

TOOLKIT FOR

Green Infrastructure



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PIONEER VALLEY
SUSTAINABILITY TOOLKIT

TABLE OF CONTENTS

BEST MANAGEMENT PRACTICES

Bioretention Areas

Downspout Disconnection

Green Roofs

Green Streets

Porous Asphalt

Rain Water Harvesting

Tree-boxing Filters

ZONING AND REGULATION

Code Review Checklist

Green Infrastructure in Zoning

Subdivision Regulations

FINANCING

Paying for Green Infrastructure

Stormwater Utilities

MODEL POLICIES AND PROGRAMS

Green Roof Model Incentives

Model Green Streets Policy

Model Regulations for Downspout Disconnection



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Bioretention Areas

WHAT IT IS

Bioretention facilities (also known as rain gardens) are landscaped depressions designed with soils and a variety of plants to receive and treat stormwater through the use of natural processes. These natural processes include the uptake of water by plants and transfer of water to the atmosphere, and infiltration (or soaking up) of water into the soils where microbial action helps to breakdown pollutants and gravity pulls water further down through the soil layers to recharge groundwater. (See Figure 1)

Bioretention facilities can be used in a variety of settings: along a street edge or as an island in a parking lot to capture storm flow from asphalt or concrete surfaces; and near residential or commercial buildings to capture storm flow from roofs. Bioretention facilities are often designed with an underdrain or an overflow that directs flow to the municipal storm drain system.

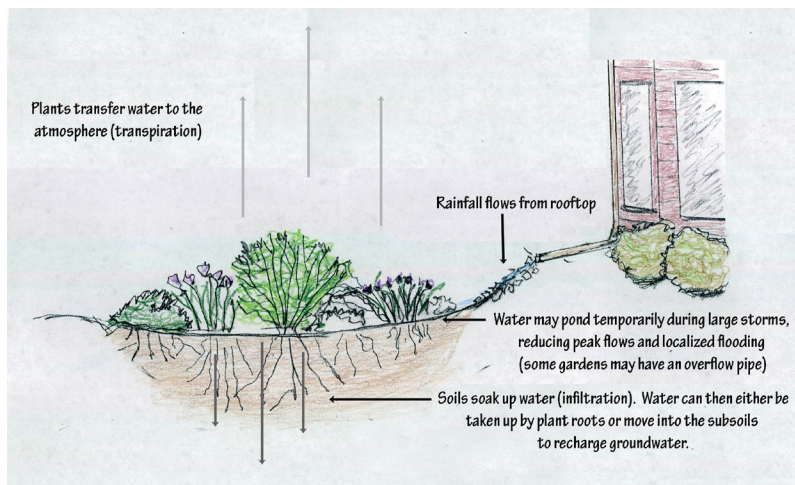


Figure 1: How a Bioretention Facility Functions



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WATER QUALITY TREATMENT

When a bioretention facility is designed with an underdrain that ultimately delivers flow to surface waters, the capacity of a facility to treat stormwater is critical. Bioretention systems have proven effective at removing many pollutants associated with stormwater: suspended solids, including particulate phosphorous, petroleum hydrocarbons, and heavy metals. The table below shows water quality treatment in the four bioretention facilities tested to date by the University of New Hampshire Stormwater Center.



A rain garden along Route 9 in Hadley, captures storm flow from a drive and parking lot. This photo is taken just after installation and before plants are really established.

Photo courtesy of Berkshire Design Group, Inc.



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Pollutant Removal in Four Bioretention Facilities at the University of New Hampshire Stormwater Center

System	Pollutant					
	Total Suspended Solids (TSS)	Total Petroleum Hydrocarbons in the Diesel Range	Dissolved Inorganic Nitrogen (NO ₃)	Total Zinc	Total Phosphorous	Average Annual Peak Flow
					% Removal	% Reduction
Bio I-48" depth (42" filter depth)	97	99	44	99	-	75
Bio II-30" depth (24" filter depth)	87	99	NT	73	34	79
Bio III-30" depth (24" filter depth)	91	64	44	75	NT	84
Bio IV-37" depth (24" filter depth)	83	65	42	67	NT	95

NT = no treatment | Source: University of New Hampshire Stormwater Center 2012 Biennial Report

To boost the ability of bioretention facilities to manage for nitrogen and dissolved phosphorous, researchers have been experimenting with optimizing soil mixtures and design. See discussion under “Design considerations.” Furthermore, Allen Davis of the University of Maryland has noted that bowl volume, media composition, media depth, underdrainage configuration, and vegetation type, all have roles in effectively helping to address objectives, depending on needs, be they hydrologic (peak flow mitigation, infiltration, annual hydrology, and stream stability) and/or water quality (total suspended solids and particulates, pathogen-indicator species, metals, hydrocarbons, phosphorus, nitrogen, and temperature). Information on how best to design systems according to these needs is evolving.

DESIGN CONSIDERATIONS

For the Pioneer Valley, major design objectives for bioretention involve flow reduction and nutrient reduction. Following is some brief guidance on design considerations relative to these objectives. As noted above, bioretention design objectives that aim to address specific target pollutants are emerging. Some of the listings below under “Links to more information” provide some resources that will be useful in this regard.

Flow reduction

Maximum volume reduction comes when bioretention facilities are located in soils that provide for good infiltration and the use of fines in the soil mix are kept to a minimum (the entry of fines into the facility should also be limited through a pretreatment element that allows for settling of particles).

Research is showing that infiltration in soils can be enhanced and preserved over time through the use of dense vegetative cover. The University of New Hampshire Stormwater Center (UNHSC) reports that of the four bioretention facilities it has studied, infiltration rates over time were optimal in the basin (Bio III) where they used a continuous dense vegetative cover. They report, “Previous studies have indicated that plant roots generally experience a 30% die back each year which aids in the development of macropores that keep soil surface infiltration capacity high over time. The data from this study suggests that the dense vegetative cover is more important than plant type for maintaining infiltration rates in vegetative systems.”

Nutrients

In designing bioretention facilities for nutrient removal, fill media selection is critical. As it breaks down organic matter typically leaches nitrogen and phosphorous and can exacerbate water quality issues. It is important to have some organic matter to aid plant growth, but limiting its use is critical for successful bioretention facilities.

Nitrogen

Research out of the University of Maryland points to two major considerations for promoting nitrogen removal:

Creation of an anaerobic zone where microbes can use forms of nitrogen (NO_2 and NO_3) instead of oxygen for respiration – Use of a deeper media layer (3 feet minimum), media with a less permeable bottom soil layer, lower infiltration rates (1 to 2 inches per hour), and design for internal water storage, (a subsurface portion of the media that provides some storage volume) are all important design components. In a 2003 study, he found that adding a suitable carbon source, particularly newspaper, to the gravel layer provides a nutrition source for the microbes, enables anaerobic respiration, and can enhance the denitrification process. Davis et al noted that while organic matter should be kept to very modest amounts to avoid leaching of nitrogen as it breaks down, there should be about 5% of total weight or 10% of total volume of organic matter to provide carbon sources. Postconstruction carbon can be supplied from plant roots, leaf litter, and of course the mulch as it breaks down.

More dense planting of vegetation with sizeable root masses (but not so aggressive so as to pose a threat to clogging underdrains) – Deeply rooted grasses, notes Davis et al, are expected to provide good performance. Note that in research at the UNHSC, nitrogen removal was poorest in the bioretention system that had a 60% sand mixture and wooded vegetation as compared to the sister system that had an Eco-Lawn.

Phosphorous

Media selection is the major considerations for promoting phosphorous removal in bioretention facilities. While modest amounts of mulch can be used, Davis et al recommend selecting media with high P-sorption potential, including iron and aluminum rich soils and iron and aluminum based water treatment residuals (a byproduct of drinking water treatment), which could be used as amendments.

Inclusion of vegetation within a bioretention facility also helps to promote phosphorous removal.

RELATED CONSIDERATIONS

General design considerations noted by the U.S. EPA National Pollutant Discharge Elimination System (NPDES) Stormwater Menu of BMP's include:

Drainage Area – Bioretention facilities should usually be used on small sites (five acres or less). When used to treat larger areas, they tend to clog. In addition, it is difficult to convey flow from a large area to a bioretention facility.

Pretreatment – Incorporating pretreatment helps reduce the maintenance burden of bioretention and reduces the likelihood that the soil bed will clog over time. Several mechanisms can be used to provide pretreatment in bioretention facilities. Often, runoff is directed to a grass channel or filter strip to filter out coarse materials before the runoff flows into the filter bed of the bioretention facility. Other features include a pea gravel diaphragm, which acts to spread flow evenly and drop out larger particles.

Slope – Bioretention facilities are best applied to relatively shallow slopes usually at five percent. A sufficient slope is needed at the site to ensure that water that enters the bioretention area can be connected with the storm drain system. These particular stormwater management practices are most often applied to parking lots or residential landscaped areas, which generally have shallow slopes.

Landscaping – Landscaping is critical to the function and aesthetic value of a bioretention facility. Native vegetation is ideal for planting. Another important feature is to select species that can withstand the type of hydrologic system it will experience. At the bottom of the bioretention facility, it is important to have plants that can tolerate both wet and dry conditions. Along the edges, it will remain primarily dry, so upland species will be the most resilient to this type of condition.

MAINTENANCE CONSIDERATIONS

When properly designed, maintenance of these systems is minimal. UNHSC notes, “... the highest maintenance burden occurs during the first two years of operation as the vegetation grows and the system begins to stabilize.” Once vegetation is established, maintenance is comparable to what is required for standard landscaping. (UNHSC, 2012 Biennial Report)

Systems with fine soils may need more cleaning due to obstruction from sediment. Long-term maintenance mainly requires inspection and scraping of surface pollutants.

PERMITTING CONSIDERATIONS

In the Massachusetts Stormwater Handbook, Volume 1 under Stormwater Management Standard #6, stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply. Discharges within Zone II require the use of a treatment train that provides 80% TSS removal prior to discharge. Bioretention facilities are a good fit for discharges within Zone IIs as they have a TSS removal rate of 90%. In addition, under the Massachusetts Stormwater Handbook, Volume 2, Chapter 2, bioretention facilities are a good option for discharges near cold-water fisheries. However, these should not be developed near bathing beaches and shellfish growing areas.

BARRIERS TO USE

Concern	Experience
Cost	<p>The cost of installing a bioretention facility can vary greatly. A “do it yourself” bioretention facility that captures flow from the roof of a single family home and where soils are well draining can cost as little as a hundred dollars with a simple planting scheme.</p> <p>Engineered systems can cost \$4 to \$6 per square foot, including the grading, underdrain, stone, and plants. An estimate from the University of New Hampshire Stormwater Center (UNHSC) provides a cost based on per acre of impervious surface draining to the facility that ranges from \$14,000 and \$25,000 per acre, not including design, permitting, or construction oversight costs.</p> <p>UNHSC further notes that in 2007 they installed a bioretention system in a parking lot median strip as a retrofit. It cost a total of \$14,000 per acre, including \$8,500 per acre for labor and installation, and \$5,500 per acre for materials and plantings. “These finding indicate that for municipalities with equipment and personnel, the retrofit costs are nearly \$5,500 per acre of drainage.” (University of New Hampshire Stormwater Center 2012 Biennial Report)</p>
Accumulation of toxics	<p>Stormwater flow from roadways and parking lots typically carries a mix of pollutants. Where bioretention facilities are used to receive, capture, and treat these flows, do facilities become toxic? Lisa Stiffler, a researcher with the Sightline Institute, a Seattle based think tank, has been investigating. She has found the following:</p> <p>Petroleum pollutants/PAHs: Studies from the field and laboratory find that rain gardens do a great job of capturing petroleum pollution, and that the chemicals are largely eliminated when they are destroyed by bacteria in the soil.</p> <p>Heavy metals: Soil and mulch in rain gardens contain particles that will adsorb and hold metals including copper, cadmium, lead, and zinc. A small fraction of the metals are sucked into plant roots and vegetation. When Northwest counties test for metals in the sediment that is scooped from the bottom of stormwater ponds or rain gardens that drain parking lots and other city surfaces — material that would likely have higher levels of metals than your average residential rain garden — they found that the contamination levels were still below soil and compost standards meant to protect human health.</p> <p>Bacteria and viruses: While some research has found bacteria and viruses in stormwater that can cause disease in humans, sunlight as well as other microorganisms in the runoff and soil of rain gardens can destroy the pathogens. Also, most of the microorganisms present come from animal waste and are less likely to cause illness in people.</p> <p>The bottom line is that the soil in rain gardens is safe for kids and pets. That said, people are advised to wash their hands after working or playing in any soil, which can contain naturally occurring metals, fecal waste from pets, or any number of compounds one would not want to ingest.</p>

Snow management	<p>If used in conjunction with parking lots or roadways, bioretention facilities should be designed to make for easy movement of plows. Planning a plow path and telling snow plow operators where to push the snow is important in keeping snow out of bioretention areas.</p> <p>According to the Massachusetts Stormwater Handbook (Vol. 2, Ch. 2), never store snow in bioretention facilities. The operation and maintenance plan must specify where on-site snow will be stored. A major reason for this is that infiltrating capabilities will become impaired due to fines that remain once snow melts.</p>
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EXAMPLES OF WHERE STRATEGY HAS BEEN IMPLEMENTED

Veterans Affairs Medical Center, Northampton, MA

Three rain gardens at the Northampton Veterans Affairs Medical Center enhance drainage through infiltration of rainfall and snowmelt, and improve aesthetics and habitat values with extensive native plantings. The three rain gardens are part of a campus rain garden master plan.

The rain garden below on the right captures flow from a 1,200 square foot area of roof. The rain garden shown below, includes a “level spreader” built of stone at the top of the system to ensure that storm flow distributes evenly across the basin and does not cause gullies or erosion. This garden below receives flow from a 1,600 square foot area of roof.



Photos courtesy Thomas Benjamin

Downspout Disconnection

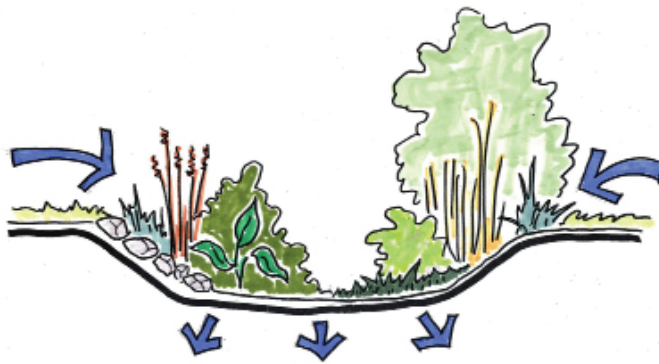
PURPOSE

Establishing a municipal downspout disconnection program provides support for a simple, low cost and low maintenance green infrastructure practice to reduce the amount of runoff entering the municipal storm or combined sewer system, thus reducing the occurrence of combined sewer overflows and associated water pollution.

The purpose of a municipal downspout disconnection program is to identify and disconnect those downspouts (also called roof leaders) that discharge into the sanitary sewer system, thereby reducing peak storm flows and associated combined sewer overflows (CSO). Sometimes, downspouts may not be directly plumbed into the sewer, but flow onto contiguously connected impervious areas such as driveways and parking lots, which drain to storm drains in the street. Under both circumstances (direct connection or overflow), redirecting downspouts to vegetated areas such as lawns or rain gardens is a recommended best practice.

In a 2011 study conducted by the Center for Watershed Protection, researchers evaluated runoff reduction at downspout disconnections to six urban residential lawns in the City of Baltimore, Maryland with C-type soils (less cohesive granular soils). On average, runoff reduction was high with an average reduction of 95% for the 1-inch rainfall event, and an average reduction of 90% for the 2-inch rainfall event. Numerous factors affect runoff reduction including soil type, age of lawn, slope, organic matter content, and management practices. The study noted that D-type (or compacted soils) would have resulted in less runoff reduction.

Rain gardens are an attractive alternative to lawn and allow 30% more water to soak into the ground than a conventional lawn (Wisconsin Department of Natural Resources, 2003). In addition to their ability to retain and infiltrate runoff, they provide important habitat for bees, butterflies and birds in urban and suburban areas.



SOURCE: www.GroundworkAppliedDesign.com

DESIGN CONSIDERATIONS

The physical disconnection is relatively simple as illustrated below, however there are a number of design considerations that need to be factored into a project.

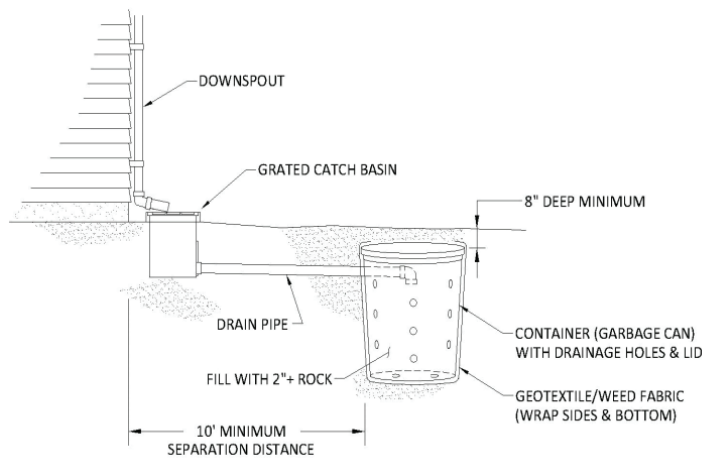
- » Evaluate soil type at the site to determine the type of on-site infiltration that will be most effective. Small highly compacted sites, or sites underlain with clay may not be feasible for on-site infiltration.
- » Direct downspout disconnections away from the basement foundation. Make sure downspout extensions end at least three feet away from basement foundations, and water is being directed on ground that slopes away from the building, however do not disconnect downspouts on slopes greater than 10%.
- » Downspout disconnections can redirect flows to vegetated areas such as a lawn or rain garden where there is the capacity for water to infiltrate into the ground.
- » Alternatively, a disconnected downspout can be plumbed into an underground drywell, gravel pit or trench where water is stored and slowly infiltrates into the ground.
- » Do not allow water to splash or pond on adjacent property. Infiltrate all water on site.
- » Do not redirect water to paved walkways and driveways as it will cause icing in the winter and unsafe conditions for pedestrians.



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A subsurface infiltration chamber can be built from a variety of materials. Key components include pipe, a perforated storage chamber, stone, and filter fabric.

SOURCE: Fairbanks Green Infrastructure Group www.fairbankssoilwater.org

HOW TO DISCONNECT A DOWNSPOUT

Step 1: Observe Your Site

It is important to understand where runoff from your downspouts go, including your house, garage, and other covered surfaces. Identify the location of downspouts and roof line, and estimate the square footage of your roof area. Map out areas in your yard for infiltration down slope of structures where you might disconnect downspouts.

Step 2: Design Your Disconnection

Make sure you have enough landscaped area for rain to soak safely into the ground. The ground area must be at least 10% of the roof area that drains to the disconnected downspout.

roof area	sizing factor	landscapes area size
500 sq. ft.	X 10% =	50 sq. ft. (5'x10')

Step 3: Disconnect and Redirect

Cut off the downspout above the old connecting pipe. Cap or plug the top of the pipe. Fittings can be either approved adapters or blind plugs. These are available at most plumbing supply stores. Secure the cut downspout to the wall with a bracket. Next, install an elbow and extension to carry water away from the house. Add a concrete “splash pad” at the ground where the water spills from the downspout onto the lawn to prevent erosion, or landscape the area with stone, or install a rain garden to infiltrate the runoff water.



Step 4: Maintenance

Proper maintenance of your gutters, downspouts, and landscaping can reduce problems.

- » Clean gutters at least twice a year, and more often if you have overhanging trees.
- » Make sure gutters are pitched to downspouts, and repair low spots.
- » Check and clear elbows or bends in downspouts to prevent clogging.
- » The ground should slope away from the structures. Don't build up soil, mulch, or other landscaping materials against the foundation and siding.
- » Avoid draining water onto impermeable plastic weed block or cloth.
- » Maintain healthy vegetation (lawn or rain garden plants) in the drainage area to minimize erosion and promote optimum infiltration.

DEVELOPING A MUNICIPAL DOWNSPOUT DISCONNECTION PROGRAM

Some examples of successful municipal downspout disconnection programs are provided below. However, it is important to understand key program components so that a missing element does not become a barrier to program implementation.

Local Policies and Regulations

Municipalities should adopt a local policy or regulation prohibiting downspout connections and establishes a local program with standards and incentives for downspout disconnection and on-site infiltration. Such a program may not be appropriate in neighborhoods where soils are not suitable for infiltration. Neighborhoods with combined sewers are high priority areas for downspout disconnection programs. Soil suitability for infiltration should be assessed in these neighborhoods prior to implementing a program.

Stormwater plumbed into the sanitary sewer can not only cause combined sewer overflows, but it increases the volume of water to be treated at the waste water treatment plant at an expense to the municipality. Clean roof runoff does not need the level of treatment sewage receives at a treatment plant. By reducing the volume of water being treated at the plant, the municipality saves money that can be used to support other infrastructure needs.

See local examples below for more information on funding and operating a downspout disconnection program.

Education and Outreach

Public service announcements, community meetings, YouTube videos, brochures, and financial incentives have proven very important to successful programs. On-going education to residents about the benefits of disconnection and redirection, and alternative uses of stormwater such as rainwater harvesting for irrigation or greywater, cannot be overlooked. This means adequate funding is needed for dedicated staff, outreach materials, and possibly materials such as a downspout disconnection kit or a drywell for infiltration.

Technical Support

All successful downspout disconnection programs provide a licensed plumbing contractor to perform the work at no cost to the homeowner. Alternatively, the homeowner can do the work themselves or hire a licensed plumber at their own expense, sometimes from a pre-approved list of contractors provided by the City. If a homeowner chooses not to use a city contractor, or a pre-approved contractor, a site inspection is performed upon completion to ensure compliance with local sewer regulations and/or plumbing codes. In some cases, dye testing may be needed to determine if a downspout is connected to or has been properly disconnected from the sanitary sewer.

Funding Sources

Funding sources are typically derived from one of the following or a combination thereof: sewer rates, stormwater utility fees, and State Revolving Fund (SRF). Dedicating funding to downspout disconnection from any of these sources is identified in planning phases such as I/I studies and master plans, capital improvement plans, or through enforcement proceedings such as Administrative and Court Orders.

DISCONNECTION PROGRAMS – LESSONS LEARNED

City of Portland, Oregon

The City of Portland, Oregon's Department of Environmental Services operated a very successful downspout disconnection program from 1993 to 2011, disconnecting more than 58,000 downspouts at a total cost of \$13 million, inclusive of disconnection construction, staffing, and outreach materials and media. The program was funded solely from their sewer and stormwater utility fee, established in 1977. Some key lessons learned include:

- » **Scale Matters** – The program targeted a large geographic area to reduce CSOs to the Columbia, Slough and Willamette Rivers. To do this successfully, they used a simple technique for disconnection that was conservatively applied to only downspouts that could be disconnected safely.
- » **Downspout Disconnections Only Tool in the Toolbox** - They did not build rain gardens or other systems, seeking as much benefit as simply as possible. If a downspout disconnection could not be done safely, they didn't do it.

- » **Build Trust with Consistent Messaging** – Consistent and persistent messaging through targeted and direct outreach to homeowners helped build trust in the community and grow the program. Homeowners were slow to sign up at first, but the programs reputation for working well with property owners and careful attention to site details encouraged others to participate.
- » **Financial Incentives are Important** - Homeowners could earn \$53 for each downspout disconnection toward the stormwater portion of their city utility bill. Homeowners could have their downspouts disconnected for free by a licensed and bonded plumber under contract with the City, do it themselves, or utilize one of the volunteer community groups trained by the City. All sites were inspected after disconnection by the City. Later, the City also established the Clean River Rewards program which offered on-going discounts on utility bills for other on-site stormwater management options.
- » **Keep Risk Low** – High safety standards meant some downspouts could not be disconnected without risk of onsite flooding or harm to workers performing disconnection.

Boston Water and Sewer Commission

The Boston Water and Sewer Commission's (BWSC) downspout disconnection program was established 25 years ago as a component of their combined sewer separation. Through numerous Infiltration and Inflow Studies, the Commission identified neighborhoods and individual properties with downspouts connected to the combined or sanitary sewer, and initiated direct outreach to property owners about disconnecting their downspouts. Homeowners may choose to allow a contractor hired by BWSC to disconnect the downspouts at no cost to the homeowner, or the homeowner may hire a licensed plumber to disconnect at the owner's expense. The program has disconnected downspouts on 39,000 buildings, and estimates to have disconnected over 75,000 downspouts.

Funding sources have varied over the course of the program. In general, funding has been provided by the Metropolitan Water Resources Authority (MWRA), which gets its funding for sewer separation projects from SRF. MWRA operates the regional Deer Island Waste Water Treatment Plant. The funding structure has varied from full coverage to a cost share depending on different factors over time including the phase of separation, funding levels, and whether the project was located in a combined or separated sewershed. BWSC's portion of the cost share structure has come from their sewer rates revenue.

To support the sewer separation program, the City adopted a Sewer Use Regulation in 1998 prohibiting downspout connection to the combined sewer and requiring disconnection. The program saves BWSC money by reducing the volume of water it sends to the Deer Island Wastewater Treatment Plant, and supports MWRA's mandates to eliminate CSOs. More about this program can be viewed here:

<http://www.bwsc.org/SERVICES/Programs/downspout/downspout.asp>

REFERENCES AND RESOURCES

CITY OF PORTLAND, OREGON ENVIRONMENTAL SERVICES. HOW TO MANAGE STORMWATER: DOWNSPOUT DISCONNECTION.

www.cleanriverspdx.org

LAW, NEELY AND DANA PUZEY. DOWNSPOUT DISCONNECTION STUDY SHOWS GREAT POTENTIAL FOR RUNOFF REDUCTION ON SMALL URBAN LAWNS. CENTER FOR WATERSHED PROTECTION WINTER NEWSLETTER, 2012.

UNIVERSITY OF CONNECTICUT. RAIN GARDENS: A DESIGN GUIDE FOR CONNECTICUT AND NEW ENGLAND HOMEOWNERS.

www.nemo.uconn.edu/raingardens/

UNIVERSITY OF WISCONSIN EXTENSION. RAIN GARDENS: A HOW-TO MANUAL FOR HOMEOWNERS. 2003

<http://dnr.wi.gov/topic/shorelandzoning/documents/rgmanual.pdf>

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Green Roofs

PURPOSE

Green roofs decrease greenhouse gas emissions caused by heating and cooling systems by making buildings more energy efficient through the installation of roofs with vegetation, soil, and membrane layers.

In recent years, green roofs have gone from a horticultural curiosity to a booming growth industry, primarily because the environmental benefits of extensively planted roofs are now beyond dispute. Whether for industrial or governmental complexes or private homes, in urban or suburban settings, green roofs provide many benefits to buildings, neighborhoods and municipalities including:

- » Reduce stormwater infrastructure needs and costs by retaining 25 to 90% of precipitation (seasonally dependant).
- » Insulate buildings by reducing heat loss (winter) and heat gain (summer) through the roof.
- » Provide new opportunities for urban agriculture, or the creation of community gardens.
- » Significantly reduce sound levels from sources such as traffic or airplanes.
- » Protect roof membrane resulting in longer material lifespan and decreased maintenance and savings in replacement costs.
- » Provide amenity space for day care, meetings, and recreation.
- » Provide aesthetic appeal, increasing property value and the overall marketability of the building, particularly for accessible green roofs.
- » Reduce 'urban heat island effect' in the summer

PROMOTING GREEN ROOFS IN THE PIONEER VALLEY

Communities can adopt local zoning incentives or provide financial incentives through municipal stormwater fee reductions, tax credits and grant programs to encourage the installation of green roofs on new and existing buildings. Examples of zoning incentives include density bonuses (typically in the form of floor area ratio (FAR) bonuses) or a reduction in parking requirements. Some cities in the United States have taken steps to mandate that all new privately-owned large buildings (typically over 50,000 sq/ft) meet LEED Certified standards, which require green roofs. Few municipalities actually require projects to achieve LEED certification.

The U.S. is far behind other countries in adopting strategies to support the installation of green roofs. Germany has emerged as the world leader not only in developing green roof technologies and systems, but in passing federal and state legislation to mandate green roofs under specific conditions and offering economic incentives to install them. The state of Nordrhein-Westfalen, for example, pays €15.00 per square meter (\$19.40/10.8 square feet) to individuals who install them, while other states offer similar programs. (Snodgrass, 2006)

ENVIRONMENTAL BENEFITS

Improved air and water quality are two important environmental benefits to green roofs. The plants and growing medium of a green roof absorb water that would otherwise become runoff, thereby reducing peak storm flows and reducing associated water pollution. Research indicates that peak flow rates are reduced by 50% to 90% compared to conventional roofs. The characteristics of the soil substrate have a major influence on the effectiveness of a green roof. The soil layer traps sediments, leaves and other particles, thereby treating the runoff before reaching an outlet. The water retention capacity of the soil is dependent upon both the properties of the soil substrate and the vegetative cover. For example:

- » 1-inch deep moss and sedum layer over a 2-inch gravel bed retains about 58% of the water
- » 2.5-inch deep sedum and grass layer retains about 67% of the water
- » 4-inch layer of grass and herbaceous vegetation retains about 71% of the water

When incorporated into a combined sewer overflow abatement strategy, green roofs can reduce the need for sewer separation or storage projects required to reduce the volume and frequency of combined sewer overflows. (MA DEP and Low Impact Development Center)

The insulation provided by a green roof improves the cooling and heating efficiency of a building. By reducing energy demand for these functions, green roofs reduce air pollution and greenhouse gas emissions associated with energy production. Additionally, by reducing roof temperatures, green roofs slow the formation of ground-level ozone. Vegetation on a green roof can remove particulate matter and gaseous pollutants including nitrogen oxides, sulfur dioxide, and carbon monoxide from the air. They also remove carbon dioxide and produce oxygen. (MA DEP)

DESIGN CONSIDERATIONS

What is the purpose of the green roof?

Identifying a green roof's purpose and incorporating that into the early stages of planning and design is critical. All of the end uses may be compatible (stormwater retention, temperature management, community garden), but each requires different design and structural emphases and will significantly impact how the roof looks and functions, including what vegetation will cover it.

Load-bearing Considerations

Load bearing is the most critical consideration for any green roof. There are no regulatory barriers to building a green roof per se. Structural engineers assess loads from two general perspectives: dead and live loads. Local building codes usually specify a roof's required live load, which includes snow, water, wind, and safety factors required for the building's performance. Live load also includes human traffic, temporary installations such as furniture or maintenance equipment, and anything else transient in nature. Dead load includes the weight of the roof itself, along with permanent elements that make up the roof's structure, including roofing layers, any permanent installations for heating and cooling, and the projected wind or snow loads. Green roofs must be designed to withstand both live and dead loads. Additionally, because extensive green roof systems must be evaluated while fully saturated – which adds from 15 to 25 pounds per square foot – this must also be factored in. (Snodgrass, 2006)

Components of the Green Roof

The term green roof actually denotes a system of comprising several components, or layers, that work together to function as a single combined unit. While a green roof can be built on a variety of decking surfaces including concrete, steel, wood, and composite, the system is only possible when other components are added to ensure that the roof is protected against collapse and degradation and several other conditions are met. The basic components include: decking, waterproofing layer, and insulation layer, a root barrier, a drainage layer, a filter layer, and a substrate or medium layer.

Vegetation and Plant Selection

The act of growing plants under atypical conditions necessarily influences their selection and maintenance in ways that differ from considerations for ground-level plants. Selecting the right plants is one of the foremost challenges. For example, without irrigation and at least 8 inches of mostly organic medium, most green roofs in North America cannot sustain a wide variety of plant species that appear in traditional gardens. (Snodgrass, 2006) Solar orientation will affect plant growth, and may be particularly important on sites with extreme slopes that have the potential to shade a roof.

Jones Ferry River Access Center Green Roof, Holyoke, MA

This green roof includes is 13,000 square foot roof built to reduce and treat stormwater runoff, improve energy efficiency within the building lowering heating and cooling costs, reduces rooftop noise and improve air quality. The building was designed to accommodate the roofing system, including a sturdier roof framing, a thick EPDM membrane for waterproofing the roof.

The six inches of growth media is an engineered blend of carefully selected materials designed to be light weight while providing superior moisture retention. It's superior to regular soil because it is lighter, free from pathogens, undesirable insects and weeds. The roofing system will weigh between 20-25 pounds per square foot saturated with water. On an annual average, 50%-80% of all stormwater that falls on the roof is retained and not released to the storm sewer system.

In a completely dry state, the R-Value of the roof garden is approximately 6. However, the higher the moisture content of the assembly, the lower the R-Value, as thermal conductivity increases. Plants function as small water pumps operating at high pressure and low volume. When materials experience a phase change from liquid to vapor, they absorb a large of amount of heat energy from the surrounding environment. In the case of water, every gallon transpired by the plants absorbs roughly 8,000 BTU's of heat energy. As a result, during hot summer days, the roof membrane temperature is typically 5-10°F cooler than the ambient air temperature. The plants, mostly sedum acclimated to grow in this area, also stabilize the growth media and absorb stormwater.

MUNICIPAL INCENTIVE PROGRAMS FOR GREEN ROOFS

Portland, Oregon

The City of Portland offers a Floor Area Ratio (FAR) bonus to developers who build rooftop gardens or Ecoroofs in certain districts of the city. The ratio of the FAR bonus varies, depending on the percentage of the total building roof that the Ecoroof or rooftop garden covers. The City also funds up to \$5 per square foot of an 'ecoroof' project through their Ecoroof Incentive Program, which runs to 2013.

Chicago, Illinois

The City of Chicago's "Green Permit Process" offers qualifying projects, such as green roof projects, an expedited permit process and possible reduction of the permit fees.

Minneapolis, Minnesota

The City of Minneapolis charges property owners for management of stormwater based on the degree to which their property is covered by impervious surfaces. Property owners could qualify for fee reductions of up to 100% by establishing onsite water-quality and/or quantity treatment systems, such as rain gardens, detention ponds and green roofs.

Toronto, Canada

The City of Toronto instituted a "green roof bylaw" that requires green roofs for all new development above 21,500 sq/ft. Coverage requirement range from 20-60% of the available roof space depending on the size of the development.

Acton, Massachusetts

The Town of Acton adopted a zoning by-law allowing for a density bonus for buildings achieving LEED certification in the East Acton Village District.

Portsmouth, New Hampshire

The City of Portsmouth adopted a density bonus for private projects that use LEED in the central business district by which a project benefits from a 0.5 increase in FAR if it meets appropriate open space requirements and build to LEED Certified standards.

Los Angeles, California

The City of Los Angeles requires all privately owned buildings in the city with more than 50 units or over 50,000 sq/ft to meet LEED Certified standards. Additionally, all City of Los Angeles building projects that are 7,500 sq/ft or larger are required to meet LEED standards.

REFERENCES AND RESOURCES

U.S. GREEN BUILDING COUNCIL, GREEN BUILDING INCENTIVE STRATEGIES:
www.usgbc.org/DisplayPage.aspx?CMSPageID=2078

TOWN OF ACTON ZONING BYLAW (SECTION 5.5B.2.2.D):
<http://www.acton-ma.gov/>

CITY OF PORTLAND ECOROOF PROGRAM:
<http://www.portlandonline.com/bes/index.cfm?c=44422>

CITY OF LOS ANGELES GREEN LA INITIATIVE:
www.ladwp.com/ladwp/areaHomeIndex.jsp?contentId=LADWP_GREENLA_SCID

CITY OF CHICAGO GREEN PERMIT PROCESS
www.cityofchicago.org/city/en/depts/bldgs/supp_info/overview_of_the_greenpermitprogram.html

CITY OF MINNEAPOLIS STORMWATER PROGRAM:
<http://www.ci.minneapolis.mn.us/stormwater/green-initiatives/>

CITY OF TORONTO GREEN ROOFS PROGRAM:
<http://www.toronto.ca/greenroofs/>

Snodgrass, Edmund C. and Lucie L. Snodgrass. *Green Roof Plants: A Resource and Planting Guide*. Timber Press, 2006.

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Green Streets

PURPOSE

Green streets are designed to treat and infiltrate stormwater close to its source while creating more vibrant and livable communities.

Stormwater runoff from streets, roads, parking lots, roofs and other impervious surfaces is a significant source of water pollution to our rivers, streams and ponds, as well as a major contributor to combined sewer overflows. Green streets can provide cost effective infrastructure solutions to reduce and manage stormwater runoff and flooding through the use of green infrastructure facilities – small, decentralized, natural or engineered systems that utilize soils and vegetation as a primary treatment mechanism. This approach integrates the built and natural environment, introducing park-like elements that enhance the pedestrian experience.

GREEN STREETS PRINCIPLES

Green streets are designed utilizing three guiding principles:

Green Infrastructure – Use naturalized systems to treat and manage stormwater close to its source.

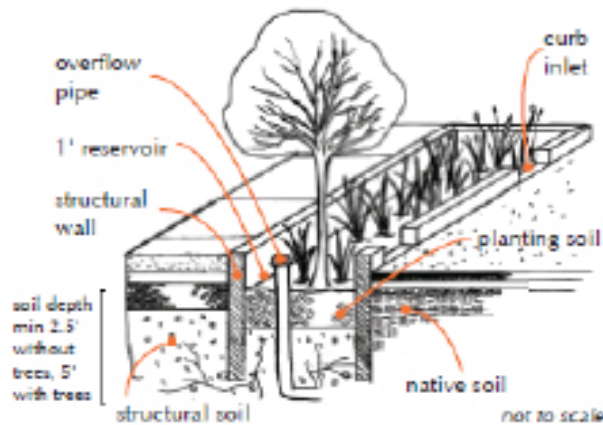
Green infrastructure (GI) uses naturalized systems to infiltrate, evapotranspire, and/or recycle stormwater runoff close to its source. Rain gardens, bioretention areas, tree box filters/trenches, green roofs, bioswales, permeable pavement, and street trees are some common GI practices. In addition to vegetation and engineered soils, GI uses permeable surfaces to intercept rain and snow melt close to the source, reducing the burden on traditional grey infrastructure systems. GI facilities seek to complement rather than replace existing grey infrastructure to achieve some of the additional benefits green streets have to offer a community.

Complete Streets – Create bicycle and pedestrian friendly streets.

Complete Streets are designed for all users regardless of age, ability, income, or mode of transportation, and prioritize the health, safety, and comfort of residents and visitors. Through the use of designated bike lanes, safe pedestrian crossings, traffic-calming elements, and accessible transit systems, Complete Streets create healthier, more pleasant streetscapes that offer opportunities to walk and bicycle safely every day.

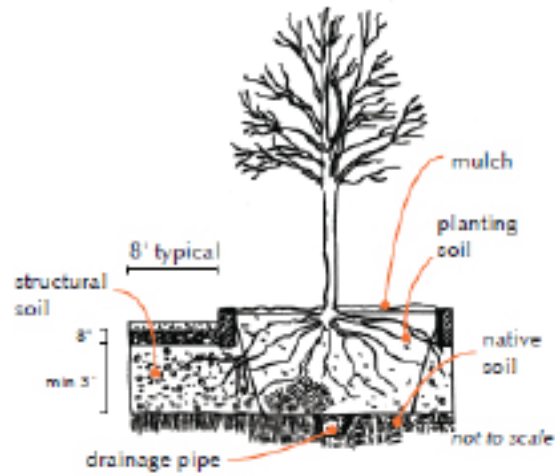
Placemaking – Generate a strong sense of place.

Placemaking is about strengthening the connection between people and the spaces they share. In this way, spaces are created that reflect the identity and history of residents, taking a number of forms from pocket parks to participatory art projects to human-scale built environments. Good public spaces can be both temporary and seasonal, as in a Saturday morning farmer's market on a local street closed to vehicular traffic, to permanent parks, plazas and boulevards. Placemaking can increase positive interactions between people, instill community pride, improve quality of, beautify a place, and support economic growth.



STORMWATER PLANTER

A stormwater planter is usually a rectangular, vegetated planter, sometimes planted with trees. Its four concrete sides double as a curb and structure for the planter and allow water to pool up to 1' before overflowing into another planter or the grey infrastructure system, storing and infiltrating water over time.



BREAKOUT

Break-outs are excavated areas filled with structural soil, often under sidewalks or roads. Used in combination with other green infrastructure tools such as tree trenches or stormwater planters, break-outs provide more room for tree roots to grow in tight spaces, increasing the longevity and survival rate of urban trees.



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ADOPTING A GREEN STREETS POLICY

Adopting a municipal Green Streets Policy demonstrates a community's commitment to achieving the principles identified above in both private and public projects. The following are examples of Green Street Policies from cities around the country:

Northampton, Massachusetts – Green Streets Policy

Northampton has developed a Green Streets Policy statement which promotes the use of green streets facilities and green infrastructure in public and private development, including:

- » Road reconstruction, new road development and bicycle and pedestrian projects;
- » Stormwater projects, and;
- » New development and redevelopment projects

through regulation, capital investment and management mechanisms as a cost effective and sustainable practice for stormwater management.

Prince George's County, Maryland – Complete and Green Streets Policy

The County requires road, sidewalk, trail, and transit related construction/reconstruction projects to include environmental site design where practicable.

District of Columbia – Green Streets Policy

The District of Columbia's stormwater rules and the Department of Transportation's Low Impact Development Action Plan inform the City's Green Streets Policy.

Cleveland, Ohio – Complete and Green Streets Ordinance

The purpose of the ordinance is to the creation of a network of Complete and Green Streets that will improve the economic, environmental, and social well-being of the city.

Tucson, Arizona – Green Streets Policy

Tucson's policy requires stormwater harvesting features to be integrated into all publicly funded roadway development and redevelopment projects.

Holyoke, Massachusetts – Green Streets Guidebook

The City's Guidebook is intended to introduce city planners and policy makers to Green Streets, advocate for Green Streets implementation in Holyoke, and serve as a preliminary set of design guidelines to transform Holyoke's streets into more ecologically, socially, and economically positive spaces. The Guidebook includes a Toolbox with design standards for Green streets strategies; nine design templates representative street characteristics in Holyoke that can be applied to future projects; a site-specific application of Green Street design principles in downtown Holyoke; an exploration of relative costs and benefits; and recommended next steps for the city to implement Green Streets.

Edina, Minnesota – Living Streets Policy

The policy enables the City to implement their Living Streets Plan for safe walking, bicycling and driving, reduced stormwater runoff, reduced energy consumption, and promoting health.

REFERENCES AND RESOURCES

CITY OF SEATTLE, RIGHT OF WAY IMPROVEMENTS MANUAL: GREEN STREETS

http://www.seattle.gov/transportation/rowmanual/manual/6_2.asp

CITY OF PORTLAND, GREEN STREETS CONSTRUCTION GUIDE

<http://www.portlandoregon.gov/bes/45379?>

CITY OF PHILADELPHIA'S GREEN CITY CLEAN WATERS,
GREEN STREETS DESIGN MANUAL

http://www.phillywatersheds.org/what_were_doing/gsdm

U.S. ENVIRONMENTAL PROTECTION AGENCY, EFFECTIVE GUIDE TO GREEN STREETS

http://water.epa.gov/aboutow/eparecovery/upload/2009_09_10_eparecovery_EPA_ARRA_Green_Streets_FINAL.pdf

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Porous Asphalt

WHAT IT IS

With roads and parking lots accounting for a high percentage of impervious surface, porous asphalt can be an ideal Best Management Practice in the right location. It essentially eliminates the impervious surface that would otherwise be created. Porous asphalt uses a standard asphalt mix with no sand or fines and a polymer binder to provide strength and stability. The void spaces of this mixture allows rain and snowmelt to pass through to a subbase of stone aggregate that both supports the asphalt layer and provides storage for and treatment of rainfall or snowmelt.

Unlike many other stormwater management facilities, porous asphalt requires no additional land or space, functioning within the footprint of the roadway, parking lot, alley, or sidewalk. By promoting infiltration, filtration, and recharge of groundwater, porous asphalt significantly reduces runoff volume and peak flows, decreases runoff temperature, and improves water quality. The University of New Hampshire Stormwater Center (UNHSC) reports that it also speeds snow and ice melt, reducing the salt required for winter maintenance. While porous asphalt is most recommended for low volume and low speed applications, U.S. Environmental Protection Agency has noted that porous asphalt has performed well in all highway pilot projects in the United States. Maine DOT has recently used porous asphalt on a high volume road in South Portland (see more information about this project under Examples).

WATER QUALITY TREATMENT

The porous asphalt design tested at UNHSC, being widely promoted now in New England, uses coarse sand as a subbase filter course that enhances effectiveness in pollutant removal rates. The facility at UNHSC has demonstrated the following:

Pollutant	% Removal
Total Suspended Solids (TSS)	99
Total Petroleum Hydrocarbons in the Diesel Range	99
Dissolved Inorganic Nitrogen (NO ₃)	No treatment
Total Zinc	75
Total Phosphorous	60
Average Annual Peak Flow Reduction	82

Source: University of New Hampshire Stormwater Center 2009 Annual Report

DESIGN CONSIDERATIONS

Stormwater design parameters – Three to five feet of vertical separation is needed from seasonal high groundwater. U.S. EPA also notes, “The load bearing and infiltration capacities of the subgrade soil, the infiltration capacity of the porous asphalt, and the storage capacity of the stone base/subbase are the key stormwater design parameters. To compensate for the lower structural support capacity of clay soils, additional subbase depth is often required. The increased depth also provides additional storage volume.”

Quality control – Careful assessment of site conditions, and quality control for material production and installation methods are essential to success.

Protect porous surface from sediment and fines – To minimize clogging and promote continued good infiltration rates over time it is critical to protect the surface and base from sediment and fines during and after construction. Pretreatment BMPs, such as filter strips and swales, may be important considerations where water is flowing from upland areas onto the surface. Devices such as chatter strips at parking lot entries can also help reduce clogging. Sanding during the winter months should be discouraged.

Specifications - For guidance on design, see specification provided by UNHSC at: <http://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/UNHSC%20PA%20Spec%20update-%20FEB-2014.pdf>.

The specification shown in Figure 1 (at right) is intended for:

1. porous asphalt pavement in parking lot applications;

2. a cold climate application based upon the field experience at the UNHSC porous asphalt parking lot located in Durham, New Hampshire. They note that the can be adapted to projects in other climates provided that selection of materials and system design reflects local conditions, constraints, and objectives.

The mix for porous asphalt requires a polymer binder, which may be difficult to acquire for small scale projects. For

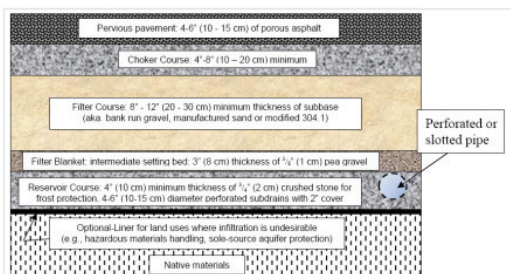


Figure 1: Typical Parking Area Cross Section for Porous Asphalt
Courtesy: University of New Hampshire Stormwater Center

example, when New England Environmental, Inc. in Amherst, MA constructed its porous asphalt parking lot in 2009 it found that the binder specified by UNH for the asphalt mix is only appropriate for larger-scale jobs, because it is only sold by the trailer truckload. New England Environmental, Inc. found a substitute binder that includes polymer fibers, much like what is used for asphalt curbing, that could be acquired by the barrel.

PERMITTING CONSIDERATIONS

The Massachusetts Stormwater Handbook currently does not allow for porous asphalt in Zone IIs, or near any other critical areas, including Outstanding Resource Waters and Special Resource Waters (see Stormwater Management Standard #6). While the stormwater management standards relate to jurisdictional areas under the Wetlands Protection Act, these standards have been applied by reference through local bylaws and ordinances to upland locations as well. MassDEP is currently proposing a revision to its guidance about porous asphalt, and porous pavements generally, as new information has become available on its treatment capabilities. Until this recommendation from MassDEP is accepted, however, any legal actions will be based on the current guidance within the Stormwater Handbook.

BARRIERS TO USE

Concern	Experience
Cost	<p>\$10 to \$12 per square foot based on costs for MassDOT Park and Ride facility in Whately, MA, including 16 inches of stone for subbase and 5 inches of surface mix. Note that the scale and size of a project can also affect price, with lower per square foot costs on larger projects.</p> <p>The UNH Stormwater Center notes that material costs alone are about 20 to 25 percent more than traditional asphalt, but total project cost for porous asphalt is comparable to those for conventional asphalt projects if one accounts for the stormwater infrastructure costs that are required to manage runoff from conventional asphalt. The University of Rhode Island in building their porous asphalt parking lots in 2002 and 2003 found that the construction costs were comparable to equivalent sized conventional parking lots.</p> <p>While initial costs of a porous asphalt facility may be slightly higher than a facility that uses conventional asphalt, the lifespan of a porous asphalt parking lot can be more than 30 years compared to 15 years for a conventional parking lot. (See: "Pervious Pavements: New findings about their Functionality and Performance in Cold Climates" by J. Gunderson, Stormwater, September 2008.)</p>
Winter performance	<p>Given the well draining stone bed and structural support of porous asphalt, the freeze thaw cycle tends to produce fewer cracks and potholes than on conventional asphalt pavement. (University of New Hampshire Stormwater Center)</p> <p>"Because of the well-drained nature of the porous pavement and reservoir base, issues related to frozen media were minimized. Significant frost penetration was observed up to depths of 71 cm without declines in hydrologic performance or observable frost heave." (Results of a study published in Journal of Environmental Engineering in January 2012 notes)</p> <p>Low to no black ice development, allowing for reduced salt application rates of up to 50 to 75 percent. Best not to use sand at all to avoid clogging of pours. (University of New Hampshire Stormwater Center)</p>
Maintenance	<p>Requires vacuuming twice each year (spring and fall), and perhaps more frequently depending on use, to prevent clogging of pores with sediment and fines. Several contractors in the region offer vacuuming services. Typically, per square foot costs will be lower with larger jobs. A municipality for example may see better value in hiring to have several lots vacuumed at once rather than each vacuumed on separate occasions.</p> <p>Repairs can be made with standard asphalt, not to exceed 10 percent of surface area. (University of New Hampshire Stormwater Center)</p> <p>For winter maintenance tips, see UNHSC recommendations related to plowing and use of salt for general maintenance, during a storm event, and between storm events. See: http://unh.edu/unhsc/sites/unh.edu.unhsc/files/docs/UNHSC%20porous%20winter%20maintenance%20fact%20sheet_1_11.pdf</p>
Clogging	<p>Studies of the long-term surface permeability of porous asphalt and other permeable pavements have found high infiltration rates initially, followed by a decrease that then levels off with time. With initial infiltration rates of hundreds of inches per hour, the long-term infiltration capacity remains high even with clogging. See: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=135&minmeasure=5</p>
Durability	<p>The University of New Hampshire Stormwater Center acknowledges that while porous asphalt is weaker than conventional asphalt pavements, durability can be greatly improved with the proper admixtures and design. It has been effective for both commercial and roadway applications. (UNHSC 2012 Annual Report)</p>

EXAMPLES OF WHERE STRATEGY HAS BEEN IMPLEMENTED

New England Environmental, Inc. headquarters, Amherst, MA

As part of developing their new LEED platinum rated office building, New England Environmental, Inc. included porous asphalt in a suite of stormwater management strategies that also includes rain gardens and grass pavers. They used porous asphalt for all travel lanes (about a 10,000 square foot area), while grass pavers were used in all parking stalls. The porous asphalt has been in place since 2008 and is performing beyond expectations with vacuuming occurring twice each year to remove sediment and fines. Owner Mickey Marcus reports that the cost for the parking lot as a whole was equivalent to the cost of a conventional parking lot with attendant stormwater management facilities. For the future, Marcus discourages the use of grass pavers in combination with porous asphalt as the pavers become too easily damaged with winter plowing. See figure 2.



Figure 2: New England Environmental, Inc. with porous asphalt drive in foreground and grass paver parking stalls in middle ground | Courtesy: Mickey Marcus, NEE

MassDOT Park and Ride facility, Routes 5 and 10, Whately, MA

At the request of the local conservation commission, which was concerned about the parking facility's proximity to a wetlands area, MassDOT used porous asphalt in the 40 parking stalls at this new Park and Ride facility in Whately, MA. The porous area has 16 inches of stone in the subgrade and 5 inches of surface mix. Construction costs ran \$10 to \$12 per square foot for the porous asphalt area. MassDOT used traditional asphalt in the travel lanes for this facility.

Maine Mall Road, South Portland, ME

Maine DOT used porous asphalt on this four lane (75-foot wide) high-volume road (16,750 AADT) as part of a larger effort to restore a local creek to its water quality classification. They installed porous asphalt on 850 linear feet and used a specification that included a 3-inch open graded friction course, followed by 6 inches of asphalt treated permeable base, 15 inches of stone reservoir, and 6 to 12 inches of porous filter material (see project location in Figure 3 and cross section in Figure 3 below.) Total project costs were \$90 per square yard and the project was funded entirely through the American Recovery and Reinvestment Act monies.¹

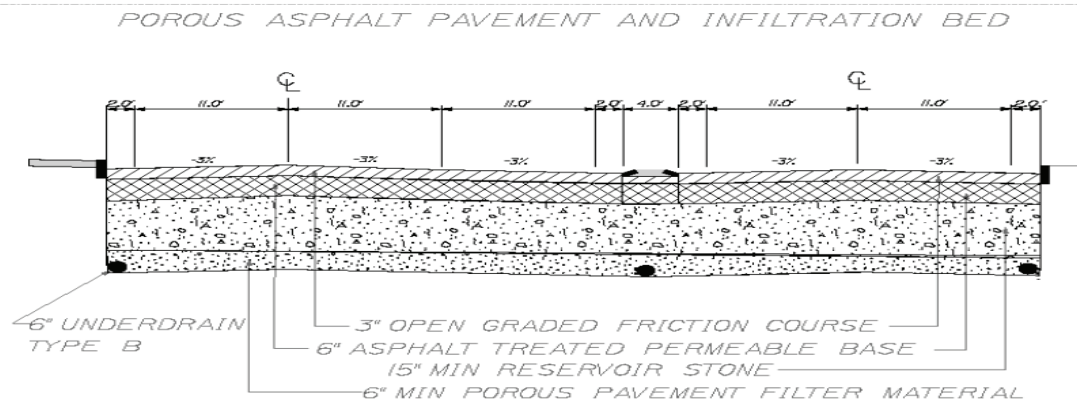


Figure 4: Cross section of porous asphalt system on Maine Mall Road | Source: Maine DOT

University of Rhode Island, Kingston, RI

In 2002 and 2003, the University of Rhode Island built two porous asphalt parking lots over a sole source aquifer. One lot is 5.5 acres and accommodates 800 vehicles while a smaller 1.47 acre lot accommodates 200 vehicles. Due to concerns of potential groundwater contamination and compaction of the asphalt, commercial and industrial vehicles are not permitted to park on these lots. In addition the recharge bed was designed to be 6 to 6.5 feet above seasonal high groundwater. Design of the facility includes a 2.5 thick porous asphalt surface layer, a 1-inch layer of choker course, and 3 to 3.5 feet of crushed rock to temporarily store and infiltrate rainfall and snowmelt. The crushed rock storage reservoir is separated from underlying soils and adjacent subsurface materials by a layer of geotextile filter fabric. Intended to prevent movement of fine soil particles up into the overlying reservoir, the fabric instead captured fines moving down from the overlying layers and became clogged so that water cannot infiltrate and moves laterally across the barrier.

Entrance areas of the parking lots are paved with conventional asphalt to accommodate heavier use and to better receive sediment deposition from tires as vehicles enter the lot. Landscaped parking lot islands act as bioinfiltration areas throughout the parking areas to provide a secondary route of infiltration during intense rainfall and in case the pavement surface gets clogged up. The outer areas of the lot are landscaped with trees and grass to keep windblown dust from nearby agricultural activities from accumulating on the porous asphalt.

During the summer of 2005, a new porous asphalt parking area was constructed expanding the existing lot and increasing the capacity from 814 to 1582 spaces. The new lot covers 5.8 acres. Several changes were made to the new lot to allow for simpler maintenance. They are:

1. Fewer, wider infiltration islands
2. Curb cuts for water entry to island bioinfiltration areas
3. Mowed grass, not meadow grass for islands
4. Fewer wheel stops, where possible, due to wheel stops being moved by cars and plowing

LINKS TO MORE INFORMATION

HEIN, DAVID K., STRECKER, ERIC, PORESKEY, AARON, ROSEEN, ROBERT, AND VENNER, MARIE FOR AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) STANDING COMMITTEE ON THE ENVIRONMENT. OCTOBER 2013. "PERMEABLE SHOULDERS WITH STONE RESERVOIRS." SEE:

[onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-25\(82\)_FR.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP25-25(82)_FR.pdf)

ROSEEN, ROBERT M., BALLESTRO, THOMAS P., HOULE, JAMES J., BRIGGS, JOSHUA F., AND HOULE, KRISTOPHER F. JANUARY 2012. "WATER QUALITY AND HYDROLOGIC PERFORMANCE OF A POROUS ASPHALT PAVEMENT AS A STORM-WATER TREATMENT STRATEGY IN A COLD CLIMATE." JOURNAL OF ENVIRONMENTAL ENGINEERING, 81-89.

UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER. OCTOBER 2009. "UNHSC DESIGN SPECIFICATIONS FOR POROUS ASPHALT PAVEMENT AND INFILTRATION BEDS." SEE:

http://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/unhsc_pa_spec_10_09.pdf

UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER. JANUARY 2011. "WINTER MAINTENANCE GUIDELINES FOR POROUS ASPHALT." SEE:

http://unh.edu/unhsc/sites/unh.edu.unhsc/files/docs/UNHSC%20porous%20winter%20maintenance%20fact%20sheet_1_11.pdf

UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER. "POROUS ASPHALT PAVEMENT FOR STORMWATER MANAGEMENT."

http://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/porous_ashpalt_fact_sheet.pdf

U.S. ENVIRONMENTAL PROTECTION AGENCY. MENU OF BMPS: POROUS ASPHALT PAVEMENT. SEE:

<http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=135&minmeasure=5>

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Rain Water Harvesting

PURPOSE

Rainwater harvesting is a means to capture runoff from rooftops and store it for non-potable uses such as irrigation and greywater plumbing. In addition to reducing the demand on public water supplies by replacing potable water with rainwater, rainwater harvesting can reduce peak stormwater flows, potentially reducing combined sewer overflows and other pollution associated with stormwater runoff.

Rainwater harvesting – collecting rainwater from impervious surfaces and storing it for later use – is gaining in popularity as communities, businesses, and homeowners seek ways to affordably manage stormwater, and address the potential for increasingly limited water resources caused by climate change. The many benefits of rainwater harvesting and reuse include:

- » Provides inexpensive supply of water for outdoor water use and non-potable indoor uses
- » Reduces stormwater runoff and associated pollution by reducing peak flows
- » Helps reduce peak summer water use demand by creating alternative water supplies

RAINWATER HARVESTING SYSTEMS

Rainwater harvesting systems typically divert and store runoff from residential and commercial roofs. Often referred to as ‘clean’ runoff, roof runoff does contain pollutants (metals or hydrocarbons from roofing materials, nutrients from atmospheric deposition, bacteria from bird droppings), but they are generally in lower concentrations and absent from many of the pollutants present in runoff from other impervious surfaces. Installing a rainwater collection system requires diverting roof downspouts to cisterns or rain barrels to capture and store the runoff. Collection containers are constructed of dark materials or buried to prevent light penetration and the growth of algae.

From the storage container, a dual plumbing system is needed for indoor uses and/or connection to an outdoor irrigation system.

DESIGN CONSIDERATIONS

Every rainwater harvesting system, from a single 60-gallon rain barrel to a 1,400-gallon underground cistern, is custom tailored to site features, intended water use, budget, whether it is new construction or a retrofit, and how much space is available for storage capacity. Points toward LEED project certification are also available for a properly designed rainwater harvesting system.

Some general design considerations for every project include:

- » The earlier rainwater harvesting is incorporated into a new building design process, the more efficient and cost effective-it will be.
- » The largest and often most expensive system feature will be the storage tank, also called a cistern.
- » Storage tanks can be installed above or below ground.
- » Storage located high on the building or the site saves energy and costs (no pumps = zero energy use).
- » Elevated storage requires structural and seismic engineering.
- » Above ground storage structures can serve additional beneficial purposes as shade or privacy structures, and as heat sinks.
- » If space permits, size the cistern to capture the occasional really large storm, and have water available for extended dry periods.
- » Cisterns designed for full time domestic water use should be sized based upon a minimum of 30 gallons per day per person. <http://www.saveourh2o.org/water-use-calculator>
- » Underground storage tanks must be anchored to keep from floating when empty.
- » Use gravity as much as possible for the movement of water in the system.
- » Plumbing, backflow, overflow, and air gaps are important design features, and may require a licensed plumber depending on local code requirements.
- » Above ground tanks must be drained completely before freezing temperatures, and thus are seasonal applications.
- » Maintenance depends on intended reuse of water. Typical maintenance includes keeping gutters and cistern screens clean as well as periodic inspection and replacement of any water treatment components and equipment, including pumps and backflow prevention devices. The tank will require cleaning annually for potable water sources.
- » Rain barrel costs, including installation, range from \$60-\$150.
- » Underground storage systems range in cost depending on the size of the cistern and the water reuse application. For example, a buried 1,800 gallon storage tank with overflow directed to a drywell recharge area, including submersible pump for supply to an irrigation system, costs \$5,000-\$6,000, including installation.

How to Size a Rain Barrel

Rain barrel volume can be determined by calculating the roof top water yield for any given rainfall, using the following general equation:

$$V = A2 \times R \times 0.90 \times 7.5 \text{ gals./ft.}^3$$

V = volume of rain barrel (gallons)

A2 = surface area of roof (square feet)

R = rainfall (feet)

0.90 = losses to system (no units)

7.5 = conversion factor (gallons per cubic foot)

Example: One 60-gallon barrel would provide runoff storage from a rooftop area of approximately 215 square feet for 0.5 inch (0.042 ft.) of rainfall.

REGULATIONS

Massachusetts has no statutes or regulations concerning rainwater harvesting. Consequently, greywater requirements are often used to govern rainwater harvesting systems, resulting in requirements that are more stringent than necessary for outdoor water use. In 2010, the International Association of Plumbing and Mechanical Officials (IAPMO) published the first of its kind Green Plumbing and Mechanical Code Supplement (GPMCS). The supplement is a separate document from the Uniform Plumbing and Mechanical Codes and establishes requirements for green building and water efficiency applicable to plumbing and mechanical systems. In addressing “Non-potable Rainwater Catchment Systems”, the GPMCS specifically identifies provisions for collection surfaces, storage structures, drainage, pipe labeling, use of potable water as a back-up supply (provided by air-gap only), and a wide array of other design and construction criteria. It also refers to and incorporates information from the ARCSA/ASPE Rainwater Catchment Design and Installation Standard, a document published in 2008 under a joint effort by the American Rainwater Catchment Systems Association (ARCSA) and the American Association of Plumbing Engineers (ASPE). (EPA, 2013)

CROSS-CONNECTIONS WITH MUNICIPAL WATER SUPPLY AS BACKUP SOURCE

State code allows the direct plumbing of municipal water supply to a RWH system as a back-up water supply provided an approved reduced pressure backflow preventer (RPBP) is installed and included under a required maintenance plan. These fixtures have a physical air gap internal to the device that separates “unregulated” harvested water from the municipal supply. A standards model of an RPBP is approved by MA DEP for use in cross-connections.

WATER RATES

Water rates are perceived as irresponsibly low by many water sustainability professionals and researchers, and seldom reflect the true costs of its use. Many communities also have a decreasing block rate structure wherein water becomes cheaper on a unit basis the more one uses. Low rates are perhaps the largest impediment to rainwater harvesting systems, since under current rate structures one would never build a harvesting system to save money on water usage, except in a rare case where a site is particularly water constrained.

TREATMENT REQUIREMENTS

Since no standards exist for secondary exposure to contaminants or bacteria from use of harvesting systems (e.g spray irrigation, toilet use, etc.), municipalities often use primary exposure thresholds (e.g drinking the water) to set water quality requirements for harvesting systems since no scientific basis for assessing risk exposure exists today. Or, greywater reuse code provisions are applied which are not necessarily appropriate and are typically considered over treatment which results in increased costs to a project limiting implementation of these systems.

CONSIDERATIONS FOR ESTABLISHING A MUNICIPAL RAINWATER HARVESTING PROGRAM

- » **Establish specific codes or regulations for rainwater harvesting** – Local codes should define rainwater harvesting and establish its position as an acceptable stormwater management and water conservation practice.
- » **Identify acceptable end uses and treatment standards** – Consider and identify acceptable uses for harvested rainwater and the required treatment for specific uses. Rainwater is most commonly used for non-potable uses and segregated by indoor and outdoor use.
- » **Detail required system components** – Delineate between rain barrels and cisterns. Needed system requirements include: pre-filtration (screens, etc.), storage containers, back-flow prevention, dual piping system, cross-connection prevention, and signage for locations of potable and non-potable water within the system. Refer to the UPC's Green Plumbing and Building Code Supplement for guidance.
- » **Permitting** – Rain barrels should not require local permitting. A building permit may be required for cistern systems used for non-potable water uses. If harvested rainwater is used for potable water, the collection and treatment system should be inspected and approved by the local Board of Health.
- » **Maintenance** – Adequate design and maintenance of the cistern and piping system is the responsibility of the cistern owner.

- » **Rates of use** – To be used efficiently for maximum stormwater retention, rainwater needs to be used in a timely manner to ensure adequate storage capacity for subsequent rain events. Municipalities should engage in outreach and education about best practices. Harvesting programs targeting combined sewer areas should promote post-storm slow draw down of rain barrels and cisterns to delay stormwater release to the sewer system and ensure maximum storage for the next storm.



LOCAL RAINWATER HARVESTING PROJECTS

Center-Pepin School, Easthampton, MA

A 305-gallon storage tank collects rainwater from a 670 square foot roof and serves as a source of irrigation water for the school yard garden. The cistern does not fully capture the first one inch storm, and overflow is directed to an existing ground level concrete channel along the building which drains to the municipal storm sewer. The system cost \$308 plus \$125 for delivery, and was installed by volunteers at the school.

MassMutual Financial Group, Springfield, MA

Roof water reclamation serves as a reservoir for on-site irrigation. 60-inch diameter HDPE piping provides 200,000 gallons of storage. An independent pumping system pressures water for irrigation system. There is automated conversion to domestic water during dry periods, and a smaller infiltration system for winter.



A similar system to the one in the photo was installed at MassMutual.

REFERENCES AND RESOURCES

GEOSYNTEC CONSULTANTS. CODE BARRIERS TO GREEN INFRASTRUCTURE/LOW IMPACT DEVELOPMENT. EMAIL COMMUNICATION, 2012.

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS. GREEN PLUMBING AND MECHANICAL CODE SUPPLEMENT. 2010.

http://www.iapmo.org/pages/iapmo_green.aspx

KLOSS, CHRISTOPHER, LOW IMPACT DEVELOPMENT CENTER. MANAGING WET WEATHER WITH GREEN INFRASTRUCTURE, MUNICIPAL HANDBOOK, RAINWATER HARVESTING POLICIES. DECEMBER, 2008.

NATIONAL CONFERENCE OF STATE LEGISLATORS. STATE RAINWATER/GREYWATER HARVESTING LAWS AND LEGISLATION. SEPTEMBER 1, 2013.

<http://www.ncsl.org/research/environment-and-natural-resources/rainwater-harvesting.aspx>

U. S. ENVIRONMENTAL PROTECTION AGENCY. RAINWATER HARVESTING: CONSERVATION, CREDITS, CODES AND COSTS LITERATURE REVIEW AND CASE STUDIES. EPA-841-R-13-002, JANUARY, 2013.

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Tree Box Filters

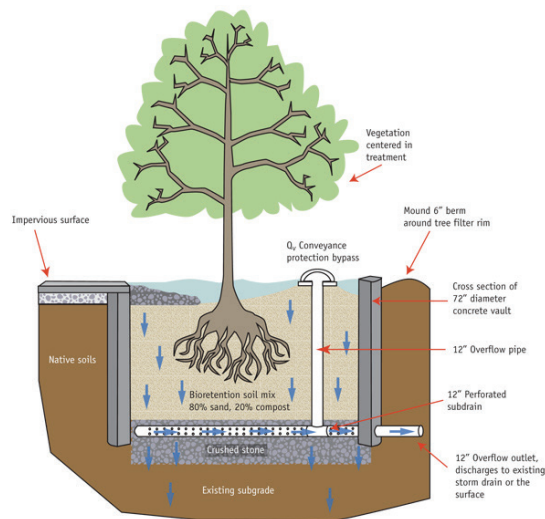
WHAT IT IS

Tree box filters are typically installed along roadways to act as mini bioretention systems. They are particularly useful in urban settings where space is limited and where traditional street tree plantings can be converted to provide stormwater management functions. A tree box filter involves a prefabricated concrete box that can be bottomless to promote infiltration or closed bottomed where soils are not conducive to infiltration. The box typically contains a metal grate at the surface to protect the integrity of the tree's roots and soils, a soils mix designed to both promote tree growth and stormwater function, a tree species (tolerant of road salt and the varying cycles of inundation and drought), and a perforated subdrain located within a bed of crushed stone at the very bottom.

Storm runoff from adjacent roadways and sidewalks enters the box through an inlet along the curbing and then soaks into and gets filtered by the soil mix. Stormwater is then taken up by tree roots, or soaks deeper into the subgrade to recharge groundwater, or collects in a perforated subdrain to discharge to the storm sewer system or to the surface.

WATER QUALITY TREATMENT

Like other bioretention systems, the tree filter box retains, degrades, and absorbs pollutants as stormwater filters through layers of mulch, soil, and plant roots. The University of New Hampshire Stormwater Center (UNHSC) installed its first tree box filter



Source: University of New Hampshire Stormwater | Center, 2009 Biannual Report

Tree box filter boxes are prefabricated bioretention cells that can be integrated into existing curb and catch basins drainage systems along streets to receive runoff from adjacent impervious surfaces.



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in 2004 and reports, “Their water quality treatment performance is high, often equivalent to other bioretention systems, particularly when well distributed through a site.” UNHSC’s 4-foot deep, 6-foot diameter facility demonstrated the following:

Pollutant	% Removal
Total Suspended Solids (TSS)	93
Total Petroleum Hydrocarbons in the Diesel Range	99
Dissolved Inorganic Nitrogen (NO ₃)	3
Total Zinc	78
Total Phosphorous	NT
Average Annual Peak Flow Reduction	NT

Source: University of New Hampshire Stormwater Center 2009 Biannual Report

During a two-year study at the University of Virginia using a manufactured tree box filter called Filterra made by Americast, Inc. researchers found “...pollutant removal rates vary as a function of the filter surface area to drainage area.” At the minimum of .33% filter surface area to drainage area ratio filtering 90% of the annual runoff (calculations that involved the rainfall distribution and frequency data from the mid Atlantic region) the expected pollutant removal rates are as shown below. They note that higher pollutant removal rates are made possible by increasing the ratio of filter surface area to drainage area.

Total suspended solids: 85%

Total phosphorous: 74%

Total nitrogen: 68%

Metals: 82%

Peak Flow Reduction

UNHSC notes in its 2009 Biannual Report that, “Without additional engineering, the tree box filters can do little to reduce peak flows unless sited in appropriate soils, such as those in groups “A” (sand, loamy sand, or sandy loam with high infiltration rates) and “B” (silt loams or loams with moderate infiltration rates).”

A technical bulletin from the Virginia Stormwater Manual notes that while tree box filters are not used generally for the attenuation of runoff for stream channel erosion control and flood control purposes, “...some degree of volume/flow reduction can be achieved

by combining this filter system with an adjacent [downstream] underground storage / detention system (gravel trench or pipes). Such a combined system may be useful for urban retrofit projects to address problems associated with combined sewer overflows or for stream protection.”

DESIGN CONSIDERATIONS

There are numerous prefabricated tree box filter structures that are commercially available. They are generally sized and spaced much like catch basin inlets. Design variations are abundant and as mentioned above, the functionality of the tree box filter can be augmented for volumetric control with adjacent underground storage or given naturally well draining soils (Groups A and B). Design (sizing, spacing, installation, and location) are done in accordance with manufacturer’s specifications.

While drainage areas may range in size from one-quarter to a half acre, there is an optimum ratio between filter surface area to drainage area that brings together cost effectiveness



Source: Neponset River Watershed Association

The Neponset River Watershed Association worked with the Town of Milton to retrofit an existing “curb and catch basin” drainage system in the Central Crossing neighborhood with tree filter boxes. The project reduced bacterial loading to Pine Tree Brook and the Neponset River while raising awareness of these facilities as a cost effective approach to stormwater management.

with pollutant removal effectiveness. The two-year study at the University of Virginia, which used the tree box filter manufactured by Filterra and rainfall distribution / frequency for the Mid Atlantic region, found that the optimum ratio between filter surface area to contributing impervious surface drainage area is 0.33% (36 ft²) of filter surface for every ¼ acre of drainage area. This would require a 6 by 6-foot filter box.

For locating tree box filters, the State of Virginia Stormwater Management Program offers the following guidelines. Tree box filters are,

...best incorporated into the overall site, or streetscape or parking lot landscaping plan. The individual box locations represent a combination of drainage considerations (based on final grades and water quality requirements), desired aesthetics, and minimum landscaping requirements, and must be coordinated with the design of the drainage infrastructure.

Because proper functioning of the soil media is so critical (as with other bioretention facilities), there are several additional consideration worth noting:

- » **Tree box filters are installed after site work is complete and stabilization measures have been implemented. It is important to protect the filter media from premature clogging and failure.**
- » **Exposing the soil, microbes, and plants to prolonged and frequent flooding and wet conditions will significantly change the hydrologic regime reducing the effectiveness of the media to capture pollutant and the microbe's/plant's abilities to cycle nutrients, break down organics and uptake heavy metals. If the filter media remains water logged for 3 or 4 days anaerobic conditions will develop, dropping both oxygen and pH levels which may kill desirable soil microbes and plants. As such, runoff should not be detained and stored in a holding tank to be metered out to the filter media over a long period of time and frequent flows (such as from basement sump pumps) must be excluded.**

BARRIERS TO USE

Following are possible concerns that may serve as barriers to use of tree box filters.

Concern	Experience
Cost	<p>There are a variety of costs described in the available literature on tree box filters, ranging from \$1,500 to \$10,000. Recent quotes from manufacturers of these systems provide perhaps a more realistic range: \$7,000 to \$12,000, depending on size and not including installation. For public projects, installations can be done by municipal public works department or they might be bid out as part of a larger construction project.</p> <p>Annual maintenance cost for an owner has been reported at approximately \$100 per unit. Annual maintenance by the manufacturer is \$500 per unit.</p>
Winter performance	<p>University of New Hampshire Stormwater Center found, "The tree box filter's ability to treat water quality remained relatively stable in all seasons... While some seasonal variation in infiltration capacity and nitrogen removal does occur, cold conditions do not seem to warrant significant design alterations."</p>
Maintenance	<p>Once the tree is established, annual maintenance is typically minimal. In UNHSC's five-year experience with the tree filter box (installed in 2004), they note that maintenance entailed only routine trash removal and periodic inspections to ensure that the bypass and soils are adequately conveying water. In 2008, they also removed the top two inches of surface fines accumulation to restore infiltration capacity (due to an accumulation of sealcoat fines and flakes which caused a noticeable reduction in infiltration). Periodic removal of surface fines (similar to that of deep sump catch basins) may be useful over the long term to support infiltration.</p> <p>Manufacturers may provide services for inspection, care, and maintenance of the tree box filter for the first year or two after installation.</p> <p>Charles River Watershed Association notes that maintenance entails the following: periodic inspection of plants and structural components, periodic cleaning of inflow and outflow mechanisms (the system comes with an observation well that can be used as a clean out), periodic testing of mulch and soil for buildup of pollutants that may be harmful to the vegetation. Biannual replacement of mulch.</p>

LINKS TO MORE INFORMATION

UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER. MARCH 2010.
“UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER 2009 BIENNIAL
REPORT.” SEE:
<http://www.unh.edu/unhsc/>

CHARLES RIVER WATERSHED ASSOCIATION. APRIL 2008. “EVALUATION OF GREEN
STREET DESIGN ELEMENTS AND BEST MANAGEMENT PRACTICES: COMPARISON OF
CONVENTIONAL AND STORMWATER TREE PITS.” SEE:
[http://www.crwa.org/hs-fs/hub/311892/file-642201447-pdf/Our_Work_/Blue_Cities_Initiative/Resources/
CRWA_Stormwater_Trees_Urban_Environment.pdf](http://www.crwa.org/hs-fs/hub/311892/file-642201447-pdf/Our_Work_/Blue_Cities_Initiative/Resources/CRWA_Stormwater_Trees_Urban_Environment.pdf)

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Code Review Checklist

PURPOSE

The Code Review Checklist is a tool for assessing the capacity of local regulations to support green infrastructure options in new development and redevelopment within a community.

There are many reasons why a community should support the development of green infrastructure in both new development and redevelopment. In addition to the effectiveness of the many structural practices designed to manage and treat storm water close to its source through natural or engineered systems, green infrastructure facilities can be beautiful, compatible with the pedestrian environment, and support place making design elements at almost any site. The pending reissuance of the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit will also require regulated communities to assess their local regulations and policies for compatibility with green infrastructure practices.

HOW IT WORKS

The Code Review Checklist is divided into several easy to follow sections that allow a community to determine:

- » if their local regulations are compliant with the draft 2010 NPDES MS4 Permit;
- » the degree to which their street design, parking lot and other local requirements affect the creation of impervious cover;
- » and the extent to which a Low Impact Design (LID) approach is integral to site planning and development.

The checklist does not offer a ranking or final score but rather identifies specific areas of local regulations that can be improved upon to better support green infrastructure and LID site planning.

NPDES MS4 Permit Compliance – Based on the draft 2010 permit, the Code Review Checklist asks a series of questions that allow the municipality to determine if their local bylaws or ordinances meet permit requirements for stormwater management program funding, illicit connections, erosion and sediment control at construction sites, and post construction stormwater management in new development and redevelopment.

Street and Parking Lot Standards in Subdivision Regulations and Zoning – Once completed, these sections of the Code Review Checklist offer a comparison between existing code requirements and LID standards for road width and length, rights of ways, sidewalks, cul de sacs, stormwater management facilities, and landscaping requirements.

Feasibility of Green Infrastructure in Other Local Regulations, Policies, and Programs

This section of the Checklist seeks information about other zoning tools such as open space or cluster development, Board of Health and wetland regulations, street tree policies and programs, and local building/plumbing codes relative to programs such as rain water harvesting.

RESOURCES

The Pioneer Valley Green Infrastructure Code Review Checklist is a compilation of guidance drawn from several resources including The Center for Watershed Protection's Code and Ordinance Worksheet, the U.S. Environmental Protection Agency's Water Quality Scorecard, and the Metropolitan Area Planning Council's Low Impact Development Toolkit Checklist for Regulatory Review.

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Green Infrastructure In Zoning

PURPOSE

Measurable standards can be adopted within municipal zoning codes, and subdivision and stormwater regulations, to promote a comprehensive approach to Low Impact Development and the integration of green infrastructure in community development.

There are many opportunities within local zoning codes and subdivision and stormwater regulations to promote Low Impact Development (LID) standards and green infrastructure including the use of incentives, code requirements with standards, and a well-defined planning process that promotes coordination between preliminary plans, site plans, and stormwater management plans. Examples include incentives such as density bonuses, infiltration requirements with design standards, and planning for multipurpose functionality of design elements such as buffers and screening for landscaping and stormwater management. Rather than adopting a separate bylaw that may conflict with other sections of the zoning code, integrate green infrastructure throughout such that it becomes the norm not an exception.

Many green infrastructure strategies have multiple benefits and offer a more comprehensive approach for addressing a range of issues and challenges. For example, a green roof takes up no extra space at all, manages storm water by reducing peak flows, improves the heating and cooling efficiency of a building, and has the potential to be a source of food production. Techniques such as bioretention areas, grass filter strips, and swales can also meet landscaping and open space requirements while addressing stormwater treatment and infiltration.

Green Infrastructure

Communities are exploring strategies that promote capture and control of rain water near where it falls. This includes the use of natural or engineered systems – such as green roofs, rain gardens, or cisterns. In these facilities, stormwater can be cleansed as it moves through soils and plant roots (treatment), returned to groundwater (infiltration), returned to the air (evapotranspiration), and/or captured to irrigate plants or flush toilets (reuse). This approach is called “green infrastructure” because of the use of plants to enhance and/or mimic natural processes. Green infrastructure contrasts with traditional “gray infrastructure” which is typically built to capture and retain large volumes of stormwater collected over a large area, and convey it to the nearest waterway.

Source: Pioneer Valley Green Infrastructure Plan, February, 2014

AN EFFECTIVE PERMITTING PROCESS IS CRITICAL

Critical to effective implementation of green infrastructure facilities is the site inventory and analysis process which should occur before any design work. Existing site conditions may offer opportunities to minimize impacts as well as the costs of stormwater management and can be identified through careful site analysis. Local zoning and permitting can promote a thoughtful process by defining the planning process, and providing standards for green infrastructure.

Town of Franklin, Massachusetts – Best Development Practices Guidebook

Franklin, Massachusetts’ commitment to expedited permitting resulted in creation of their Best Development Practices Guidebook to take the guess work out of permitting requirements for developers. Critical to smooth and successful permitting is their four step process for site plan and subdivision applications that begins with an existing site conditions map and an initial pre-development meeting, held every Wednesday at 3 PM, with representatives from all town boards, the police and fire departments, and Town Counsel. Developers are offered guidance on how to meet multiple permit requirements and community planning objectives with the least amount of time and expense. Through this process, LID and green infrastructure strategies are coordinated with other project requirements early in the planning process.

http://www.town.franklin.ma.us/Pages/FranklinMA_planning/initiatives/bestdevelopment.pdf

INTEGRATING GREEN INFRASTRUCTURE STANDARDS

Drainage

A best practice for eliminating conflicting standards is to reference the local stormwater bylaw or regulation within needed sections of the zoning code for appropriate drainage standards, thereby keeping all drainage standards and specifications in one section of the local code. All zoning standards for drainage should be consistent with the purpose and standards identified in any local stormwater management bylaw, regulation or policy to provide a seamless process for promoting LID site planning. Conserving the natural hydrologic function of a site, reducing impervious surfaces and preventing runoff are key principles in ensuring post development peak flows do not exceed predevelopment peak flows. Green infrastructure facilities should be explicitly encouraged for treatment, attenuation, and infiltration of stormwater at decentralized locations around a site to capture stormwater at its source.

Dimensional and Density Regulations

Explicitly allow bioretention areas, rain gardens, filter strips, swales, and constructed wetlands within required setback areas.

Allow reduction in frontage (and corresponding road length/paved area) where appropriate, such as in Open Space Residential Developments, at the outside sideline of curved streets, and around cul-de-sacs. Removal of all frontage requirements for open space developments allows greater flexibility for such projects.

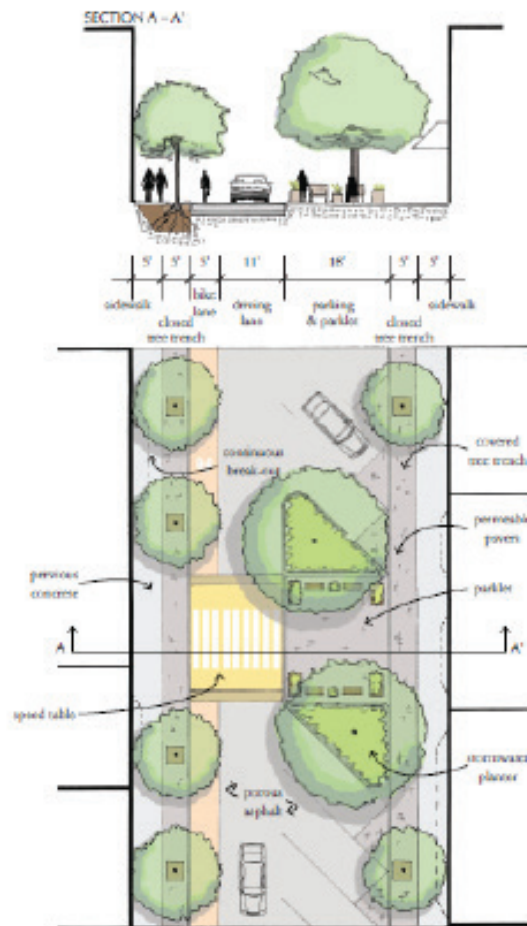
Setbacks for front, rear, and side yards should promote a walkable streetscape and support community character which means they will likely vary based on land use. In a mixed use district, setbacks should include enough space to comfortably design a pedestrian sidewalk against the building, a single lane automobile access lane or driveway, and a substantial vegetated buffer adjacent to the residential use as a screening buffer that can also serve as stormwater green infrastructure. A rear setback of 30-50 feet maybe required to ensure that loading, trash removal and other similar activities have adequate room. Flexibility in these standards due to lot configuration is important.

Site Preparation, Landscaping, Screening and Buffers

Landscaping requirements and objectives vary as a function of land use and activity. Emphasize native vegetation preservation on-site, and note that screening and buffer areas can be used for stormwater management provided that screening functions are not compromised. Consider including design standards for landscaping and screening that encourage the use of green infrastructure facilities. In the same way that architectural design standards serve a town, design standards for landscaping can support place-making within neighborhoods and across a community.

Roads

Roadways should be designed to be as narrow as possible while still wide enough to accommodate travel lanes, regular on-street parking (where required), and the passage of emergency vehicles, school buses, and the occasional delivery truck. Many local standards will specify that local urban roads be paved to a width of between 28 and 32 feet, while local rural roads might have a standard of only 22 feet in width. These guidelines are appropriate for high density development or higher vehicle volumes but are generally excessive for most suburban and rural developments. At a minimum, local codes and regulations should not discourage or prohibit impervious cover reductions. Curbs should be eliminated wherever possible to allow road drainage into open channel systems or other green infrastructure facilities. Requirements for curb and gutter infrastructure (i.e. requirements for new subdivisions to connect to storm sewer infrastructure) can be replaced with requirements for "perforated curb and swale" infrastructure, or simply roads without curbs where appropriate.



In thriving commercial areas, shaded pedestrian seating areas and calmed vehicular traffic invite people out in the neighborhood. Covered tree trenches manage stormwater and landscape pedestrian paths between the sidewalk and road, guiding circulation in the commercial district.

SOURCE: Holyoke Green Streets Guidebook, 2014

Landscaping and street standards can work well together to support community development objectives such as an improved pedestrian experience with a downtown commercial shopping district as illustrated in the City of Holyoke's Green Streets Guidebook (2014) image herein.

Example Road Travel Widths for Local Streets

Minimum Road	Parking	Average Daily Trips (ADT)	Number of Dwelling Units Served
20	Parking on both sides*	<200	20
22	Parking on one side*	200-400	20-40
26	Parking on both sides	400-2,000	40-200
28	Parking on one side	>2,000	>200
32	Parking on both sides	>2,000	>200

*Parking is restricted to one side during a snow emergency. No parking is designated of road is a designated fire lane. Source: Rhode Island Low Impact Development Site Planning and Design Guidance Manual. Horsley Witten Group and RI DEP, March 2011.

The standard ROW width of between 50-60 feet can also be excessive in many situations. Wide ROWs require more clearing and grading, potentially changing the ecological function of a site and creating more expense. The ROW need only be wide enough to contain all of the cross sectional elements including sidewalks, utility easements, parking lanes, drainage features, and travel lanes which depend on the size, density and location of the development. More moderate standards for ROW construction may include a 44- to 50-foot ROW width for 26- to 30-foot wide local urban and suburban streets. In a rural setting, a 40-foot ROW for 22-foot wide local roads might be more appropriate.

Also in subdivisions, there are opportunities to reduce the required radius of a cul-de-sac (down to an outer road radius of 30 to 40 feet), and to allow hammerhead turnarounds. On dead end streets, hammerhead turnarounds can provide a feasible way to reduce paved area while providing sufficient turnaround space for larger fire vehicles.

REDUCING IMPERVIOUS SURFACES IN PARKING REQUIREMENTS

Communities should establish both minimum and maximum parking ratios to provide adequate parking while reducing excess impervious coverage. Parking reductions could be allowed for factors such as: mixed land uses, access to alternative transportation, demographics, and utilization of Transportation Demand Management (TDM) Programs including subsidized mass transit and parking cash out programs. Flexibility is a key component to providing adequate but not excessive parking.

Off Street On-site Parking Requirements - Identify maximum parking spaces. Consider requiring a Special Permit for an increase in maximum parking allowance. Some on-site parking requirements could be met off-site particularly in redevelopment sites and compact mixed use centers.

Shared Parking and Other Opportunities to Reduce Parking Requirements - Establish formulas for the utilization of shared parking for uses with different peak demand periods (e.g. work day peak demand period 9am-5pm; housing peak demand period 6pm-8am). Provide a model shared parking agreement and facilitate implementation. An alternative to shared parking is increasing the number of zoning districts that have minimal parking requirements.

Parking and Loading Space Standards - Allow for smaller stalls for compact cars, up to 30% of total parking spaces. Allow pervious pavement driveways and parking stalls, soils permitting, in all zoning districts. Encourage pervious pavement in overflow parking areas and shoulders. Snow storage should not coincide with these areas as it may include sand which will clog pervious pavement and prevent infiltration. This is especially important if porous pavement is being utilized for stormwater management. Edging and curbing can be eliminated or perforated to allow stormwater flows into infiltration and bioretention areas. For larger parking lots, require separating parking rows with planting strips that may function to manage stormwater and shade the lot reducing the heat island effect. Shade tree requirements in planting strips should also take into consideration stormwater treatment.

On-Street Parking Demand - Wider residential streets are often justified by the need to provide on-street parking. However, providing a continuous parking lane on both sides of the street is usually an inefficient and expensive way to satisfy the required parking for residential areas, since most of the required parking per unit can be met in driveways or through shared parking. Consider using one or both of the on-street parking lanes as a traffic lane (i.e. a queuing street), both traffic movement and parking needs could be met with a narrower street.

SIDEWALKS

Flexible design standards should be adopted that are based on safe pedestrian movement and limiting impervious cover. Constructing five-foot wide sidewalks on both sides of the street is not always appropriate, even in medium to high density developments. A three- or four-foot sidewalk on one side of the street is appropriate for many situations. Where practicable, sidewalks should be graded to drain into front lawns, reducing the total amount of runoff generated by the roadway. Consider permeable surfaces such as permeable asphalt or compacted aggregate where appropriate. Walkways may be removed from the roadway entirely and used to provide access to natural features or connect other destinations such as a playground, park or adjacent development.

The Town of South Hadley, Massachusetts allows subdivision developers to pay a fee in lieu of sidewalks in small developments where a sidewalk network may not serve a purpose. The fee contributes to bicycle and pedestrian projects in other areas of town.



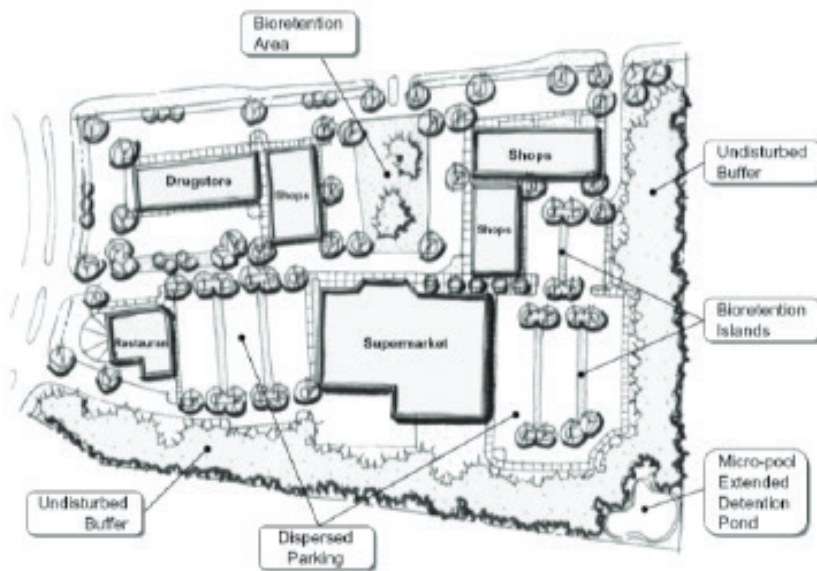
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OPEN SPACE PROTECTION IN ZONING

Open Space Residential Development (OSRD), Open Space Design (OSD), Conservation Development and Natural Resource Protection Zoning (NRPZ) are the current zoning models for what was previously called cluster or flexible development. This approach utilizes LID site design strategies for conserving natural hydrologic functions and reducing impervious surfaces for preventing runoff, integrating green infrastructure as a fundamental design element. These plans retain native vegetation and natural areas, and structure site layout to greatly reduce street infrastructure. The open space set aside should be based on resource values, not by formula such as X% of the development. The four step planning process reverses the typical subdivision planning process by first, designating open space based on an environmental analysis, siting houses next, layout of roads and trails, and last, lot lines are drawn.



This commercial shopping plaza set aside an undisturbed buffer and integrated green infrastructure facilities to reduce impervious coverage and provide a natural vegetated corridor around the site.

Source: Rhode Island Low Impact Development Site Planning and Design Guidance Manual. Horsley Witten Group and RI DEP, March 2011.

REFERENCES AND RESOURCES

THE CONWAY SCHOOL. CITY OF HOLYOKE GREEN STREETS GUIDEBOOK.
MARCH, 2014.

Mass Audubon's Shaping the Future of Your Community Outreach and Assistance Program

<http://www.massaudubon.org/our-conservation-work/community-outreach/sustainable-planning-development/shaping-the-future-of-your-community-program/workshops/protecting-land-habitat>

Massachusetts Smart Growth/Smart Energy Toolkit

http://www.mass.gov/envir/smart_growth_toolkit/pages/how-to-SG.html

RHODE ISLAND LOW IMPACT DEVELOPMENT SITE PLANNING AND DESIGN
GUIDANCE MANUAL. HORSLEY WITTEN GROUP AND RI DEP, MARCH 2011.

www.dem.ri.gov/programs/bpoladm/suswshed/pdfs/lidplan.pdf

PIONEER VALLEY GREEN INFRASTRUCTURE PLAN, "TABLE 4.3 GREEN
INFRASTRUCTURE DESIGN RESOURCES". PIONEER VALLEY PLANNING
COMMISSION, FEBRUARY 2014.

www.pvpc.org/file/pvpc-green-infrastructure-plan-final-02-18-14pdf

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Subdivision Regulations

What it is

Subdivision regulations guide the private development of new roads. They control layout and construction, specifying municipal requirements for location, width, and grades of proposed ways. They also specify requirements for public utilities. As streets typically account for 50 to 75 percent of impervious cover in the developed environment, it is critical that these regulations encourage and even require best practices for stormwater management. These regulations should also be consistent with requirements within a municipality's stormwater management bylaw/ordinance.

Cost Savings in a Subdivision Project



Photo: Nashua Telegraph

In Pelham, New Hampshire, a subdivision that took a low impact approach to site development and used green infrastructure stormwater management practices **realized a 6% savings on the total cost of stormwater infrastructure**¹ The road shown here makes use of porous asphalt, allowing rainfall to soak into the surface and filter through underlying soils.

For more on porous asphalt, see related fact sheet.

Within subdivision regulations, best practices can be addressed in the early stages of the planning process itself, and within requirements for the following:

- » location and length of roadways
- » right of ways
- » paved roadway width
- » curbs
- » drainage
- » sidewalks
- » utilities
- » landscaping
- » cul de sacs

Planning process

Approval for a subdivision project typically begins with submission of a preliminary plan, which helps initiate a conversation about the project between the developer, planning board, and board of health. This early stage in the project provides communities with an opportunity to promote an integrated site design process and use of distributed stormwater management practices to best match the predevelopment hydrologic condition. This could include advancing provisions within stormwater management regulations and also within zoning regulations for: 1. Open Space Residential Development, which allows for a more compact development pattern to preserve open space and reduce the amount of paved surfaces through clustering of development to the least environmentally sensitive areas; or 2. where appropriate Traditional Neighborhood Development (TND), which involves the more traditional neighborhood pattern used prior to the automobile, and includes small lots and homes with porches oriented toward the street. TNDs typically have narrow roads and on-street parking coupled with reductions in required off-street parking.

For preliminary plan submission, municipalities could provide to developers a standard site analysis checklist to maximize design and functionality of best stormwater management practices. This could include many of the same steps within the conservation development process, beginning with a good site analysis to designate natural drainage areas, important conservation areas, and locating development areas. Applicants could bring the results of this analysis to a pre-application conference. As part of this analysis and reporting, the applicant could identify proposed best stormwater management practices. Soil testing for this site analysis could be for the site overall and not as rigorous as the more detailed soil work necessary to design a stormwater management facility.

It may be useful to include credits for improved stormwater management practices. The Massachusetts Department of Environmental Protection (DEP) stormwater standards as incorporated into the state's Wetlands Protection Act Regulations has established a "LID Site Design Credit" whereby in exchange for directing runoff from roads and driveways to vegetated open areas, preserving open space with a conservation restriction, or

directing rooftop runoff to landscaped or undisturbed areas, developers can reduce or eliminate the traditional BMPs used to treat and infiltrate stormwater.²

Location and length of roadways

Protecting important natural features and minimizing disturbance and amount of paved area is a first line approach to protecting hydrology on a previously undeveloped site. This can be achieved by identifying opportunities to reduce:

- » cut and fill, thereby minimizing disturbance of native soils
- » unnecessary contouring of the site, and
- » removal of native vegetation.

In addition, streets ought to be located in order to protect important natural features, avoiding low areas and steep slopes.

Developers should be encouraged to limit clearing within the right-of-way to the minimum necessary for constructing roadway, drainage, sidewalk, and utilities, and to maintaining site lines. During site development, permeability of soils for infiltration should be preserved. Where soils are compacted by construction vehicles, contractors should be required to reestablish permeability.

Alternative street layouts should be explored for options to increase the number of homes per unit length and minimize the length of the roadway. This might be achieved through clustering of the development or through Traditional Neighborhood Design as described above.

Right of ways

A right of way is the strip of land that contains all the elements of a roadway. At a minimum, this typically includes vehicle travel lanes, grading and drainage, and utilities. It also can include bike lanes, shoulders, on-street parking, curbs, sidewalks, and vegetated areas. Right of ways between 50 and 60 feet wide are standard, but this it has often led to overdesign with excessive clearing, grading and extensive use of the width for paving.

Good design has not so much to do with the width of the right of way itself, but considerations of context and what makes for efficient and effective use of the right of way. What makes sense for the elements of a right of way on a busy suburban road will likely not make sense for a low volume rural road.

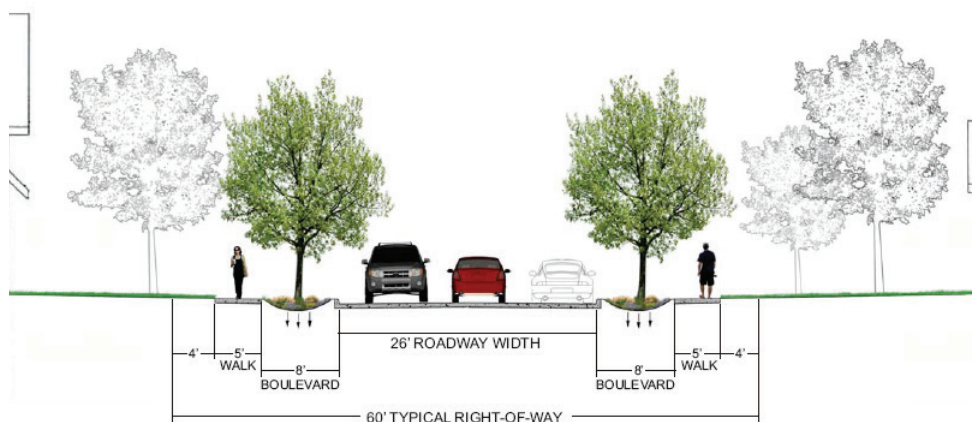
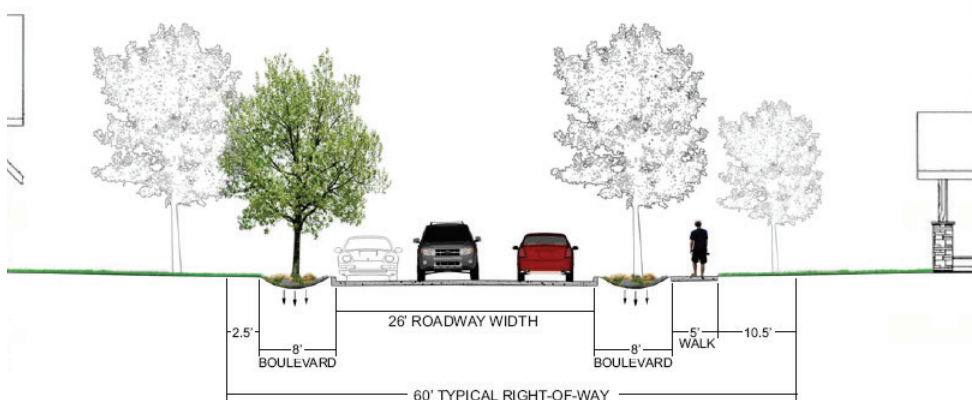
Several communities in Minnesota have developed “Living Streets” policies that take context into consideration. This policy brings together “complete streets” objectives of providing for multiple modes of transportation (vehicular, pedestrian, and bicycle) and “green streets” objectives of reducing environmental impacts (through reduced impervious surface and improved stormwater management). In thinking about how to accommodate these various objectives within the right of way, these communities have developed design options that can be deployed depending on what specific objectives there may be for a project. In Maplewood, Minnesota, there are three design options for

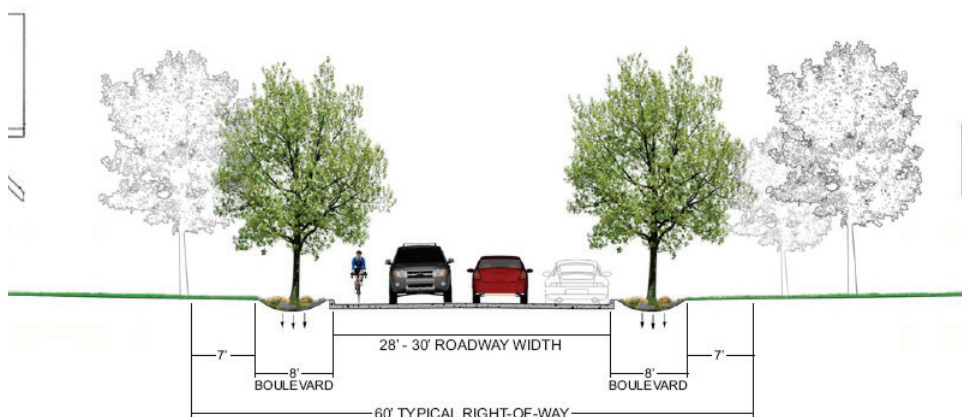
a local street with a 60-foot right of way (note that not all 60 feet in the right of way is used):

Guidelines from Edina, Minnesota's Living Street Policy are useful in thinking about right of way use:

- » Provide bicycle accommodation on all primary bike routes.
- » Allocate right-of-way for boulevards (stormwater infiltration facility)
- » Allocate right-of-way for parking only when necessary and not in conflict with Living Streets
- » principles
- » Consider streets as part of our natural ecosystem and incorporate landscaping, trees, rain
- » gardens and other features to improve air and water quality

Municipalities ought to consider the use of drawings that show how the elements of a right of way cross section might vary given different contexts. Such drawings provide a clear understanding about objectives and efficient and effective use of the right of way area.





28' to 30' roadway width with parking on one side; and 8-foot boulevard/stormwater infiltration facility on each side

Source: City of Maplewood, Minnesota, Living Streets Policy, Adopted January 28, 2013

Paved roadway width

Narrower road widths produce advantages not only in terms of reduced stormwater impacts, but also lower development costs, improved community character, and enhanced pedestrian safety. As a result, it is important for municipalities to revisit and update roadway width standards within subdivision regulations. Many existing standards are based on universal application of guidelines for highways or very large scale subdivisions planned more than 50 years ago. Revised standards should involve the minimum required pavement width and derive from careful considerations with public works and emergency response officials of traffic volume, on-street parking (where required), and passage of emergency vehicles and school buses. Typical road width reduction standards are shown on the following page.

Communities might also explore the use of permeable shoulders to reduce overall imperviousness of a roadway. This would involve combining a traditional asphalt surface for the travel lanes and an adjacent porous surface for the shoulder or bike lane area. Snow and ice management for the roadway must avoid sand so as to avoid clogging of the porous shoulder area. For more information, see a recent publication entitled, "Permeable Shoulders with Stone Reservoirs," referenced more fully in the Links to More Information Section below.

Emergency Vehicle Access

Emergency access considerations can have direct bearing on street width. Under the Massachusetts' fire marshal code, the minimum fire access lane width is 18 feet. Generally speaking, this can be met by two 9-foot travel lanes. The purpose of a fire access lane is to allow one fire truck to operate while allowing enough space for a second truck to pass by during the event of an emergency. Fire access lanes can be located on roads, but they must not be obstructed (i.e. by parked cars or snow).

While the state fire marshal code provides a minimum width, fire access lanes cannot be standardized across the state. Each community has different needs and fire apparatus that range in size. Communities may increase minimum fire access lane widths if required for their particular equipment. Alternatively, municipalities may select fire access equipment that allows for narrower lanes consistent with community design goals.

Table 5: General Parameters for Residential Road Design

Parameter	Single Use Residential Wide	Single Use Residential Medium	Single Use Residential Narrow	Single Use Residential Alley
Traveled Way				
Typical ADT	4,999 < 1,500	1,499 < 400	399 < 0	100 < 0
Design speed	25-30 mph	20 mph	20 mph	15 mph
Operating speed	20-25 mph	20 mph	15-20 mph	15-20 mph
Number of Through Lanes	2	2	2	1
Lane Width	10-12 feet	10-12 feet	10 feet	9-10 feet
Shoulder	2 feet	2 feet	2 feet	2 feet
Bike Lanes	Shared road Or 6 feet wide	Shared road	Shared road	Shared road
Utility Easement Width	----	----	10 feet	10 feet
Range of ROW Width	40-50 feet	36-40 feet	33-36 feet	20 feet
Roadside				
Desirable Roadside Width (pedestrian, swale, and planting strip)	5.5-12 feet	5.5-10 feet	5.5 feet	None
Grass Plot/Planting Strip	0-6 feet	0-6 feet	0-6 feet	None
Minimum Sidewalk Width	4 feet one side ok	4 feet/Shared road	Shared road	Shared road
Street Lighting	At intersections and pedestrian scale lighting at residential driveways.	At intersections and pedestrian scale lighting at residential driveways.	At intersections and pedestrian scale lighting at residential driveways.	At intersection with road
Intersections				
Traffic control	Stop signs, 4-way yield	4-way yield	4-way yield	Yield exiting alley
Curb Radii	15-25 feet	15-25 feet	15-20 feet	15 feet

Source: Sustainable Neighborhood Road Design: A Guidebook for Massachusetts Cities and Towns, May 2011, American Planning Association, Massachusetts Chapter and Home Builders Association of Massachusetts (page 27).

Cul de sacs

The required radius for a cul-de-sac also impacts the amount of impervious area. In the Pioneer Valley, minimum cul-de-sac radius requirements (at outer road edge) are typically set between 60 and 120 feet, and hammerhead turnarounds, which would greatly reduce impervious cover, are not typically allowed. Better stormwater management recommendations often call for cul-de-sacs to be designed with an outer road radius of 30 to 40 feet, as well as allowing for hammerhead turnarounds in lieu of cul-de-sacs.

Also in subdivision regulations, there are opportunities to reduce the required radius of a cul-de-sac (down to an outer road radius of 30 to 40 feet), and to allow hammerhead turnarounds. On dead-end streets, hammerhead turnarounds can provide a feasible way to reduce paved area while providing sufficient turnaround space for larger fire vehicles.

- » E. Cul de sac or dead end street -- Revise cul de sac requirements for granite curbing to allow bioretention area on landscaped island (soils permitting). This could entail curbing that is perforated to allow for the flow of runoff to the bioretention area;



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- » Minimize the required radii for cul-de-sacs - radius of 35 feet is optimal, depending on emergency vehicles;
- » Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.



Cul-de-sac infiltration island accepts stormwater from surrounding pavement. Note flat curb.



The cross section drawing to left shows how a cul de sac can be designed to serve as a bioretention area for stormwater runoff. The photo to the right shows a bioretention cul de sac in Waterford, Connecticut, that is designed to collect and filter roadway runoff from a residential development.

Curbs

Currently subdivision regulations typically call for the use of curb and gutter infrastructure connected to storm sewer infrastructure. This traditional approach produces stormwater flows that have greater impacts on local rivers and streams. As an alternative, regulations can promote roads without curbs where appropriate or the use of “perforated curbs.” Perforated curbs are curbs with gaps that allow stormwater to move from the street through to a stormwater management facility that could include swales or planters, such as tree box filters. (See image on the following page.)

Another alternative involves the use of “invisible curbs.” Invisible curbs are granite curbs that are buried along the street edge so as to allow stormwater to flow over into a stormwater management facility. Invisible curbs provide the structural support needed to plow from curb to curb, thereby retaining the desired roadway width even in snowy conditions. (See images on the following page.)



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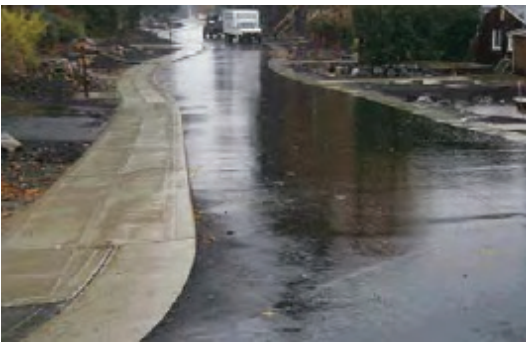
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Perforated Curbs

Perforated curbing allows stormwater to enter planters that are designed to soak up rainfall.



Invisible Curbs

"Invisible" curbs along the street edge allow runoff to move into bioretention swales.

Drainage

Standards for drainage within the subdivision regulations should encourage and even require better site design with a low impact development approach that includes:

- » conservation of open space, natural drainage systems, native vegetation and other resources on site;
- » minimizing and disconnecting impervious surfaces;
- » clustering, and eliminating impervious surfaces that are connected to the municipal stormwater system; effective BMP selection and placement

This section should also refer to and be consistent with the stormwater management bylaw/ordinance. It should identify which size projects require a stormwater management permit, and what are the design parameters for drainage (i.e., water quality volume treatment, which targets pollutant transport; channel protection volume, which targets erosion; and overbank and extreme flood protection). For communities that have adopted for upland areas the *Massachusetts Stormwater Handbook*, the design parameters with Standard 2 address downstream and off-site flooding. It requires that the post-development peak discharge rate is equal to or less than the pre-development rate from the 2-year and the 10 year 24 hours storms. The Model LID Bylaw prepared

by the Massachusetts Executive Office of Energy and Environmental Affairs suggests performance standards that go further, including treatment of discharges and protection for channels, overbank flooding, and extreme flooding.

The drainage section should also address requirements for bridge openings and major culverts. There are now important habitat preservation and climate change adaption considerations that ought to be considered in the design of these facilities. *The Massachusetts River and Stream Crossing Standards* should be referenced as an important resource for design of these facilities.

Sidewalks

In addition to roadways, sidewalks provide another important opportunity to reduce impervious area or provide better management of stormwater runoff. Regulations can promote a variety of strategies for achieving this, including:

Use of porous surfacing material for sidewalks and bus waiting areas. A recent publication on complete streets by the City of Boston that promotes the use of porous materials in certain sidewalk zones describes the advantages of this choice in paving:

Permeable pavements provide increased traction when wet because water does not pool, and the need for salt, sand, and plowing is reduced during winter due to low/no black ice development. Compared to traditional paving methods, long-term maintenance costs may be lower in cold climates since permeable pavements resist cracking and buckling in freeze-thaw conditions. Nevertheless, permeable paving requires regular maintenance including: annual inspection of paver blocks for deterioration; periodic replacement of sand, gravel and vegetation; and annual industrial vacuuming of pavements to unclog sand and debris (Note: The use of sand in ice prevention should be avoided because it will clog pavement pores.)³

Flexibility in sidewalk standards to accommodate best management practices. This might include allowing alternatives to the minimum sidewalk standards or alternatives to sidewalk layout where pedestrian circulation makes use of common areas rather than street rights of way.

Grading of impervious sidewalk surfaces to direct stormwater runoff to bioretention areas or other such facility to eliminate or keep flow out of the municipal storm drain system

Utilities

Rather than require all electric, telephone, cable TV, fiber optic, and other conduits to be installed away from the road and its edge, allow placement of utilities under the paved section of the right of way. This creates essential space along the roadway edge for stormwater management facilities.

Often there is concern that such placement of utilities under the road will result in traffic delays and additional costs to utility companies. In the *Rhode Island LID Site Planning and Design Guidance for Communities*, however, authors from the Horsley Witten Group

note that the reality is, “The amount of pavement needed to be removed during such operations can be decreased through better diagnostic tests and trenchless technologies for utility construction and repair.”

If the idea of putting utilities under the road edge is too great a concern for Departments of Public Works, then the next best strategy is to place utilities directly abutting roadway pavement, within 1 to 2 feet.

Landscaping and trees

Trees, shrubs, and ground covers are essential to good stormwater management. Leaves, needles, branches, and bark intercept rainfall so that it can then evaporate to the atmosphere. Leaf litter and mulch on the ground creates a spongy surface for retention of stormwater. Rainfall that reaches the roots is taken up into plants and then transpired to the atmosphere. Roots also help to stabilize soils and prevent erosion.

Subdivision regulations can recognize these important benefits through the following:

- » Encourage both preservation of existing stands of trees and mature trees on site as well as plans that incorporate trees into stormwater management practices. This can be done through specific requirements and through a system of credits. Calculating stormwater benefits of certain species based on size can be done through the National Tree Benefit Calculator at: www.treebenefits.com/calculator/
- » Allow for bioretention areas or other vegetated stormwater facilities within treebelt areas and to count toward other required landscaping features, including site, parking or perimeter screening. This creates areas that function on several levels, including aesthetics and stormwater management.

LINKS TO MORE INFORMATION

AHBL FOR PUGET SOUND PARTNERSHIP. NOVEMBER 2011. INTEGRATING LID INTO LOCAL CODES: A GUIDEBOOK FOR LOCAL GOVERNMENTS. SEE:

http://www.psp.wa.gov/LID_GLG.php

AMERICAN PLANNING ASSOCIATION, MASSACHUSETTS CHAPTER, AND HOME BUILDERS ASSOCIATION OF MASSACHUSETTS. MAY 2011. "SUSTAINABLE NEIGHBORHOOD DESIGN: A GUIDEBOOK FOR MASSACHUSETTS CITIES AND TOWNS." SEE:

www.apa-ma.org/apa-ma_documents/.../NRB_Guidebook_2011.pdf

CENTER FOR WATERSHED PROTECTION AND USDA FOREST SERVICE. "USING TREES TO REDUCE STORMWATER RUNOFF." FOR THIS POWERPOINT PRESENTATION, SEE:

<http://www.slideshare.net/watershedprotection/using-trees-to-reduce-stormwater-runoff-formatted-presentation?type=powerpoint>

ALSO SEE WEB PAGE RELATED TO THIS COLLABORATION:

<http://www.forestsforwatersheds.org/reduce-stormwater/>

LAWRENCE, TIMOTHY AND MYERS, MONIQUE. 2009. "EMERGENCY SERVICES AND STORM WATER MANAGEMENT." CALIFORNIA SEA GRANT PROGRAM. SEE:

www-csge.ucsd.edu/BOOKSTORE/Resources/LID_FACTSHEET.pdf

RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND COASTAL RESOURCES MANAGEMENT COUNCIL. MARCH 2011. "RHODE ISLAND LOW IMPACT DEVELOPMENT SITE PLANNING AND DESIGN GUIDANCE MANUAL." SEE:

www.dem.ri.gov/programs/bpoladm/suswshed/pdfs/lidplan.pdf

1 In his presentation, "Right Practice, Right Place: Green Infrastructure Technologies that Work in New England" at EPA's Growing Your Green Infrastructure Program, December 2012, Robert Roseen noted that in addition to reducing the number of acres to be cleared, the developer was able to avoid the use of 1,616 feet of curbing, 785 feet of pipe, 8 catch basins, 2 detention basins, and 2 outlet control structures.

2 Information on the LID Site Design Credit is found in Volume 3 of the Massachusetts Stormwater Handbook.

3 For more information, see the document from which this quote is drawn:
http://www.bostoncompletestreets.org/pdf/2/chap2_5_sidewalk_materials.pdf

FOR MORE INFORMATION, PLEASE CONTACT

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Paying for Green Infrastructure

WHAT IT IS

Paying for green infrastructure projects can happen in a variety of ways. Green infrastructure facilities can be integrated into projects where stormwater management is already a component. This often presents important savings in avoided costs. Green infrastructure can also be paid for through a variety of mechanisms, including: stormwater utilities, fees tied to permitting, connection fees, establishment of betterments and management districts, bonds and loans, and sponsorships. While stormwater utilities are covered in a separate fact sheet within this series, the other financing mechanisms are described in more detail below.

AN INTEGRATED APPROACH

Wherever there are considerations of stormwater management, as there are in most public development or redevelopment projects, there is a role for green infrastructure. Funding for green infrastructure work can come from a variety of sources already used to cover the costs of such projects, including roads, combined sewers, railways, sidewalks, and schools. See diagram below.



Opportunities for Integrating Green Infrastructure with Other Projects

Recognizing the full value of green infrastructure can be an important impetus for integration of such facilities in existing projects. These are often referred to as secondary benefits. These are not typically part of stormwater projects that rely solely on traditional “gray”/underground infrastructure. Secondary benefits include: social, such as avoided flooding and healthier neighborhoods; economic, such as job creation and increased property values; and environmental such as cleaner waters and improved air quality. This more comprehensive accounting method is known as the “Triple Bottom Line” of green infrastructure used most notably by Philadelphia in their planning for green infrastructure. (For more information on the Triple Bottom Line approach, see Philadelphia’s Long Term Control Plan Update (2009).) By integrating green infrastructure across the range of municipal projects while also accounting for all of the benefits to be derived, proponents can think more broadly and call on a far wider range of sources for project funding. (See Pioneer Valley Green Infrastructure Plan, page 82-84 for matrix showing Potential Sources for Enhanced Project Funding at: <http://www.pvpc.org/plans/pioneer-valley-green-infrastructure-plan> .

The City of Lancaster, Pennsylvania, accounted for these benefits in terms of “avoided costs or savings.” With a goal of reducing annual average stormwater runoff by 1.053 billion gallons within the next 25 years, the city developed a study—drawing from their green infrastructure plan and a national valuation guide. The study involved placing a value on practices, such as bioretention and other infiltration practices by monetizing the benefits of services, such as: improved water quality, increased groundwater recharge, reduced flooding, reduced energy use, and reduced atmospheric CO₂. The result is projections showing significant annual avoided costs/savings at the end of the 25-year implementation period. See table below.

Projected annual avoided costs/savings in Lancaster, PA, case study (benefits accrued at end of 25-year implementation period)	
\$122.4 billion per year	Water - Avoided costs for wastewater treatment and the use of traditional “gray infrastructure” through green roofs, tree planting, permeable pavement, bioretention and infiltration practices, and water harvesting
\$2,368,000	Energy - Reduced electricity and natural gas usage due to green roofs, tree planting, water harvesting, providing insulation shading, wind blocking, and evaporation

\$1,023,000	Air quality - Reduced emissions of nitrogen dioxide, ozone, sulfur dioxide, and particulate matter due to uptake and absorption, reduced energy emissions, reduced ozone with trees, green roofs, permeable pavement, and bioretention and infiltration practices
\$786,000	Climate change-related benefits in reduced CO2 through direct carbon sequestration, reduced water and wastewater treatment, reduced energy production due to vegetation and permeability.

Source: Webinar presented by Hal Sprague of Center for Neighborhood Technology, Valuing Green Infrastructure: Economic, Environmental, and Social Benefits, September 26, 2013, for the Vermont Agency of Natural Resources.

Portland Takes Direct Approach

A national leader in green infrastructure, the City of Portland, Oregon, took a direct approach to integrating green infrastructure into projects as a way to abate stormwater flows into the combined sewer system. One strategy entailed adopting a green streets policy whereby all City of Portland funded development, redevelopment or enhancement projects meeting the threshold in their stormwater management manual (of developing or redeveloping 500 square feet of impervious surface) must incorporate green street facilities.¹ This policy led to what EPA has described as, "...a formal process to overlay multi-bureau project plans and scheduled capital improvement projects to identify how public and private projects can achieve multiple community and environmental benefits through green infrastructure."² To cover the costs of green streets projects, Portland supplemented funds from general budget and capital improvement funds with innovation grants from EPA, revenue from a stormwater utility fee and from a one percent tax on construction projects that cannot meet the City's stormwater management regulations. What they learned, as did other case study communities examined by EPA, is that the increased investment necessary to include green infrastructure in large undertakings is typically a very small percentage of the total project costs. In addition, the use of green infrastructure elements can also decrease overall project costs, particularly with reductions in use of concrete or asphalt. Portland's story underscores how integrating or overlapping green infrastructure with street development, redevelopment, or enhancement can yield tremendous value. For Pioneer Valley cities and towns where might there be other possibilities of overlap that may be worth exploring?



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STORMWATER PERMIT FEES

Stormwater permit fees address potential stormwater impacts related to new construction. The fees are typically site specific and can be an unreliable source of funding when development slows.

Currently, three communities in the region assess stormwater permit fees to review and permit new development projects (Agawam, Northampton, and Wilbraham). While there is no direct connection between these permit fees and funds to maintain the stormwater system, stormwater permit fees are paid into general funds, and most communities pay for stormwater system maintenance from the general funds. In a sense, then, some part of these permit fees may help to cover some stormwater system maintenance costs.

CONNECTION FEES

Northampton is one community that currently charges a fee for a property's initial connection to the stormwater system. Connection fees for stormwater might be augmented based on a practice in Westfield relative to wastewater. The City of Westfield established a connection fee associated with new sewer hook ups aimed at helping to increase capacity at the wastewater treatment plant (where the City was reaching capacity). For every new gallon of sewage to be generated, the customer pays a fee equivalent to the cost of fixing 5 gallons worth of infiltration and inflow. It may be worth exploring whether this same strategy could be applied to stormwater whereby new connections to the system help to mitigate other flows into the system, thereby preserving capacity and avoiding the need for costly expansion projects.

BETTERMENTS AND MANAGEMENT DISTRICTS

MGL Chapter 80 allows for the assessment of cost of public improvements by municipalities. Whenever a certain location or district receives exclusive benefit or advantage from a public improvement, betterments can be assessed in that area for the improvement. This could be the case where several neighborhoods in a town require improved stormwater infrastructure. The cost of improvements can be offset by charges to those properties located within that jurisdiction.

To implement the Long Creek Watershed Management Plan in Maine (the result of a citizen's lawsuit over impaired waters), landowners in four municipalities joined forces to create the Long Creek Watershed Management Plan District. The District collects fees from property owners and uses the money to restore Long Creek and install stormwater retrofits. The fee is \$3,000 per acre of impervious surface per year.

BONDS AND LOANS

Bonds are useful to initiate large capital projects, but they involve borrowing money and accruing debt. MassDEP's Clean Water State Revolving Loan Fund (SRF) has been an important source for low interest loans for many water infrastructure projects in the Pioneer Valley.

A 2014 letter from MassDEP Division Municipal Services Director Steve McCurdy, notes that MassDEP will receive a \$47.6 million federal grant to subsidize the CWSRF program and that at least 10 % of these monies must be dedicated in 2014 to Green Infrastructure projects or components as defined by EPA. The 2014 Intended Use Plan lists 12 new Green Infrastructure construction projects in Massachusetts and 3 additional Green Infrastructure construction projects are on the 2014 Carry-Over list. "The exact monetary value of the Green components of these projects will be determined when project applications are submitted, but are expected to be well in excess of the \$4.76 million requirement," he concludes.

In addition, the SRF program has offered principal forgiveness for Environmental Justice projects, those projects occurring in areas defined to be a neighborhood with annual median household income (MHI) less than 65 percent of the state MHI.

SPONSORSHIPS

Several communities have been able to tap into local businesses to provide donations and sponsorships for green infrastructure projects.

In Portland, Maine, businesses helped to cover \$20,000 of the \$64,000 cost for a demonstration rain garden along the tidal Back Cove. The garden covers 2.5 acres of land adjacent to a popular recreational trail that is heavily used by walkers, joggers, and cyclists. The project's popularity led to the installation of a second rain garden adjacent to the trail's parking area, which was designed and funded by Stantec, a national engineering firm with local offices. Signage at the rain gardens highlights corporate sponsors.⁸ This idea builds on the successful Adopt a Trail corporate sponsorship program run by Portland's local land trust.

In Lynchburg, Virginia, a new corporate sponsorship program is drawing funding for the installation of demonstration rain gardens in prominent public places throughout the City. Each garden is sponsored by a local business, which is then credited with an attractive sign onsite. To date, this program has raised over \$1.6 million and established 50 gardens.

Virginia also has a related statewide program called Streetscape Appearance Green Enhancement (SAGE), a comprehensive roadside management program that has been in existence since 2006. Funded entirely by donations, but managed by municipalities, the program aims to beautify local streetscapes, boost civic and community pride, and facilitate future economic development. Municipalities manage the donations through a 501(c)3 non-profit and contributions are organized so as to cover construction, maintenance, and renewal, typically after 5 years.

OTHER POTENTIAL AND FUTURE SOURCES

Hazard Mitigation Funding

Though green infrastructure implemented area wide could help to mitigate natural hazards and build community resiliency, grant programs out of the Massachusetts and Federal Emergency Management Agencies do not as of yet provide opportunities for funding of green infrastructure stormwater management projects. The Massachusetts Emergency Management Grant Program's State Hazard Mitigation Officer Richard Zingarelli notes:

Standard hazard mitigation projects require a benefit-cost analysis that shows that the cost of the project is exceeded by the benefit as measured by direct reduction of damages from natural hazards. The difficulty is that it is difficult, if not impossible, to quantify a direct reduction in damage that results from measures like green roofs and porous pavement. As a result, any limited eligibility for funding in these programs would fall under the "5% Initiative" of the Hazard Mitigation Grant Program (HMGP), which allows for setting aside up to 5% of the total available HMGP funding for activities that are difficult to evaluate using traditional cost-effectiveness criteria.

It is important to know that the use of the word "mitigation" in emergency preparedness means avoidance and preparation (resiliency) and is more closely linked to the concept of "adaptation" in climate change.

WATER QUALITY CREDITS TRADING

Water quality trading is a market-based approach—an idea that has emerged from the energy market—that enables jurisdictions to achieve needed pollution controls through the purchase of credits for a particular pollutant. Landowners can produce water quality credits by implementing green infrastructure practices that reduce volume and pollutants, and typically at a much lower cost than a municipal treatment facility. EPA notes, "Through water quality trading, facilities that face higher pollutant control costs to meet their regulatory obligations can purchase pollutant reduction credits from other sources that can generate these reductions at lower cost, thus achieving the same or better overall water quality improvement. In most cases, trading takes place on a watershed level under a pollutant cap (the total pollutant load that can be assimilated by a waterbody without exceeding water quality standards) developed through the TMDL

process or a similar type of water quality analysis that produces information on pollutant loadings and resulting water quality conditions.”

For the Long Island Sound TMDL, the state of Connecticut adopted trading legislation. Public Act No. 01-180, which establishes the trading framework for a Long Island Sound Nitrogen Credit Exchange Program to be directed by a Nitrogen Credit Advisory Board appointed by the General Assembly and the governor. EPA notes, “The Nitrogen Credit Exchange Program establishes a well-defined trading structure supported and regulated by limits mandated in state law. The state legislation specifies trading ratios (e.g., delivery and location ratios) and accounting methodologies to formalize all calculations used in trading.”

LINKS TO MORE INFORMATION

ENVIRONMENTAL FINANCE CENTER UNIVERSITY OF MARYLAND. 2014. LOCAL GOVERNMENT STORMWATER FINANCING MANUAL: A PROCESS FOR PROGRAM REFORM. SEE:

[http://efc.umd.edu/assets/efc_stormwater_financing_manual_final_\(1\).pdf](http://efc.umd.edu/assets/efc_stormwater_financing_manual_final_(1).pdf)

NATURAL RESOURCES DEFENSE COUNCIL. FEBRUARY 2012. FINANCING STORMWATER RETROFITS IN PHILADELPHIA AND BEYOND. SEE:

<http://www.nrdc.org/water/files/stormwaterfinancing-report.pdf>

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. 2013. COMMUNITY BASED PUBLIC PRIVATE PARTNERSHIPS FOR GREEN INFRASTRUCTURE-DRIVEN STORMWATER RETROFITS: A WEBINAR.

ENVIRONMENTAL FINANCE CENTER, UNIVERSITY OF NORTH CAROLINA. 2014. A CATALOG OF FINANCE PUBLICATIONS ON GREEN INFRASTRUCTURE APPROACHES TO STORMWATER MANAGEMENT. SEE:

<http://www.efc.sog.unc.edu/reslib/item/catalog-green-infrastructure-and-stormwater-finance-publications>

USEPA. 2009. FUNDING STORMWATER PROGRAMS FACTSHEET. SEE:

www.epa.gov/region1/npdes/stormwater/assets/pdfs/FundingStormwater.pdf

CHARLES RIVER WATERSHED ASSOCIATION FOR MA COASTAL ZONE MANAGEMENT. 2007. ASSESSMENT OF STORMWATER FINANCING MECHANISMS IN NEW ENGLAND. SEE:

www.crwa.org/projects/stormwater/Municipal%20SFM%20Case%20Studies%20Repo.pdf

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Stormwater Utilities

WHAT IT IS

For many cities and towns there are significant costs associated with operating, maintaining, and upgrading stormwater infrastructure. The municipal system for capturing and conveying stormwater from rooftops, driveways, and roadways can include the hundreds of catchbasins along street edges and miles of underground pipes.

Establishing a stormwater utility is one important strategy to creating a reliable funding source for this work. Currently there are between 1,500 and 2,000 stormwater utilities in the United States, 5 of which are located in Massachusetts (Fall River, Newton, Northampton, Reading, and Westfield).

Most municipalities in the Pioneer Valley rely on allocations from the general fund to service stormwater infrastructure. These allocations, however, are not keeping pace with actual needs for upgrading aging systems, reducing localized problems—such as flooding and erosion—and meeting regulatory requirements for environmental protection.

A stormwater utility operates much like an electric or drinking water utility. Fees collected from property owners go into a dedicated fund to pay specifically for the work of operating, maintaining, and improving stormwater infrastructure. This reinforces the idea that like other utilities, stormwater management is a public service. Monies can be used to pay for operation and maintenance expenses, project or capital-related expenditures, staffing, engineering, permitting, inspection, and program management costs.

In 1998, the City of Chicopee was the first municipality in Massachusetts to collect a fee for maintenance and upgrade of stormwater infrastructure, but the program is technically not a “stormwater utility” as funds go into a water pollution control account that also receives funding for projects that include the sanitary sewer system. So the program is referred to simply as a “stormwater fee.”

HOW IT WORKS

Since impervious surfaces (roofs, driveways, and roadways) are what produce the runoff from rainfall and snowmelt that must be managed, stormwater utility rates are most commonly based on the amount of impervious surface on a property. For residential customers, many municipalities set rates according to a method called Equivalent Residential Unit (ERU). This unit is derived from the impervious area footprint of a typical single-family home. The City of Newton, Massachusetts, for example, currently has an ERU of 3,119 square feet. Each residential property is thus billed \$25 per year based on this average of 1 ERU. Non residential

properties, including industrial and commercial properties are billed based on 6 ERUs or \$150 per year. The City has been exploring a different rate structure for residences of more than three households and commercial and industrial properties since the current flat rate of 6 ERUs has properties with small impervious areas (small downtown shops, etc.) paying the same as properties with large impervious areas (shopping malls). The new rate would assign a certain number of ERUs to a commercial and industrial property based on actual impervious area. Rates for larger properties in some municipalities are sometimes not based on ERUs, but rather a dollar per unit cost based directly on the area of impervious surface on a property.

A guidance document prepared by the National Association of Flood and Stormwater Management Agencies notes, “The fundamental objective of a stormwater utility/service fee is attainment of equity. Service fee rate methodologies are designed to attain a fair and reasonable apportionment of cost of providing services and facilities.”

Enabling Legislation

In Massachusetts there are two companion pieces of legislation that allow municipalities to set up stormwater utilities: MGL Chapter 83 Section 16 and MGL Chapter 40 Section 1A. The first, MGL Chapter 83 Section 16, is relatively new enabling legislation that allows municipalities to set up a stormwater management utility and charge utility fees for managing stormwater. The second, MGL Chapter 40 Section 1A, provides a definition of a district for the purpose of water pollution abatement, water, sewer, and/or other purposes. Together, these two pieces of legislation allow a municipality to set up an authority to manage stormwater and to charge utility fees for managing stormwater.

WHERE THEY ARE USED CURRENTLY IN MASSACHUSETTS

Two of Massachusetts' five stormwater utilities are located in the Pioneer Valley. (See table below.) The cities of Northampton and Westfield are currently the only municipalities in the region with programs that collect fees specifically dedicated to maintenance and upgrade of stormwater infrastructure. Westfield instituted a stormwater utility in 2010 for the purpose of financing a stormwater management division, responsible for meeting federal requirements for stormwater monitoring and maintaining the City collection system. Northampton adopted a stormwater utility in 2014 to generate funding for meeting federal permit requirements and attending to aged stormwater and flood control infrastructure.

There are roughly 6,600 smaller residential properties (1-3 family) in Northampton. Under the billing formula these properties are divided into four groups based on the impervious surface area on each property. All properties within each group pay the same fee. This standard fee is calculated based on the average impervious and pervious areas for all properties within each group. Based on the annual budget of \$1,980,056, the annual residential fees are estimated to be:

Stormwater Utilities/Fees in Massachusetts

Community	Date Created	Equivalent Residential Unit (ERU)*	Fee	Annual Revenue
Chicopee	1998	2,000 s.f.	Single family residential at \$100 per year Multi family, industrial, commercial properties at \$1.80 per 1,000 square feet, with a minimum charge of \$100 per year and a maximum charge of \$640 per year	\$1,500,000 (2012)

Fall River	2008	2,800 s.f.	Residential: 1 to 8-family at \$140 per year Commercial, industrial and residential properties greater than 8 family at \$140 per year for 2,800 square feet of impervious surface	\$4,660,000 (2012)
Newton	2006	3,119 s.f. Proposed change: 2,600 s.f.	Residential at \$25 per year, with those receiving elderly discount, \$17.52 per year Non residential at \$150 per year (Proposed change involves replacing the flat fee with a fee based on area of imperviousness. This would include residences with 3 or more units.)	\$725,000 (2012)
Northampton	2014		1 to 3 family homes annual residential fee estimated to be: \$63.94 for impervious area <2,250 sq. ft. \$91.05 for impervious area 2,250 to 3,056 sq. ft. \$125.61 for impervious area 3,056 to 4,276 sq. ft. \$259.07 for impervious area >4,276 sq. ft.	\$2,000,000 (estimated)
Reading	2006	2,552 s.f.	Single and two-family residences at \$40 per year Multi-family, commercial, and industrial properties at \$40 per 3,210 square feet annually	\$357,000 (2012)

Westfield	2010	NA	Residential at \$20 per year Commercial properties at \$.045 per 1,000 square feet up to a maximum of \$600 per year	\$560,000 (2012)
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*Residential customers are typically billed for stormwater runoff based on the Equivalent Residential Unit (ERU). An ERU is based on the amount of impervious surface area or percent impervious area found at the typical single-family home within the municipality.

DISCOUNTS AND CREDITS

Local governments with stormwater utilities can encourage better practices on private property by reducing fees in exchange for facilities that reduce the need for service by the municipal stormwater system. Discounts and credits can be geared to promote impervious surface reductions, onsite management or volume reduction, or the use of specific practices, such as raingardens/bioretention facilities, drywells, cisterns, or green roofs.

The City of Chicopee has just begun to implement a “Rain Smart Rewards” ordinance that offers a stormwater fee reduction of up to 50 percent in exchange for implementation of improved stormwater management practices by property owners.

In Minneapolis, Minnesota, 50 percent of the stormwater fee can be waived if the property owner can demonstrate that the runoff from a 10-year, 24-hour storm event can be managed on site. If a property owner can demonstrate that the runoff from a 100-year, 24-hour storm event can be managed on site, the entire stormwater fee is waived.

Portland, Oregon’s Clean River Rewards program provides stormwater utility fee discounts to encourage residential and commercial property owners to manage stormwater on site (35 percent discounts) and/or on the public right of way that serves their property (65 percent discounts). Partial credits are also given for ecoroofs, four or more trees over 15 feet tall, and for properties with less than 1,000 square feet of imperviousness. There is a Residential Discount Calculator and a Commercial Discount Calculator on the program’s website so that property owners can calculate what changes they might make to obtain certain savings.

Starting July 1, 2014, credits in Northampton will be available for small residential stormwater improvements (rain gardens and porous driveways), construction and maintenance of larger stormwater best management practices, protected open land, commonly owned undeveloped properties and educational programs. Senior (needs-based), low income, and protected land credits are automatically applied based on documentation by the Northampton Assessor’s Office. All other credits will require submission of an application and other documentation.

BENEFITS

Establishing a stormwater utility is no easy task. It requires tremendous effort in terms of education and politics. The process, however, helps everyone to understand the service provided by the municipal stormwater system and the significant costs of operating, maintaining, and improving this infrastructure. In the end, the utility provides a dedicated and stable source of funding to maintain and upgrade an aging system, reduce localized problems—such as flooding and erosion, and meet regulatory requirements for environmental protection.

A stormwater utility has other benefits as well:

- » **Creates an equitable way to pay for stormwater services, especially if the fee structure is based on the amount of impervious surface. Discounts or offsets can be provided to low-income residents or elderly, further ensuring the fee's equitability.**
- » **Tax-exempt properties like universities, hospitals, and places of worship are required to pay the fee, so that they help cover the cost of services they receive**
- » **Typically easier for the municipality to institute than other forms of funding. “In many communities, new taxes require a vote of approval by the public, while a fee is a charge that municipalities have the authority to leverage for the services they provide.”⁶**
- » **May enable municipalities to consolidate or coordinate responsibilities previously dispersed among several departments and develop programs that are comprehensive, cohesive, and consistent year to year**
- » **Creates funding that can be leveraged to meet grant and bond requirements**
- » **If a credit or reduction is offered, the fee can become an incentive for improved stormwater management on private property thereby reducing the service demand on the municipal system**

IMPORTANT CONSIDERATIONS

To achieve desired objectives, several considerations should be taken into account when proposing and establishing a stormwater utility:

Start with a thoughtful outreach campaign that generates enthusiasm for the community's stormwater vision. If property owners understand the benefits they will receive, they are more likely to support the fee. As part of this, it is important to work in advance with religious institutions, private schools, hospitals, and non profits to be clear that the utility is like other utilities that they must pay. And education should be ongoing.

As part of setting rates and calculating bills, develop a sound methodology with rigorous quality assurance. GIS mapping should be integral to this method if area of impervious cover is a factor in setting rates.

Set rates so that the fee provides adequate revenue to achieve stormwater goals. If the fee is unreasonably high, it will not be supported. If it is too low, promised benefits will not materialize and public support is likely to erode.

Give some advance thought to determining how stormwater utility fees can be collected. Typically, they have been collected either on a separate bill, added to a water collection bill, or added to the property tax bill.

Be sure that the greatest costs are directed toward those who create the most runoff, particularly commercial and industrial facilities with large areas of impervious cover, rather than residential and other properties with low impervious cover.⁷ At the same time, municipalities should be sensitive to where residents may already be paying stormwater management fees through homeowner associations.

Ensure that fees do not harm low-income residents, as in Detroit, where an increase in stormwater fees caused some low-income residents to be unable to pay their water bill and have their water turned off. Sliding fee scales, bill discounts, crisis vouchers, and zero interest loans for qualified customers are options for offsetting the burden on lower income residents.

LINKS TO MORE INFORMATION

METROPOLITAN AREA PLANNING COUNCIL. 2013. STORMWATER UTILITY FUNDING STARTER KIT. SEE:

<http://www.mapc.org/stormwater-utility-funding-starter-kit>

(Note: A well done update of PVPC's 1998 kit called, "How to Create a Stormwater Utility.")

ROSS STRATEGIC AND INDUSTRIAL ECONOMICS, INC. FOR US EPA, REGION 1. 2013. EVALUATION OF THE ROLE OF PUBLIC OUTREACH AND STAKEHOLDER ENGAGEMENT IN STORMWATER FUNDING DECISIONS IN NEW ENGLAND: LESSONS FROM COMMUNITIES. SEE:

<http://www.epa.gov/evaluate/pdf/water/eval-sw-funding-new-england.pdf>

WESTERN KENTUCKY UNIVERSITY. 2012. STORMWATER UTILITY SURVEY. SEE:

<http://www.wku.edu/engineering/civil/fpm/swsurvey/>

ENVIRONMENTAL FINANCE CENTER, UNIVERSITY OF NORTH CAROLINA. 2012. STORMWATER UTILITY DASHBOARD. SEE:

http://efc.unc.edu/tools/NCStormwaterDashboard_2012.html

DELANY, JOE, K. HONETSCHLAGER, AND T. MCINTIRE. 2009. STRUCTURING A STORMWATER UTILITY. TOWN OF READING, MA. SEE:

<http://www.salemsound.org/PDF/ReadingStormwaterUtility.pdf>

USEPA. 2009. FUNDING STORMWATER PROGRAMS FACTSHEET. SEE:

www.epa.gov/region1/npdes/stormwater/assets/pdfs/FundingStormwater.pdf

CHARLES RIVER WATERSHED ASSOCIATION FOR MA COASTAL ZONE MANAGEMENT. 2007. ASSESSMENT OF STORMWATER FINANCING MECHANISMS IN NEW ENGLAND. SEE:

www.crwa.org/projects/stormwater/Municipal%20SFM%20Case%20Studies%20Repo.pdf

NEW ENGLAND ENVIRONMENTAL FINANCE CENTER. 2005. STORMWATER UTILITY FEES: CONSIDERATIONS AND OPTIONS. SEE:

<http://efc.muskie.usm.maine.edu/docs/StormwaterUtilityFeeReport.pdf>

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PIONEER VALLEY
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Green Roof Model Incentives

The following green roof model incentives are excerpted from municipal bylaws, regulations and policies from around the United States, and offer example language for customizing incentives to meet the needs of your municipality.

FLOOR AREA RATIO BONUS

City of Portland Zoning Code Title 33, Chapter 33.510 Central City Plan District

Rooftop Gardens Option In CX, EX, and RX zones outside of the South Waterfront Subdistrict, developments with rooftop gardens receive bonus floor area. For each square foot of rooftop garden area, a bonus of one square foot of additional floor area is earned. To qualify for this bonus option, rooftop gardens must meet all of the following requirements.

- a. The rooftop garden must cover at least 50 percent of the roof area of the building and at least 30 percent of the garden area must contain plants.
- b. The property owner must execute a covenant with the City ensuring continuation and maintenance of the rooftop garden by the property owner. The covenant must comply with the requirements of 33.700.060.

GREEN ROOF POLICY

City of Portland, Green Building Policy

NOW THEREFORE, BE IT RESOLVED that the Portland City Council amends the City of Portland's Green Building Policy to direct all City Bureaus and the Portland Development Commission to:

- » Require design and construction of all new City-owned facilities to include an ecoroof with at least 70% coverage AND high reflectance, Energy Star-rated roof material on any remaining non-ecoroof roof surface area; OR, Energy Star-rated roof material when an integrated ecoroof/Energy Star-rated roof is impractical;

GREEN ROOF BYLAW

Toronto, Canada Green Roof Bylaw

<http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=83520621f3161410VgnVCM10000071d60f89RCRD&vgnnextchannel=3a7a036318061410VgnVCM10000071d60f89RCRD>

Toronto Municipal Code Chapter 492, Green Roofs

The Bylaw applies to new building permit applications for residential, commercial and institutional development made after January 31, 2010 and will apply to new industrial development as of April 30, 2012. The full bylaw is available at the web link above.

§ 492-2. Green roofs required.

A. Every building or building addition constructed after January 30, 2010, with a gross floor area of 2,000 square meters or greater shall include a green roof with a coverage of available roof space in accordance with the following chart:

Gross Floor Area (Size of Building)	Coverage of Available Roof Space (Size of Green Roof)
2,000 — 4,999 m ²	20%
5,000 — 9,999 m ²	30%
10,000 — 14,999 m ²	40%
15,000 — 19,999 m ²	50%
20,000 m ² or greater	60%

GREEN PERMIT PROCESS

City of Chicago Green Permit Process

http://www.cityofchicago.org/city/en/depts/bldgs/supp_info/overview_of_the_greenpermitprogram.html

Projects meeting the following criteria are eligible for the Green Permit Process:

- » Permit applications that include green technologies such as green roofs, rainwater harvesting, solar panels, solar thermal panels, wind turbine and geothermal systems are **REQUIRED** to be submitted through a Green Permit Program Project Administrator.
- » Commercial project participant must earn certification within the LEED rating system
- » Smaller Residential Project participant must earn certification under the Chicago

Green Homes Program checklist based rating system or LEED for Homes.

- » Green Menu Items – All Green Permit Program participants must utilize certain green strategies or green technologies to receive incentives offered by the Green Permit Program.
 - » Green roofs improve the urban environment by combating the urban heat island, reducing stormwater runoff, and reducing the energy use of the building beneath.
 - » For projects with no other green roof requirement, provide 50% green roof. For projects with a green roof required by Department of Planning and Development, add 25% to the DPD green roof requirement.

GREEN ROOF FEE CREDIT

City of Chicago Green Roof Fee Credit

http://www.cityofchicago.org/content/dam/city/depts/bldgs/general/GreenPermit/Green_Roof_Checklistada.pdf

FEE STRUCTURE	
<input type="checkbox"/> Building Permit Fee	Building permit fee calculation is based on building occupancy and area of work. Please visit our website for additional information and to use the permit fee calculator. www.cityofchicago.org/buildings
<input type="checkbox"/> Green Roof Fee Credit	A credit of \$0.05 per square foot of green roof provided will be applied to your total permit fee.
<input type="checkbox"/> Building Permit Deposit	50% of total building permit fee due at permit submittal meeting. Please make checks payable to The City of Chicago Department of Revenue

Minneapolis Fee Reductions

http://www.minneapolismn.gov/publicworks/stormwater/fee/stormwater_fee_stormwater_mngmnt_feecredits

The Stormwater Credit system provides:

- » Up to 50 percent credit (reduction) in your stormwater utility fee for management tools/practices that address stormwater quality
- » 50 percent or 100 percent credit (reduction) in your stormwater utility fee for management tools/practices that address stormwater quantity

Below is a partial list of stormwater BMPs approved for use in the Quality Credits program:

- » Rain Gardens
- » Pervious Pavers
- » Wet Ponds
- » Dry Wells
- » Sand Filters

- » Filter Strips
- » Infiltration trenches
- » Green Roofs

Only those properties that can demonstrate the capacity to handle a 10-year or 100-year rain event can receive a stormwater quantity credit. To apply for a stormwater quantity credit, property owners must have their applications certified by a state licensed engineer or landscape architect.

Property owners can apply for either the “Standard Quantity Reduction Credit” or the “Additional Quantity Reduction Credit.”

Standard Quantity Reduction Credit. The Standard Quantity Reduction Credit is a 50 percent credit on a property’s stormwater fee. The “Standard Quantity” credit is based on a property’s stormwater quantity management tools/practices being able to retain the 10-year, 24-hour type II SCS storm event. To qualify for this credit, the property owner must demonstrate that stormwater from the property is controlled with an on-site constructed stormwater quantity management tool/practice (BMP).

Additional Quantity Reduction Credit. The Additional Quantity Reduction Credit is a 100 percent credit on a property’s stormwater fee. To be eligible for the “Additional Quantity” credit, a property’s stormwater quantity management tools/practices must be able to retain the 100-year, 24-hour type II SCS storm event. To qualify for this credit, the property owner must demonstrate that stormwater from the property is controlled with an on-site constructed stormwater quantity management tool/practice (BMP).

You can learn more about stormwater quantity management tools/practices from the Minnesota Stormwater Manual.

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Model Green Streets Policy Statement

A Green Streets policy can be adopted by a municipality to encourage the transformation of impervious city street surfaces into landscaped green-spaces that capture stormwater and recharge it on sight.

Model Policy from Northampton Massachusetts

In City Council, October ____, 2014

Ordered, that the City adopt a Green Streets and Infrastructure Policy

WHEREAS, Stormwater runoff from streets, roads, parking lots, roofs and other impervious urban surfaces is a significant source of water pollution to our rivers, streams and water bodies, and also is a key contributor to inflow into sanitary sewers; and

WHEREAS, Green Streets may provide cost-effective infrastructure solutions to reduce and manage stormwater runoff and flooding, including from more intense storm and flooding events and reduce localized flooding from surcharging, adapt to climate change, and manage stormwater runoff; and

WHEREAS, Green Streets improve water quality by filtering stormwater, removing contaminants and cooling the stormwater before it encounters groundwater or surface water bodies, such as rivers, all of which ultimately benefit watershed health. Facilities that filter stormwater through vegetation and soil can reduce total suspended solids (TSS), organic pollutants /oils, and heavy metals by at least 90%; and

WHEREAS, Green Streets foster unique and attractive streetscapes that protect and enhance neighborhood livability, integrate the built and natural environments, enhance the pedestrian environment, and introduce park-like elements into neighborhoods; and

WHEREAS, Green Streets can serve as urban greenways or pathways and provide a preferred means of connecting neighborhoods and parks/recreation areas in ways that are attractive to pedestrians and bikers and complement complete streets; and

WHEREAS, Green Streets encourage the planting of landscapes and trees which contribute environmental benefits such as reduced summer air temperatures, reductions in global warming through carbon sequestration and air pollution screening.

WHEREAS, green infrastructure may help to reduce the long-term costs of gray infrastructure maintenance, and complement gray infrastructure with hybrid systems of gray, piped infrastructure combined with green, vegetated infrastructure; and

WHEREAS, a Green Streets and Infrastructure policy demonstrates the City's commitment to achieving comparable infrastructure required for private developments and complements the City's complete streets policy by providing pedestrian and bicycle access; and

WHEREAS, forthcoming U.S. Environmental Protection Agency Municipal Separate Storm Sewer System (MS4) stormwater permits will require that the city control the amount and quality of stormwater discharged from the MS4s to rivers, streams, lakes, ponds, and wetlands; and

WHEREAS, recharge of groundwater sources is a key mitigation activity under the soon to be amended Massachusetts Water Management Act regulations 310 CMR 36.00; and

DEFINITIONS:

- » **Green Infrastructure:** Infrastructure which keeps rain close to where it falls, using structures to improve on-site infiltration, such as rain gardens, green roofs and permeable pavements, to promote cleaner, slower, and smaller storm flows to nearby rivers and streams;
- » **Green Street:** A subset of Green Infrastructure in which the street handles significant amounts of stormwater on site through use of vegetated and/or soil-infiltration facilities. Green Streets can include landscaped street-side planters or swales or tree box filters or porous pavement that capture stormwater runoff and allow it to soak into the ground as soil and vegetation filter pollutants.

RESOLUTION

Now, **THEREFORE, IT IS HEREBY RESOLVED** that the City of Northampton adopts a policy to promote the use of green street facilities and green infrastructure in public and private development through regulation, capital investment, and management mechanisms as a cost-effective and sustainable practice for stormwater management in current and future projects wherever technically and economically feasible. This includes:

- » Road reconstruction, new road development and bicycle or pedestrian projects;
- » Stormwater projects; and
- » New development and redevelopment projects

Further, it is city policy to:

- » Incorporate and maintain green street facilities and green infrastructure into all City-funded development, redevelopment, and enhancement projects, to the extent technically and economically feasible, and utilizing the best technology available at the time to meet water quality goals with the lowest lifecycle costs; and
- » Ensure that regulations require and incentivize all development to incorporate some Green Streets and green infrastructure features; and
- » Ensure coordination and communication between City departments, in particular, Public Works and Planning and Sustainability, to ensure implementation of this policy, as well as fully addressing competing priorities.

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Model Sewer Regulations For Downspout Disconnection

REGULATIONS GOVERNING THE USE OF SANITARY AND COMBINED SEWERS AND STORM DRAINS OF THE BOSTON WATER AND SEWER COMMISSION

Adopted February 27, 1998

Section 4 - Wastewater-Stormwater Separation.

(a) The plumbing of any existing or new building shall be so constructed as to keep all stormwater, surface water, groundwater, roof and surface runoff, subsurface drainage, uncontaminated cooling water, and uncontaminated industrial process water, non-contact cooling water, and non-contact industrial process water separate from sanitary sewage and industrial wastes, and from the building sewer.

(b) The building drain conveying wastewater from plumbing fixtures within the building shall discharge to a building sewer, while the building drain conveying stormwater and other drainage shall discharge to a building storm drain.

(c) Where separate storm drains and sanitary sewers are provided, and the Commission has determined that on-site retainage of stormwater is not possible, building storm drains shall be connected to a storm drain. Connection of a building storm drain to a sanitary sewer is prohibited.

(d) Where separate storm drains and sanitary sewers are provided, building sewers shall be connected to a sanitary sewer. Connection of a building sewer to a storm drain is prohibited.

(e) Where only a combined sewer has been provided, and the Commission has determined that on-site retainage of stormwater is not possible, the separate building storm drain shall be connected to the building sewer in a manner prescribed by the Commission's

Requirements for Site Plans and the building sewer connection shall be made to such combined sewer.

(f) The Commission shall require an owner to eliminate a source of infiltration or inflow whenever the Commission determines that the source is resulting in excessive infiltration or inflow to be discharged directly or indirectly to the sanitary sewer system.

Section 5 - Connections to Combined Sewers.

In order to prevent the direct discharge of wastewater to receiving waters under dry weather conditions, a building sewer shall not be connected to a combined sewer overflow.

Section 6 - Connections to Manholes.

Building sewer connections for new or substantially rehabilitated buildings shall not be made directly to Commission-owned manholes unless expressly authorized in writing by the Commission.

Section 7 - Connections to Catch Basins.

Private drains, including but not limited to, building storm drains for new or existing buildings and drains from irrigation systems, shall not be connected directly to catch basins.

Section 8 - Connections from Individual Wastewater Disposal Systems.

Connection of an individual wastewater disposal system, whether directly or indirectly, to a Commission sewer or drain is prohibited.

Section 7 - Connections to Catch Basins.

Private drains, including but not limited to, building storm drains for new or existing buildings and drains from irrigation systems, shall not be connected directly to catch basins.

Section 8 - Connections from Individual Wastewater Disposal Systems.

Connection of an individual wastewater disposal system, whether directly or indirectly, to a Commission sewer or drain is prohibited.

Section 9 - Dye Testing of Connections.

Prior to activating water service, every new building sewer shall be dye tested by the Commission, or by the owner or his designee in the presence of a Commission inspector, to establish that the building sewer is properly connected to the Commission's wastewater system. The Commission may conduct dye testing of an existing building sewer to establish that it is properly connected to the Commission's wastewater system. The

Commission may require the owner forthwith to eliminate a connection from a building sewer to a storm drain (also referred to as an illegal connection) at the owner's expense. Where separate sanitary sewers and storm drains exist, the Commission may also dye test, or require the owner to dye test in the presence of a Commission inspector, a new or existing building storm drain to establish that the building storm drain is properly connected to the Commission's storm drainage system. The Commission may also require the owner forthwith to eliminate a connection from a building storm drain to a sanitary sewer at the owner's expense.

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