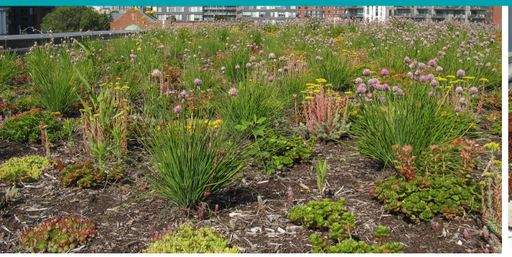
Green Roofs



Green Roofs consist of a layer of vegetation and planting medium installed on top of a conventional flat or sloped roof. Green roofs are touted for their environmental benefits as they improve energy efficiency, reduce urban heat island effects and create greenspace for passive recreation and aesthetic enjoyment. They are also desirable for their water quality, water balance and peak flow control benefits. The green roof acts like a lawn or meadow by temporarily storing rainwater in the planting medium and ponding areas. Excess rainfall enters underdrains and overflow points and is conveyed to a storm sewer or other stormwater practice in the building drainage system. After a storm, a large portion of the stored water is evapo-transpired by the plants, evaporated or slowly drains away.

DESIGN

ROOF

Flat roofs should be pitched with positive drainage ≥2% (1:50) towards roof drains. For roofs with pitch greater than 10% (1:10) additional geo grid or cellular components should be included in the design. These structures reduce the flow rate of the draining water and help to stabilize green roof components. Green roofs can be installed on slopes greater than 20% (1:5), but specialized design advice should be sought for the addition of components required to secure the green roof in place. Extensive green roofs do not require additional insulation layers. The underlying roof may be of warm, cold or inverted design. Extensive green roofs add loads of around 70 to 300 kg/m^2. A structural engineer should be consulted during design to account for distributed loads, including snow accumulation, and live loads associated with construction and maintenance staff and equipment. As a fire resistance measure, non-combustible materials, such as stone or pavers, should be installed around all roof openings and at the base of all adjoining walls that contain openings.

WATERPROOFING MEMBRANE

Roof membranes should be waterproof, root resistant, resilient to temperature change and comply with appropriate Canadian General Standards Board (CGSB) standards as specified in the Ontario Building Code. In most cases a new roof with a modern membrane will not require a separate root penetration barrier. In retrofit scenarios an additional root barrier may be recommended to protect an older roof membrane.

DRAINAGE AND FILTER LAYER

The underlying drainage layer is most often a pre-formed plastic sheet that includes depressions for water storage and perforations to drain excess water. This design has the advantage of being most lightweight but has minimal impact on flow rates once the water has percolated onto the waterproof membrane below. An alternative drainage layer solution is to use a granular medium to increase the tortuosity of the flow path and slow peak flow rates. A geotextile layer is included to prevent migration of the planting medium into the drainage layer. A freely draining geotextile should be used to prevent water-logging of the planting medium. Observations of green roof assemblies that include geotextile have shown a reduction of flow from specifications owing to interactions of planting medium particles with the geotextile.

PLANTING / GROWING MEDIUM

Green roof planting media used in Ontario can be classed according to the proportion of composted material it contains. ASTM International have a number of standards relating to various design considerations for green roofs. These standards provide good technical advice on the testing of systems and components (see Specifications).

Testing results should be interpreted in relation to the objectives of the green roof. A product complying with overseas guidelines may not serve the needs of a green roof installed in Ontario. In particular, the German FLL guide recommends green roof media specifications which may not provide optimal stormwater management or growing conditions in Ontario's climate. In many proprietary systems the default option for planting medium is a granular material with very low organic matter content. However, many companies can arrange for a higher organic matter alternative to be substituted if requested. The sensitivity of the receiving water to which the green roof ultimately drains should also be taken into consideration when selecting the planting medium or proprietary system. Planting media with less compost in the mix will leach less nitrogen and phosphorus. Low nutrient media also promotes the dominance of stress tolerant native plants. Fertilizer applied to the planting medium during production and the period during which vegetation is becoming established should be coated, controlled release fertilizer to reduce the risk of damage to vegetation and leaching of nutrients into overflowing runoff. Fertilizer applications should not exceed 5 g of nitrogen/m^2.

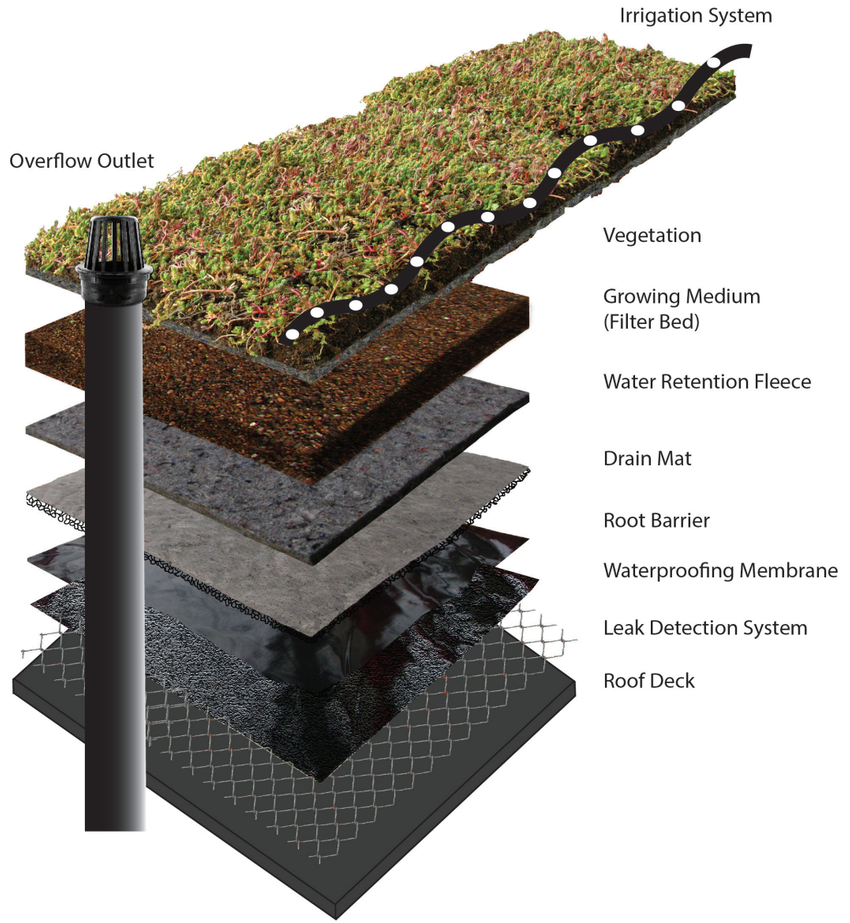
PLANTS

The choice of vegetation on an extensive green roof is insignificant in stormwater management compared to the choice of planting medium or the provision of irrigation. The vegetation should be selected to be resilient to both very wet and very dry periods. Sedum species are the most common choice, demonstrating excellent longevity in systems with or without irrigation. Mixtures of both sedum and native species can add biodiversity and pollinator habitat benefits.

CONVEYANCE AND OVERFLOW

Once the planting medium is saturated, all runoff, including filtrate and/or overland flow, should be directed to a traditional roof storm drain system. Landscaping style catch basins should be installed with the invert set to the desired ponding elevation. Alternately, roof drain flow restrictors can be used. Excess runoff can be directed through roof leaders to another stormwater practice, such as a rainwater harvesting cistern, infiltration trench, bioretention cell or swale, or simply drain to a pervious area.

BMP	Ability to meet stormwater criteria		
	Water balance	Water quality	Stream erosion control
Green Roofs	Yes	Partial	Yes



DESIGN, CONT.

IRRIGATION

Regular irrigation has been shown to substantially reduce the runoff reduction performance of extensive green roofs. One way to meet the irrigation needs of green roofs is through the use of smart technologies. Responsive sensors that suppress irrigation after a rain event are routinely installed on green roofs to conserve water. Improvements can be made by using a soil moisture sensor to trigger irrigation. State-of-the-art management systems use predicted weather data to suppress irrigation ahead of storm events. Due to their limited water retention capacity, many green roofs are coupled with rainwater harvesting cisterns, to capture excess water. It then becomes desirable to use as much harvested water for irrigation as possible to regain the cistern storage capacity between storm events. Green roofs can be irrigated to saturation daily throughout the growing season without damaging the vegetation. Maximizing evaporation with spray irrigation is the faster way to empty a cistern, and provides some cooling benefit for the building and its surroundings.

MODULAR SYSTEMS

Modular systems are trays of vegetation in a planting medium that are prepared and grown off-site and placed on the roof for complete coverage. There are also pre-cultivated vegetation blankets that are grown in flexible planting media structures, allowing them to be rolled out onto the green roof assembly. The advantage of these systems is that they can be easily installed and removed for maintenance.

VEGETATION-FREE AREAS

Vegetation-free areas are often required around the perimeter of the roof to reduce wind uplift, on larger areas requiring firebreaks, for access paths and around drains. To prevent accumulation of sediment and migration of the vegetation, the vegetation-free areas should not be filled with decorative aggregate or river rock. Instead concrete pavers or other surfaces that do not actively trap particles will reduce weeding maintenance.

INTENSIVE VS. EXTENSIVE

There are two types of green roofs: intensive and extensive. Intensive green roofs consist of a thicker planting medium layer (>15 cm deep), can be planted with deeply rooted plants, and are designed to include pedestrian pathways and gathering areas. Extensive green roofs consist of a thinner planting medium layer (≤15 cm deep) with herbaceous vegetative cover. Guidance here focuses on extensive green roofs.
Biue roofs are an addional practice also designed to detain stormwater on the rooftop, but without incorporating the planting medium or plants used in a green roof.

BLUE ROOFS

On blue roofs, stormwater is detained and then slowly released over time through the use of flow control devices or structures. As stormwater is detained, peak flows are reduced. Some blue roof designs can also promote increased stormwater evaporation resulting in lower runoff volumes. While a blue roof requires slightly less maintenance than a green roof because since they require no plant care, blue roofs cannot provide the heat reduction benefits of a green roof.

COMMON CONCERNS

WATER DAMAGE TO ROOF

Green roofs are designed with redundant waterproofing layers to prevent leaks and protect the roof deck. While failure of waterproofing elements may present a risk of water damage, a warranty can ensure that any damage to the waterproofing system will be repaired. Leak detection systems can also be installed to minimize or prevent water damage.

VEGETATION MAINTENANCE

Extreme growing conditions that exist on rooftops can have an impact on plant survival. Appropriate plant selection will help to ensure plant survival during weather extremes. Plants should be low growing, drought tolerant and able to survive short periods of inundation. Irrigation during the first year may be necessary to establish vegetation. Vegetation maintenance needs decrease substantially after the first two years of establishment.

COLD CLIMATE

Green roofs are a practical stormwater best management practice (BMP) for cold climates. Snow can protect the vegetation layer and once thawed, will percolate into the planting medium to be either absorbed or drained away just as it would during a rain event. If an irrigation system is included it needs to be disconnected from the water supply and distribution lines blown dry in the fall, prior to on-set of freezing winter temperatures, and reconnected in the spring.

COST

An analysis to determine cost effectiveness for a given site should include the roof lifespan, energy savings, stormwater management requirements, aesthetics, market value, tax and other municipal incentives. It is estimated that green roofs can extend the life of a roof structure by as much as 20 years by reducing exposure of the roof materials to sun and precipitation. Green roofs can also reduce building energy demand by as much as 75%.

ON PRIVATE PROPERTY

Property owners or managers will need to be educated on their routine operation and maintenance needs, understand the long-term maintenance plan, and may be subject to a legally binding maintenance agreement. An incentive program such as a storm sewer user fee based on the area of impervious cover on a property that is directly connected to a storm sewer could be used to encourage property owners or managers to maintain existing practices.

PLANNING

ROOF SLOPE

Green roofs are typically installed on roofs with shallow slopes up to 10% but can be specially designed for roofs with steeper pitches.

DRAINAGE AREA AND RUNOFF VOLUME

Green roofs are designed to capture precipitation falling directly onto the roof surface. They are generally not designed to receive runoff diverted from other source areas, such as portions of adjacent conventional roofs.

STRUCTURAL REQUIREMENTS

Load bearing capacity of the building structure and roof need to be sufficient to support the weight of the green roof structure, planting medium, vegetation and accumulated water or snow, and may also need to support pedestrians, concrete pavers, etc.

CONSTRUCTION

An experienced professional green roof installer should install the green roof. The installer must work with the construction contractor to ensure that the waterproofing membrane installed is appropriate for use under a green roof assembly. Conventional green roof assemblies should be constructed in sections for easier inspection and maintenance access to the membrane and roof drains. Green roofs can be purchased as complete system from specialized suppliers who distribute all the assembly components, including the waterproofing membrane. Alternatively, a green roof designer can design a customized green roof and specify suppliers for each component of the system.

OPERATION AND MAINTENANCE

Green roof maintenance is typically greatest in the first two years as plants are becoming established. Vegetation should be monitored to ensure dense coverage. A minimum 2-year warranty on plants should be included in the construction contract.

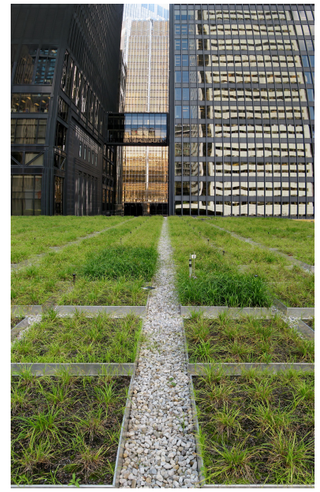
Operation of a green roof includes irrigation and leak detection. Watering should be based on actual soil moisture conditions as plants are selected to be drought tolerant. Electronic leak detection is recommended. This system, also used with traditional roofs, must be installed prior to the green roof.

Routine maintenance should occur at least twice per year and should include weeding to remove volunteer seedlings of trees and shrubs and debris removal. In particular, the overflow conveyance system should be kept clear of obstructions.

GENERAL SPECIFICATIONS

ASTM International released the following Green Roof standards in 2005:

ASTM #	Specification
E2396-05	• Standard Test Method for Saturated Water Permeability of Granular Drainage Media
E2397-05	• Standard Determination of Dead Loads and Live Loads associated with Green Roof Systems
E2398-05	• Standard test method for water capture and media retention of geocomposite drain layers for green roof systems
E2399-05	• Standard Test Method for Maximum Media Density for Dead Load Analysis of Green Roof Systems
E2400-06	• Standard Guide for Selection, Installation, and Maintenance of Plants for Green Roof Systems



For more information:

Visit the online Low Impact Development Stormwater Management Planning and Design Guide for more information including links to all sources cited: wiki.sustainabletechnologies.ca.

LID Stormwater Inspection and Maintenance Guide (TRCA, 2016): sustainabletechnologies.ca.

LID Construction Guide (CVC, 2012): sustainabletechnologies.ca.

The water component of the Sustainable Technologies Evaluation Program is a collaboration of:

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