Initial Capital Cost per Square Foot (incl. installation)	Annual Service Contract Cost per Square Foot
<b>Green Roof Inc.</b>	\$16-\$18	\$1.50-\$3*	\$26-\$29	\$1.50-\$3*
<b>Xero Flor America</b>	\$13.50-\$15.50	\$0.15-\$0.25	\$14.50-\$16.50†	\$0.15-\$0.25
<b>Roofscapes, Inc.</b>	\$9.25-\$10	\$0.25	\$23.75-\$24.25‡	\$0.25

<sup>^</sup>All pricing provided by vendors subsequent to being supplied project information.

\*This price is reported based on trained access to difficult rooftop conditions.

†This is not an actual intensive system.

‡Includes irrigation system but without controls/plumbing.

In each case it was necessary to report a range in cost due to a number of uncertainties inherent in the process, as well as slight variations in the product options. Installation and maintenance costs would vary significantly with building heights, access, and construction phasing. Material costs would vary with project scale and with “extras” included in the different green roof systems. For example, as part of their intensive systems Roofscapes installs (without controls or connections) a drip irrigation line buried within the growing medium. This feature is not included in the prices from the other vendors. Accessories which are not included in the cost estimates may be essential to the design and successful green roof performance. Edge restraints or ballast systems may be required at the perimeters of the planted areas, pavers or another type of walkway may be needed to provide public access; and irrigation is necessary for all intensive green roofs and during the first season for many extensive systems. Estimates of these costs are not provided in this report, as they are highly dependent on the specifics of the rooftop designs. The reader should assume, therefore, that the costs reported in Table 6 represent the baseline costs to procure and install green roof components over a roof area that is already determined to be structurally sufficient, insulated, and waterproofed.

Every effort was made to compare similar performance products when presenting estimated costs. However, this was not always possible given the range of products studied. Of the extensive systems, the Green Roof Inc. product provides double the growing medium depth of the other vendors, thus potentially requiring a reduced total coverage area to meet MADEP stormwater retention requirements. Xero Flor’s thicker medium system is not an actual intensive green roof and would not support the plant diversity available with the other intensive roofs. Their prevegetated mat, however, can be used in combination with a granular growing medium, thus making it possible to expand horticultural options with cuttings and plugs. Also, Xero Flor requires that their extensive system be irrigated during the first two years after installation, thus increasing the total project cost by an additional \$2 - \$4/ft<sup>2</sup>. Green Roof Inc. and Roofscapes do not explicitly require irrigation of their extensive green roofs.

Roofscapes stipulates the cost of their extended maintenance contract provided through their installers. Xero Flor and Green Roof Inc. would negotiate that price on a project specific basis and have provided a price range based on conditions, scale and terms of the project. Green Roof Inc.'s estimate presumes the use of certified personnel trained specifically for difficult rooftop conditions and all the health and safety requirements associated with precarious work. All three vendors estimated installation and maintenance costs based on union wage scales.

### **Recommendations**

Vita Nuova recommends the following to Urban Edge regarding the planning, design and procurement of their green roof systems.

1. Urban Edge should meet the minimum retention requirement of 0.5 inches of rainfall over the entire building footprint by installing green roof systems.
2. Urban Edge should determine what additional programming interests they will have on each roof area, including parking, mechanical, and types of public access. Where intensive green roofs are desired, the area, use and appearance of the system should first be determined. Remaining detention needs should be met by extensive systems.
3. Design collaboration between the architects, builders and landscape architects should begin well before decisions are made regarding roof configuration, structure, drainage, and materials. Egress should be consistent with rooftop programming interests. Irrigation needs and maintenance access should be anticipated. The choice of a waterproofing system should also be considered and consistent with the application of a green roof. Safety and security should also be addressed.
4. Consider that mobilization and demobilization represent a large portion of the green roof installation cost. Planning minimally staged installation to correspond with construction phasing can improve ease of equipment access and reduce installation costs significantly.
5. Negotiate a long-term service or maintenance contract that also extends the warranty period for the maximum possible length of time.
6. Emphasize the use of native plants that will provide forage for local and migratory bird species.

Vita Nuova also recommends selection of a full-service vendor that can offer a wide range of products to meet all of the programming needs of the project. Price breaks can be negotiated in advance and based on project scale. The most full-service vendor reviewed in this report is Roofscapes. Roofscapes does not provide installation of conventional roofing systems. Green Roof Inc. and Xero Flor both have relationships with waterproofing system manufacturers. It may prove to be more cost effective to procure a complete conventional and green roof system from a single vendor along with a wrap-around warranty. However, roofing contractors do not generally provide the full range of green roof products available on the market, nor do they have the depth of expertise with green roofing systems. With sufficient advanced planning, the roofing contractor and independent green roof vendor may be able to coordinate installation and resolve concerns regarding design and material compatibility.

Vita Nuova believes that each of the green roof vendors reviewed here offer high quality products that could meet most project needs and perform well under most conditions. We thank these vendors for their time in preparing their thorough responses to our many questions and constraints.

## Appendix A

### Statement of Work City of Roxbury, Massachusetts Sustainability Pilot

The following statement of work describes the tasks to be completed by Vita Nuova under a subcontract with SRA International, an EPA contractor, for an assessment of the Jackson Square Redevelopment Initiative for Urban Edge, a community development corporation based in Roxbury, MA. Vita Nuova proposes to develop a **Green Roof Planning Report** for the proposed Brownfields Redevelopment.

#### **Task 1: Review existing data**

Vita Nuova will review of the site-related master plan design documents and supporting materials for the Jackson Square Redevelopment Initiative. Additionally, Vita Nuova will review stormwater detention requirements from the Boston Sewer and Water Commission when provided by Urban Edge for site-related information. The purpose of the review is to prepare and provide technical assistance to Urban Edge in designing appropriate remedies for cleaning up sites, and related site preparation activities, in order to facilitate sustainable reuse of the buildings.

#### **Task 2: Conduct on-site project assessment**

Vita Nuova will continue the assessment process by conducting a site visit to Jackson Square. Meeting with Urban Edge representatives and touring the site will result in meaningful dialog and observations, providing a valuable context for the data reviewed in the previous step. Vita Nuova will use this information to provide technical assistance to Urban Edge in designing appropriate remedies for cleaning up sites, and related site preparation activities, in order to facilitate sustainable reuse of the buildings.

#### **Task 3: Analyze options**

With a comprehensive overview of the project based on the site visit and the review of existing data, Vita Nuova will evaluate three green roof products for application at the site in the Jackson Square Redevelopment Initiative Master Plan.. Factors to be compared by Vita Nuova in the analysis of each system will include, cleanup and site preparation options, up front costs, life cycle cost, maintenance requirements, impact on building structural and drainage systems, storm water management impacts including impacts on the Boston sewer system, building energy performance, local regulatory requirements. Vita Nuova will also consider heat island impacts, water quality improvements, air quality impacts, possible habitat value improvements, and the review of hydrologic data at the site.

#### **Task 4: Review Conclusions with Client**

Vita Nuova will provide results of Task 3 and hold a conference call or webinar with the client to review the options identified in the previous task and to comment on specific project details for the site. The focus here will be to ensure that the analysis is sufficient to enable Urban Edge and their partners to make informed decisions when selecting green roof systems buildings that comprise the Jackson Square Redevelopment Initiative Master Plan.

#### **Task 5: Complete Final Report**

Vita Nuova will prepare a Final Report for the client that summarizes cleanup and site preparation options to promote sustainable green roof building renovation options.

**Deliverable: Comparative Green Roof Planning Report**

Vita Nuova will develop a summary of recommendations for green roof systems for each building type at the Jackson Square brownfield site. The summary of recommendations for site preparation will document the pros and cons of the three green roof systems to enable the best strategies for incorporating green roofs into cleanup and site preparation at Jackson Square. The recommendations will include an overview of the site preparation and cleanup costs associated with each system, a summary of potential maintenance issues, a review of the potential structural and drainage systems that may need to be integrated into the overall site preparation, and a summary of the energy performance and water demand impacts to the over site preparation plan.

**DELIVERABLES**

**DATES**

Site Visit

Within one month of receiving all background documents or notices to proceed from SRA.

Analysis Completed

One month from Site Visit

Review Analysis with Client via Conference call or Webinar

Within two weeks of Analysis Completion

Final Report

Within two weeks of Conference call

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**Appendix B: Green Roof Master Matrix**

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Jackson Square Redevelopment Initiative  
Green Roof Master Matrix

Bldg ID	Name/Address	Phase	Site	Building Use	Gross SF	Stories	Construction Type	Building Footprint (sf)	Roof Type (Flat/Sloped)	Roof Access?	Upper	Rooftop Available for Green Roof (sf)	Proposed Type (Intensive/Extensive)	Modular/Built In Place (BIP)	Growing Medium	Growing Medium Depth (in)	Drainage System	Irrigation System? (Y or N)	Green Roof Footprint	Estimated Cost (per sf)	Total Estimated Cost	Estimated Amount of Stormwater Absorbed (gallons)	Estimated Heat Island Impact (how to quantify??)	Load Requirements (lb/ft2)	Roof Framing Requirements	Civil Engineering Requirements	Annual Maintenance requirements including cost, tasks, etc.	Warranty (materials, installation)	Pros and Cons of system	Design considerations	
A	225 Centre St	1	I	Mixed Use (Res & Retail)	129,050	6	Steel?	19,625	Flat	Limited	Upper	14,120	Extensive	BIP	granular	2	composite/synthetic with channels	N	9,884	\$9.25	\$91,427	4620.8		34			\$2,471	2 years establishment, up to 10 years extended.			
											Lower	1,380	Intensive	BIP	granular	6	pipes in pea gravel	Y/N	690	\$24.00	\$16,560	1032.24		55			\$173	2 years establishment, up to 10 years extended.		Plan green roof boundaries and roof access in advance of construction.	
B	Youth & Family Center (1531 Columbus Ave)	1	I	Community Center	30,500	3	Steel?	12,580	Flat	Limited	Upper	3,060	Extensive	BIP	granular	2	composite/synthetic with channels	N	2,142	\$9.25	\$19,814	1001.4		34			\$536				
											Lower	9,520	Intensive	BIP	granular	6	pipes in pea gravel	Y/N	4,760	\$24.00	\$114,240	7120.96		55			\$1,190				
C	1562 Columbus	1	II	Mixed Use (Res & Retail)	60,700	5	Steel?	15,180	Flat	Limited	Upper	2,245	Extensive	BIP	granular	2	composite/synthetic with channels	N	1,572	\$9.25	\$14,536	734.7		34			\$393				
											Middle	10,295	Extensive	BIP	granular	2	composite/synthetic with channels	N	5,765	\$9.25	\$53,328	2695.2		34			\$1,441				
											Lower		Intensive	BIP	granular	6	pipes in pea gravel	Y/N	1,441	\$24.00	\$34,591	2156.1848		55			\$360				
D	Webb Building (1542 Columbus Ave)	1	II	Office	13,500	3	Wood?	4,551	Flat	No		4,551				composite/synthetic with channels	N	3,186	\$9.25	\$29,468	1489.3		34			\$796			Recommending use of "Roof-Rug" product for this retro-fit application.		
													Extensive	Modular	Non-woven fabric	2															
E	Ritchie Street	4	II	Residential	33,320	4	Wood?	10,404	Flat	No	Upper	2,150	Extensive	BIP	granular	2	composite/synthetic with channels	N	1,505	\$9.25	\$13,921	703.6		34			\$376				
											Lower	8,254	Extensive	BIP	granular	2	composite/synthetic with channels	N	5,778	\$9.25	\$53,445	2701.1		34			\$1,444				
F	1542R Columbus Ave	1	II	Dept of Youth Services	13,400	2	Wood?	6,673	Flat	No																					
H	Indoor Active Recreational Facility	4	II	Indoor Skating Rink	36,000	1.5	??	28,894	Curved	No																					
I	DPW Facilities	3	II	Office, Maintenance	28,575	1-2	??	9,780	unknown	No																					
J	260 Centre Street	1	III	Small shop retail	3,500	1	Wood?	3,573	Flat	No		3,573				composite/synthetic with channels	N	2,501	\$9.25	\$23,135	1169.3		34			\$625					
K	50-70 Jackson Street	2	III	Residential	59,140	6	Wood?	7,750	Flat	No		7,750				composite/synthetic with channels	N	5,425	\$9.25	\$50,181	2536.2		34			\$1,356					
L	32 Jackson Street	3	III	Mixed Use (Res, Retail, Parking)	111,030	4	Steel?	29,964	Flat	No		6,705				composite/synthetic with channels	N	4,694	\$9.25	\$43,415	2194.2		34			\$1,173					
M	15 Jackson Street	3	III	Residential	38,800	5	Steel?	9,688	Flat	No		9,688				composite/synthetic with channels	N	6,782	\$9.25	\$62,730	3170.4		34			\$1,695					
N	Amory Street	3	III	Mixed Use (Res & Retail)	29,800	4	Steel?	6,892	Flat	No		6,892				composite/synthetic with channels	N	4,824	\$9.25	\$44,626	2255.4		34			\$1,206					
O	250 Centre Street	3	III	Mixed Use (Res & Retail)	89,200	5-10	Steel?	12,080	Flat	No	Upper	8,510	Extensive	BIP	granular	2	composite/synthetic with channels	N	5,957	\$9.25	\$55,102	2784.9		34			\$1,489				
											Lower	3,570	Extensive	BIP	granular	2	composite/synthetic with channels	N	2,499	\$9.25	\$23,116	1168.3		34			\$625				
P	240 Centre Street	4	III	Mixed Use (Res & Retail)	50,280	6	Steel?	8,396	Flat	No	Upper	1,486	Extensive	BIP	granular	2	composite/synthetic with channels	N	1,040	\$9.25	\$9,622	486.3		34			\$260				
											Lower	6,910	Extensive	BIP	granular	2	composite/synthetic with channels	N	4,837	\$9.25	\$44,742	2261.3		34			\$1,209				
					<b>726,795 sf</b>						<b>186,030 sf</b>						<b>110,659 sf</b>						<b>75,281 sf</b>	<b>\$797,999</b>	<b>42,282 gal</b>						

US EPA ARCHIVE DOCUMENT

## Appendix C: Warranty and Maintenance Information – Example

The following is an excerpt from the warranty and maintenance contract provided by Roofscapes, Inc. The language below refers to conditions regarding the extensive green roof systems provided by Roofscapes, and is intended as a guide or contract for establishment period maintenance plans (2 years, included in installation price) and optional extended maintenance plans (up to 12 years total, includes extended warranty). This information should provide a clear sense of regular maintenance requirements for the Roofscapes systems as well as other green roof systems.

### Watering

The plants selected for this project are drought tolerant. In fact, growing conditions for these plants will be optimum when they are exposed to episodes of media desiccation. By keeping the surface of the media dry, it will also be easier to minimize the germination of weed seeds. The media is intended to optimize the use of applied rainfall. Periodic hand watering during the establishment period may be advisable, and will be conducted at the discretion of the service contractor. Following establishment of the cover, further irrigation is discouraged. However, in conditions of sustained drought, hand watering may be undertaken at the discretion of the service provider. Frequent watering will be detrimental to the vegetated cover.

### Fertilization

Regular fertilization of the green roof is recommended. Soil tests should be conducted each spring in order to assess plant nutritional requirements. The nutrient applications should be made in early spring and fall. Optimal soluble nitrogen levels (nitrate plus ammonium) are 1 to 5 ppm. Over-fertilization can seriously disturb the green roof. [Typical nutrient applications for this type of green roof are two pounds per 1,000 square feet, using 90-day release 14-14-14 fertilizer, e.g., Osmacote® or Meister®.]

### Gardening

Two or three maintenance trips each year should be sufficient. (Two visits per year are required for compliance with the Maintenance Plan.) During the 24-month establishment period a total of six visits are required. The principal activity will occur in mid spring and late fall, when conditions are conducive to weed germination and establishment. Thorough weed removal at these times is required. Periodic additional weeding, while not necessary, may be conducted. However, weeding more frequently than once every two months is not recommended. Excessive weeding, and the resulting foot traffic and disruption of the cover, may prove detrimental. Patches of bare media may be covered by distributing cuttings taken from adjacent plants or by separating and transplanting healthy plants. Sedum cuttings should be at least one-inch long and should preferably include some “air roots.” Cuttings will set best in the early spring and late fall, but can be planted at any time except when the temperature is below freezing. A light dusting of compost may accelerate growth. Indications of a system upset should be reported to Roofscapes, Inc. within 30 days of the previous maintenance visit. Examples of upsets include: a) large bare spots, b) colonization of the green roof by annual grass, moss or weeds, c) high mortality rates for one or more plant species, d) loss of media to wind scour, or e) perennially moist or spongy areas. Weeding should be by hand pruning or, as appropriate, chemical weeding. Immature extensive green roofs are particularly vulnerable to colonization by annual grass, especially crabgrass. A pre-emergent crabgrass treatment may be advised. Under no circumstance shall the following proscribed activities be undertaken:

- Digging or use of pointed or sharpened tools (i.e., trowels, shovels, spades, weeders, hand cultivators, etc.).

- Use of lawn staples or stakes for any purpose, including the tethering of tarps or erosion mats.
- Mowing or scything.

If there is any concern that damage has been done to the underlying waterproofing system as a result of maintenance activities, report the nature of the event to Roofscapes, Inc. within 24 hours.

### **Traffic**

This roof is not designed for pedestrian access. Foot traffic associated with maintenance activities should be kept to a minimum.

### **Winter Maintenance**

All plant varieties in the cover system are winter hardy. No special requirements apply to winter protection.

### **Drainage**

As part of each maintenance visit, the drain outlets (scuppers) should be inspected to make certain that they are free from clogging or obstructions. Correct any problems and report them to Roofscapes, Inc. Evidence of periodic pooling of water following rainfall events or of surface runoff across the surface of the cover should be immediately reported to Roofscapes, Inc.

### **Waterproofing**

During each maintenance visit, examine exposed components of the waterproofing system, including flashings and counter-flashings. Report any damage or deterioration to Roofscapes, Inc. within three (3) days of the maintenance visit.

**x-Year Standard Warranty**  
**For Roofmeadow® Green Roof System**

*Project Name:*

*Effective Date:*

**Roofscapes, Inc. Standard Warranty**

This Standard Warranty covers the Roofmeadow® vegetated roof cover (“Roofmeadow® Assembly”) components of the roofing system.

Definitions

*Licensed Roofscapes, Inc. Installer:* Contractor that is licensed by Roofscapes, Inc. to install Roofmeadow® Assemblies.

*Roofmeadow® Assembly:* All components above the protection layer (conventional roof configuration) or insulation (protected roof configuration) and installed by a Licensed Roofscapes, Inc. Installer.

Repair and warranty services for the Roofmeadow® Assembly, shall be provided by a “Licensed Roofscapes, Inc. Installer”.

Only License Roofscapes, Inc. Installers with a current license from Roofscapes, Inc. to install Roofmeadow® Assemblies are authorized to issue any warranty in conjunction with the installation of a Roofmeadow® Assembly. The terms for all warranties begin at the point of substantial completion of the Roofmeadow® Assembly. **Roofscapes, Inc. or the Licensed Roofscapes, Inc. Installer shall have no obligation under this warranty until all invoices for materials, installation, and services have been paid for in full.** Moreover, Roofscapes, Inc. shall not issue its warranty until it has an opportunity to inspect the finished installation and is satisfied that the work is complete.

This warranty applies to Roofmeadow® Assemblies for which:

- 1) Roofscapes, Inc. has reviewed and approved all waterproofing specifications and details;
- 2) the underlying waterproofing system has been (1) tested for watertightness using Electric Field Vector Mapping® or other methods acceptable to the waterproofing manufacturer and Roofscapes, Inc., and (2) inspected and certified by the waterproofing manufacturer as being water-tight and compatible with the Roofmeadow® Assembly;
- 3) the waterproofing has been maintained in a protected condition<sup>1</sup> between the time that the waterproofing has been certified by the waterproofing manufacturer and the time that the

<sup>1</sup> According to the recommendations of (waterproofing manufacturer), and as approved by Roofscapes, Inc.

- Licensed Roofscapes, Inc. Installer is provided access to inspect the waterproofing and commence installation of the Roofmeadow® Assembly;
- 4) the Licensed Roofscapes, Inc. Installer, in addition to the waterproofing installer and/or waterproofing manufacturer, inspected the waterproofing no more than five (5) days (unless otherwise agreed) prior to Roofmeadow® Assembly installation, and the waterproofing manufacturer certified that the waterproofing is watertight and consistent with the waterproofing manufacturer's installation guidelines for green roof projects;
  - 5) the Licensed Roofscapes, Inc. Installer or the Roofscapes, Inc. representative executed the Roofscapes, Inc. Acceptance Form and returned it to Roofscapes, Inc.;
  - 6) all labor and materials for installation of the Roofmeadow® Assembly have been furnished by a Licensed Roofscapes, Inc. Installer, and
  - 7) Owner agrees to execute a Roofscapes, Inc. – accepted maintenance agreement (“Green Roof Maintenance Agreement”), which complies with the Maintenance Plan (attached), with a contractor accepted by Roofscapes, Inc. for semi-annual inspections, weeding, and appropriate care and fertilization during the warranty period. However, Roofscapes, Inc. shall not be liable for any damage to the Roofmeadow® Assembly or the underlying waterproofing caused by a contractor that is not a Licensed Roofscapes, Inc. Installer.

Roofscapes, Inc., warrants to the Owner, that, subject to all the terms, conditions and limitations stated herein, Roofscapes, Inc. will repair flaws which impair the functioning of the Roofmeadow® Assembly, provided these flaws originate from errors in design, material defects, improper assembly, incompatibility between components, or deterioration. **Such impairments may include those that interfere with the ability of the Roofmeadow® Assembly to support a robust ground cover, including but not limited to loss of soil to wind or compression, reduction in soil permeability, development of anaerobic conditions in the profile, loss of drainage capacity, development of soil pathogens, and changes in pH.**

### Terms, Conditions, Limitations

1. Owner will confirm any damage or defect *in writing* to Roofscapes, Inc. (at their main office at 7135 Germantown Avenue, Second Floor, Philadelphia, PA 19119) within three (3) business days of discovery.
2. If, on inspection by Roofscapes, Inc., Roofscapes, Inc. determines that the problem is caused by a defect in components of the Roofmeadow® Assembly, then Roofscapes, Inc. shall affect repairs. Roofscapes, Inc.'s liability shall be limited to repair of defective or damaged components of the Roofmeadow® Assembly and to restoration of the Roofmeadow® Assembly. The decision of Roofscapes, Inc. with respect to repairs shall be final and binding.
3. The Standard Warranty excludes plant materials and mechanical/electrical systems including irrigation systems and equipment<sup>2</sup>. For warranty provisions governing plants, see the Workmanship Warranty, below.
4. During the period of this warranty, Roofscapes, Inc., its agents and employees, shall have free access to inspect the roof during regular business hours.

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<sup>2</sup> As appropriate, independent warranties will be issued for specific mechanic/electronic systems, such as irrigation equipment, supplied by Roofscapes, Inc.

5. Roofscapes, Inc. does not warrant performance of the waterproofing system or any of its components. A separate warranty will be provided by the waterproofing applicator and/or the waterproofing manufacturer.
6. Leaks in the waterproofing system resulting from the following conditions will not be regarded as the responsibility or liability of Roofscapes Inc.:
  - Failure of a seam
  - Failed building or expansion joints
  - Improper assembly
  - Assembly that is inconsistent with the as-built construction documents
  - Root penetrations, unless the installation is provided with a Roofmeadow® root-barrier subsystem
  - Inferior or degraded waterproofing membrane
  - Settlement, distortion, or cracking of the roof deck, walls, or foundation of the building
  - Punctures and abuse associated with the activities of other trades
7. Roofscapes, Inc. will not accept responsibility or liability for damage resulting from a proscribed activity, including:
  - Failure to comply with Maintenance Plan for the Roofmeadow® Assembly.
  - Use of sharp, pointed, or metal-edged tools in maintaining the cover vegetation (i.e., shovels, hand spades, trowels, weeders, hand cultivators).
  - A deficient, pre-existing condition or equipment is causing water entry.
  - Placement of lawn staples as part of any activity on the roof, including irrigation installation.
  - Any construction subsequent to the installation of the Roofmeadow® Assembly that has not been authorized in writing by Roofscapes, Inc., including, but not limited to the installation of decks, planters, irrigation systems, air conditioner condensers, pavers, or sky lights. The Owner must promptly notify Roofscapes, Inc. in writing about any proposed alterations, additions or changes of any kind that will affect the Roofmeadow® Assembly.
  - Alterations or repairs made on or through the completed Roofmeadow® Assembly, or objects, such as, but not limited to, fixtures, equipment, or structures that are placed on or attached to the completed Roofmeadow® Assembly without first obtaining written authorization from Roofscapes, Inc.
  - Removal of any portion of the cover system (including the uprooting of plants) without prior written notification of Roofscapes, Inc..
  - Pedestrian travel or recreational use, except in areas specifically designated for these purposes.
  - Act of negligence, accident, or misuse including, but not limited to vandalism, and falling objects.
  - A significant change in the use of the building by the Owner or his lessee expected by Roofscapes, Inc. to affect the Roofmeadow® Assembly as originally installed.
  - A loss of integrity of the building envelope and/or structure, including, but not limited to partial or completed loss of roof decking, wall siding, windows, doors, or other envelope components, or Roofmeadow® Assembly damage by wind blown objects.
  - Failure by the Owner or lessee to use reasonable care in maintaining the roof as described in the Maintenance Plan.
8. Roofscapes, Inc. cannot accept responsibility or liability for damage caused by lightning, gale, hurricane, tornado, earthquake or any act of God or other unusual action of the elements.

9. Maintenance of a healthy foliage cover is essential to the long-term performance of the Roofmeadow® Assembly. Failure to maintain a robust foliage cover may result in loss of media to wind scour, reduction in runoff management function, or deterioration of components due to UV exposure. Preservation of a robust foliage cover will require ongoing and regular maintenance. Additionally, the appearance of the Roofmeadow® Assembly should be expected to change over the years. A process of natural succession will result in the botanical evolution of the vegetated cover; consequently, the future distribution of plants species cannot be accurately predicted.
10. After the 24-month establishment period, the Owner may elect to assume responsibility for on-going maintenance. In the absence of either a paid and continuous Green Roof Maintenance Agreement with a Licensed Roofscapes, Inc. Installer or documentation from the Owner demonstrating compliance with the Maintenance Plan, this warranty will be voided, and damage or deterioration of the Roofmeadow® Assembly resulting from the failure to maintain the foliage cover will not be the responsibility or liability of Roofscapes, Inc. or the Licensed Roofscapes, Inc. Installer. Owner shall supply annually a copy of the executed Green Roof Maintenance Agreement that complies with the Maintenance Plan and that stipulates semi-annual inspections, weeding, and appropriate care and fertilization for the duration of the warranty.
11. If a leak is detected and reasonable attempts to locate the source of the leak without disturbing the Roofmeadow® Assembly have been inconclusive, then Roofscapes, Inc. agrees to locate the leak and uncover the waterproofing system. If, at Roofscapes, Inc.'s discretion, the site investigation demonstrates that the leak is caused by something other than defects in the Roofmeadow® Assembly (i.e., leaking seams, leaking plumbing, deteriorated masonry, etc.), then the Owner shall reimburse Roofscapes, Inc. for its emergency response service, including the cost of (1) exploring for leaks and uncovering the area(s) and (2) restoring the disrupted portions of the Roofmeadow® Assembly. This warranty does not apply to the removal and replacement of non-vegetated overburden systems. The decision of Roofscapes, inc. with respect to leak detection and uncovering shall be final and binding.
12. If, at Roofscapes, Inc.'s discretion, the site investigation demonstrates that the leak is the result of defects in the materials of the *Roofmeadow® Assembly* or defective workmanship or activities of (1) an agent of Roofscapes, Inc. or (2) a Licensed Roofscapes, Inc. Installer, then Roofscapes, Inc. or the Licensed Roofscapes, Inc. Installer shall be responsible for (a) uncovering the area, (b) exploring for leaks, (c) the cost to repair the waterproofing damage, and (d) restoring the disrupted portions of the Roofmeadow® Assembly at its own cost and subject to the terms of the Workmanship Warranty.<sup>3</sup> Neither the Standard Warranty nor the Workmanship Warranty applies to the removal and replacement of non-vegetated overburden systems. The decision of Roofscapes, inc. with respect to leak detection and uncovering shall be final and binding.
13. Should leak detection be required, no more than 100 square feet will be uncovered at one time. The material associated with uncovering subsequent 100 square foot areas will be deposited on the adjacent previously uncovered areas. In this way, the entirety of the roof area can be uncovered in a step-wise manner, without exposing more than 100 square feet at time and maintaining the waterproofing system in a protected condition.
14. This warranty is given in lieu of all other warranties, expressed or implied, including any warranty of

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<sup>3</sup> If requested, Roofscapes, Inc. will include a 'no-fault' warranty provision in which Roofmeadow® Assembly restoration will be provided without regard to the cause of the damage or defect. 'No fault' coverage is available only for projects in which the waterproofing is compatible with electric leak detection methods (i.e., EFVM). A fee will be assessed for providing a 'no-fault' warranty provision.

merchantability or fitness for a particular purpose. The remedies stated herein are exclusive remedies, and Roofscapes, Inc. and its licensee, shall not be responsible or liable for any indirect consequential or incidental damages or further loss of any kind whatsoever, including, but not limited to, damage to the building on which the components of the roof are situated, damage to the contents thereof, or any other property or persons.

- 15. This warranty is extended solely and exclusively to the Owner of the building at the time the Roofmeadow® Assembly is installed. It does not extend, nor is it otherwise assignable or transferable to any other party unless approved in advance and in writing by Roofscapes, Inc. and the costs to process the transfer and to inspect and repair the Roofmeadow® Assembly, if necessary, are paid for by the original Owner.
- 16. Any controversy or claim arising out of or relating to this warranty shall be settled by arbitration in the State of Pennsylvania, by the American Arbitration Association in accordance with the Construction Industry Arbitration Rules, and judgment upon the arbitration award may be entered in any court having jurisdiction thereof.
- 17. The failure of Roofscapes, Inc. at any time to enforce any of the terms or conditions stated herein shall not be construed to be a waiver of such provision.
- 18. The Owner must comply with every term and condition stated herein.

NO REPRESENTATIVE OF ROOFSCAPES, INC. HAS AUTHORITY TO MAKE ANY REPRESENTATION OR PROMISE EXCEPT AS STATED HEREIN.

Issued by \_\_\_\_\_

Date \_\_\_\_\_

Charles D. Miller, P.E., Principal  
Roofscapes, Inc.  
7135 Germantown Avenue, 2<sup>nd</sup> Floor  
Philadelphia, PA 19119

SEAL

## Workmanship Warranty

In addition to this Standard Warranty, the Licensed Roofscapes, Inc. Installer hereby extends a separate twenty-four months Workmanship Warranty. This Workmanship Warranty covers 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 installation, they are determined to be defective or not in accordance with contract documents.

If a leak is detected within the first 24 months after installation and if the leak is determined to be the result of (1) defective workmanship of the Licensed Roofscapes, Inc. Installer or (2) any activities of the Licensed Roofscapes, Inc. Installer, its technicians or representatives,<sup>4</sup> then the Licensed Roofscapes, Inc. Installer shall be responsible for (1) exploring for leaks, (2) uncovering the area at its own cost, (3) the cost of repair of the damage, and (4) restoration of the disrupted portions of the Roofmeadow® Assembly.

The Owner must give notice *in writing* to both the Licensed Roofscapes, Inc. Installer and to Roofscapes, Inc. (at its main office at 7135 Germantown Avenue, Second Floor, Philadelphia, PA 19119) within thirty (30) days of discovering said defect. The obligation of the Workmanship Warranty shall run directly to the Owner with a copy to Roofscapes, Inc.

This two-year Workmanship Warranty also includes a guaranty to replace plant materials as needed to maintain a minimum foliage coverage rate of 80 percent after the 24 month establishment period following the Roofmeadow® Assembly installation. Cover rates shall be estimated separately for each 400 square-foot grid of the vegetated surface.

This Workmanship Warranty shall apply only to installations where 1) the plant list is approved by Roofscapes, Inc., 2) the installation density is according to the recommendations of Roofscapes, Inc., 3) installation occurs within the recommended planting window for the specified plant varieties and climatic conditions, and 4) maintenance for the first twenty-four months is provided exclusively by a licensed Roofscapes, Inc. installer.

This Workmanship Warranty shall be given in lieu of all other warranties, expressed or implied, including any warranty of merchantability or fitness for a particular purpose. The remedies state herein are exclusive remedies, and Roofscapes, Inc. and the Licensed Roofscapes, Inc. Installer shall not be responsible or liable for any indirect consequential or incidental damages or further loss of any kind whatsoever, including, but not limited to, damage to the building on which the components of the roof are situated, damage to the contents thereof, or any other property or persons.

This Workmanship Warranty shall be extended solely and exclusively to the Owner of the building at the time the Roofmeadow® Assembly is installed. It will not extend, nor will it otherwise be assignable or transferable to any other party unless approved in advance and in writing by the Licensed Roofscapes, Inc. Installer.

Licensed Roofscapes, Inc. Installer \_\_\_\_\_

Date \_\_\_\_\_

<sup>4</sup> If requested, Roofscapes, Inc. will include a 'no-fault' warranty provision in which Roofmeadow® Assembly restoration will be provided without regard to the cause of the damage or defect. 'No fault' coverage is available only for projects in which the waterproofing is compatible with electric leak detection methods (i.e., EFVM). A fee will be assessed for providing a 'no-fault' warranty provision.

NO REPRESENTATIVE OF THE LICENSED ROOFSCAPES, INC. INSTALLER HAS AUTHORITY TO MAKE ANY REPRESENTATION OR PROMISE EXCEPT AS STATED HEREIN.

## Basic Maintenance Plan \_\_\_\_\_ Roofmeadow® Assembly

This project consists of a \_\_\_\_\_ Roofmeadow® green roof assembly without irrigation. Routine maintenance during the 24-month establishment period is intended to insure survival of the vegetated cover and promote the development of robust and durable ground cover. It is not guaranteed that the vegetated cover will remain weed free or that all plantings will remain constant in appearance. Supplemental maintenance may be provided to satisfy the aesthetic requirements for this project. Supplemental services, if any, shall be outlined in a Green Roof Maintenance Agreement with the service contractor.

During the 24-month establishment period, the green roof shall be maintained by a service contractor accepted by Roofscapes, Inc.

For Roofscapes, Inc.'s Warranty to remain in force after the two-year establishment period:

1. The green roof must be maintained by a service provider accepted by Roofscapes, Inc.
2. Green roof maintenance must demonstrate compliance with this Maintenance Plan

The specific requirements of the Maintenance Plan are as follows:

### Watering

The plants selected for this project are drought tolerant. In fact, growing conditions for these plants will be optimum when they are exposed to episodes of media desiccation. By keeping the surface of the media dry, it will also be easier to minimize the germination of weed seeds. The media is intended to optimize the use of applied rainfall.

Periodic hand watering during the establishment period may be advisable, and will be conducted at the discretion of the service contractor. Following establishment of the cover, further irrigation is discouraged. However, in conditions of sustained drought, hand watering may be undertaken at the discretion of the service provider. Frequent watering will be detrimental to the vegetated cover.

### Fertilization

Regular fertilization of the green roof is recommended. Soil tests should be conducted each spring in order to assess plant nutritional requirements. The nutrient applications should be made in early spring and fall. Optimal soluble nitrogen levels (nitrate plus ammonium) are 1 to 5 ppm. Over-fertilization can seriously disturb the green roof. [Typical nutrient applications for this type of green roof are two pounds per 1,000 square feet, using 90-day release 14-14-14 fertilizer, e.g., Osmacote® or Meister®].

## Gardening

Two or three maintenance trips each year should be sufficient. (Two visits per year are required for compliance with the Maintenance Plan.) During the 24-month establishment period a total of six visits are required. The principal activity will occur in mid spring and late fall, when conditions are conducive to weed germination and establishment. Thorough weed removal at these times is required. Periodic additional weeding, while not necessary, may be conducted. However, weeding more frequently than once every two months is not recommended. Excessive weeding, and the resulting foot traffic and disruption of the cover, may prove detrimental.

Patches of bare media may be covered by distributing cuttings taken from adjacent plants or by separating and transplanting healthy plants. Sedum cuttings should be at least one-inch long and should preferably include some 'air roots.' Cuttings will set best in the early spring and late fall, but can be planted at any time except when the temperature is below freezing. A light dusting of compost may accelerate growth.

Indications of a system upset should be reported to Roofscapes, Inc. within 30 days of the previous maintenance visit. Examples of upsets include: a) large bare spots, b) colonization of the green roof by annual grass, moss or weeds, c) high mortality rates for one or more plant species, d) loss of media to wind scour, or e) perennially moist or spongy areas.

Weeding should be by hand pruning or, as appropriate, chemical weeding. Immature extensive green roofs are particularly vulnerable to colonization by annual grass, especially crabgrass. A pre-emergent crabgrass treatment may be advised. Under no circumstance shall the following proscribed activities be undertaken:

- Digging or use of pointed or sharpened tools (i.e., trowels, shovels, spades, weeders, hand cultivators, etc.)
- Use of lawn staples or stakes for any purpose, including the tethering of tarps or erosion mats
- Mowing or scything

If there is any concern that damage has been done to the underlying waterproofing system as result of maintenance activities, report the nature of the event to Roofscapes, Inc. with 24 hours.

## Traffic

This roof is not designed for pedestrian access. Foot traffic associated with maintenance activities should be kept to a minimum.

## Winter Maintenance

All plant varieties in the cover system are winter hardy. No special requirements apply to winter protection.

## Drainage

As part of each maintenance visit, the drain outlets (scuppers) should be inspected to make certain that they are free from clogging or obstructions. Correct any problems and report them to Roofscapes, Inc. Evidence of

periodic pooling of water following rainfall events or of surface runoff across the surface of the cover should be immediately reported to Roofscapes, Inc.

## **Waterproofing**

During each maintenance visit, examine exposed components of the waterproofing system, including flashings and counter-flashings. Report any damage or deterioration to Roofscapes, Inc. within three (3) days of the maintenance visit.

## **Proscribed Activities**

**Window Washing:** The plants installed as part of this green roof are tolerant of acidic fluids and some detergents. Fluids used for cleaning adjacent windows or walls must be approved in advance by Roofscapes, Inc.

**Pet Wastes:** Pets shall not be permitted access to the green roof.

**Herbicides or Pesticides:** Herbicides and/or pesticides that are not approved in advance by Roofscapes, Inc. may not be applied to the green roof.

## **Documentation**

Each maintenance visit shall be documented using report forms provided by Roofscapes, Inc. Reporting requirements include: a) description of maintenance activities, including any corrective measures, b) assessment of the condition of the plants, c) results of inspection of the exposed portions of the waterproofing system. A copy of each report shall be sent to Roofscapes, Inc.

## **Warranty**

Pursuant to the Standard Warranty, Roofscapes, Inc. shall support its Standard Warranty if Owner agrees to comply with the Maintenance Plan, which includes documentation and timely notification of a system upset.