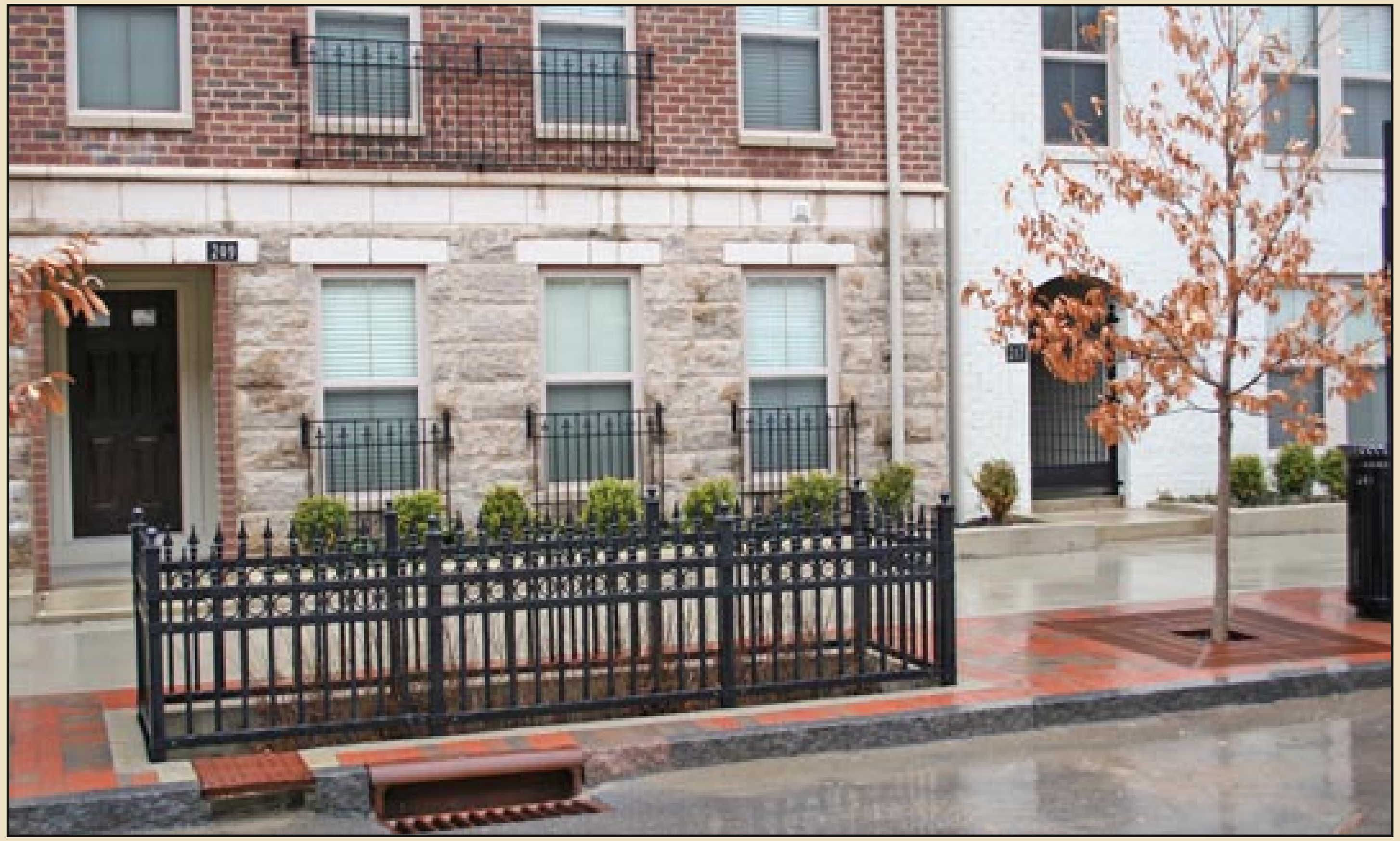
ROUNDTABLE

Bioswales and Raingardens in the Urban Forest



Street-side bioretention wells in Upper Arlington, Ohio capture stormwater from the street before the water enters the storm sewer system. Carefully selected shrubs and perennials fill the well adjacent to sawtooth oak (*Quercus acutissima*). Photo by Steve Cothrel

Bioswales and raingardens offer improved stormwater management over the conventional method of funneling water on impervious surfaces into a storm drain. The benefit for trees in bioswales or raingardens is additional soil space for root growth. In parking lot designs, most bioswales offer more soil volume to collect water runoff than the typical curbed planting spot or tree cutout. This increased volume of soil allows for larger trees and less adjacent infrastructure damage by tree roots. The use of structural soils under hardscape and pavement near bioswales creates additional storage reservoirs for stormwater collection.

In larger bioswale designs, trees can be arranged in a non-linear pattern, offering the opportunity for size and species diversity, which may reduce disease spread and increase the longevity of the planting. Species selection must consider the wide variation in soil moisture from very wet to dry, and irrigation is usually needed during dry periods. In some climates, rain only occurs in the winter and in this case, evergreen trees will be the most effective at stormwater interception. Depending on climate and availability, these could include Douglas fir (*Pseudotsuga menziesii*), swamp gum (*Eucalyptus ovata*), pond or marsh pine (*Pinus serotina*), and southern magnolia (*Magnolia grandiflora*).

In many communities, bioswales and raingardens fit well with the push for sustainable infrastructure and climate protection. They can offer reduced capital costs compared to traditional storm drain system construction. In addition to rain interception, trees in bioswales provide benefits such as shade, improved air quality, and connection with nature.

If designed properly, the bioswale or raingarden will not cause a reduction in parking spaces or site use while still meeting the stormwater needs of the site. During an exceptional storm event the system may be overloaded; however, this can also occur with traditional storm drain systems.

As with any landscape design, the proper trees should be selected for the site. The soils and infiltration need to be correct for the intended volume of stormwater. We have opportunities to advise city planners on soil recommendations and species choices for suitable sites. The final step in any design is to include a long-term maintenance plan so the trees are maintained and grow the large canopy we envision when the plan is drawn up.

—Gordon Mann, Consulting Arborist and Urban Forester, Mann Made Resources, Auburn, California

River birch (*Betula nigra*) is a good candidate for many rain garden and bio-swale applications. Pervious concrete was used for the parking spaces in this Upper Arlington, Ohio park. Photo by Steve Cothrel

Bioswales and raingardens are sites where stormwater can be retained and allowed to recharge slowly in the ground, infiltrating back into the soil. This reduces stormwater overloads to existing infrastructure systems, which otherwise cause flooding. Advantages also include water table recharge, a reduced need to build expensive storm sewer infrastructure, and a smaller volume of polluted water running into our lakes and streams.

A bioswale or raingarden is an area that is graded to collect surface rainfall and runoff from paved surfaces. It should be constructed to allow for good infiltration, but it may have standing water for part of the time. In fact, the recognition that these landscapes may be flooded for some of the time has largely driven the choice of plant materials. However, raingardens and bioswales are not always wet. The key to successful plant selection for these sites is to choose plants that can tolerate wet *and dry* periods.

Trees and shrubs that can accomplish this in the Northeast, Mid-Atlantic, and Midwest regions of the U.S. follow. It is important to keep in mind other selection criteria such as soil pH, hardiness, pest and disease resistance, and sun and shade exposure when making these selections.

Plants that tolerate both wet and dry soils:

Trees

- American Hornbeam (*Carpinus caroliniana*)
- Baldcypress (*Taxodium distichum*)
- Bur Oak (*Quercus macrocarpa*)
- Honeylocust (*Gleditsia triacanthos*)
- Pin Oak (*Quercus palustris*)
- Planetree (*Platanus* x *acerifolia* or *P. occidentalis*)
- River Birch (*Betula nigra*)
- Swamp White Oak (*Quercus bicolor*)

Shrubs

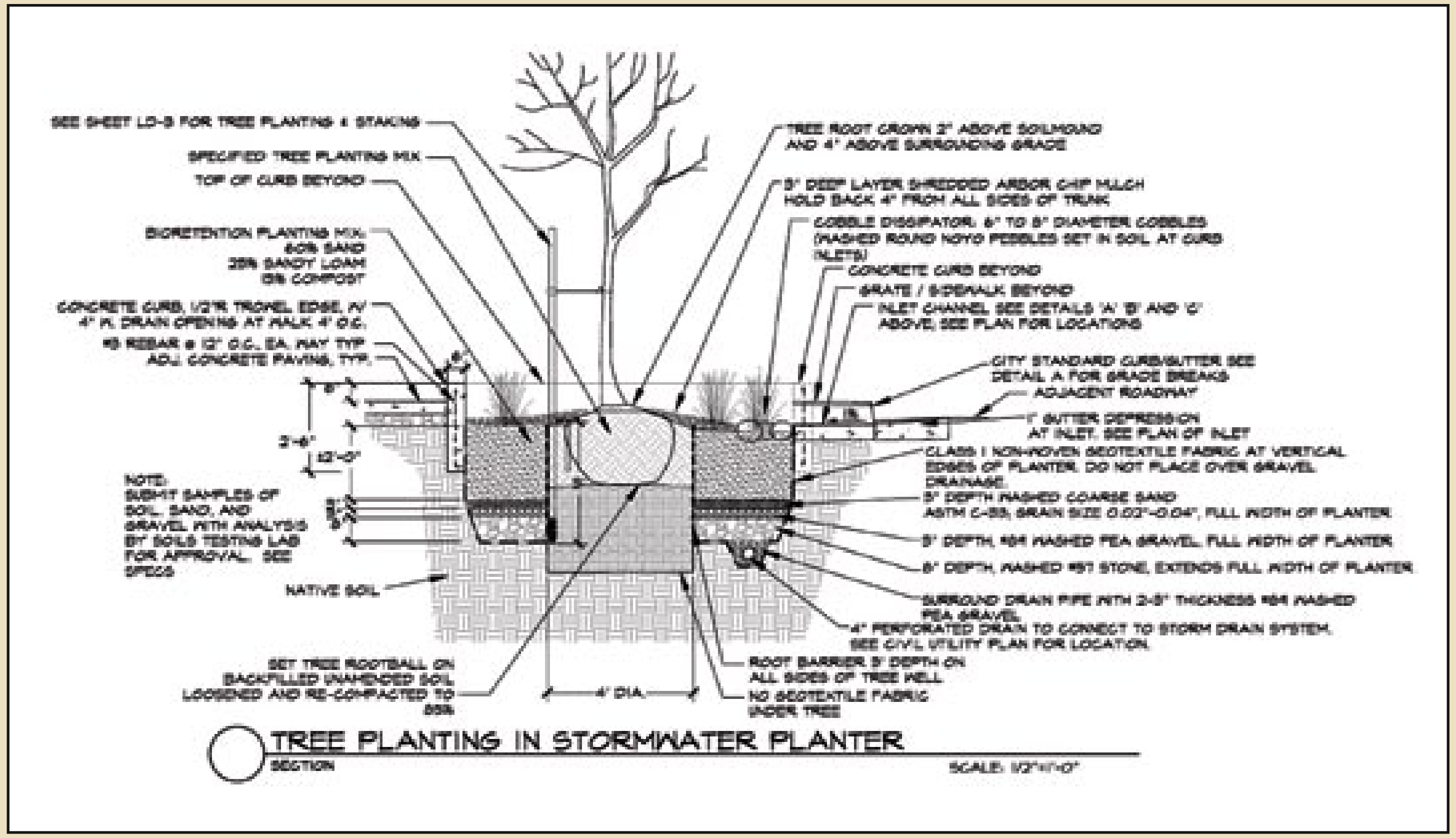
- False Indigo Bush (*Amorpha fruticosa*)
- Black Chokecherry (*Aronia melanocarpa*)
- Buttonbush (*Cephalanthus occidentalis*)
- Grey Dogwood (*Cornus racemosa*)
- Silky Dogwood (*Cornus amomum*)
- Redtwig Dogwood (*Cornus sericea* or *Cornus alba*)
- Winterberry Holly (*Ilex verticillata*)
- Bayberry (*Myrica pensylvanica*) (for more upland edge spots)
- Dwarf Purple Osier Willow (*Salix purpurea* 'Nana')

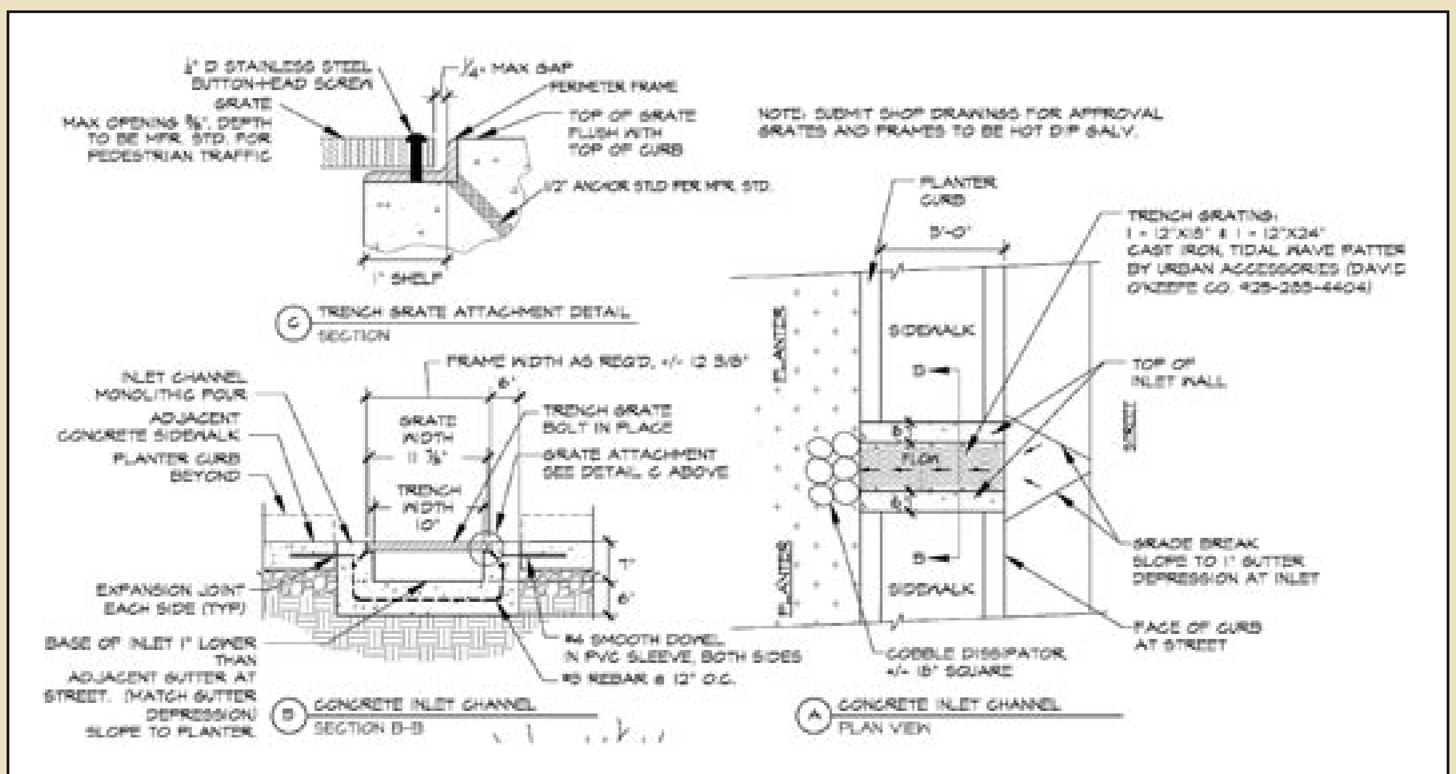
—Dr. Nina Bassuk, Director, Urban Horticulture Institute, Cornell University

Red maples (*Acer rubrum*) and grasses fill rain garden structures that allow stormwater to enter both through openings in the street curb and scuppers in the stone edge along the sidewalk. Photo by Steve Cothrel

As part of infrastructure improvements, stormwater planters installed on the West Capitol Avenue streetscape in West Sacramento, California were designed to treat storm runoff (see accompanying diagram). Each stormwater planter has two openings in the curb that allow runoff to be directed from the street into the planter.

The soil in the planter includes a bioretention planting mix, coarse sand, pea gravel, and washed stone above a perforated pipe and geotextile filter fabric. The mix allows the runoff to be cleaned before discharging through the perforated pipe and into the existing storm drain system to continue downstream.





Three perspectives on a West Sacramento, California stormwater planter; see diagram for construction details • Photos by Dena Kirtley

Because there is little precipitation in West Sacramento from June through October, trees and plant material within the planter are irrigated during these months.

Any tree suitable for your region can be planted within these planters because they drain rapidly, even during a major storm event. However, it is not advisable to plant trees with aggressive root systems as they could impact the flow of water to the perforated pipe below. Decorative plant material surrounding the tree should also be chosen from plants suitable for the region.

Please note that the root barriers in the drawings on page 30 were removed once the tree was planted to allow the tree to develop a healthy root system.

—Dena Kirtley, Urban Forest Manager, City of West Sacramento, CA

This entry highlights water quality projects designed by the Milwaukee, Wisconsin Environmental Engineering Section in 2008-2010. The projects demonstrate how City roads can be redesigned to become a solution to stormwater quality problem rather than a source for pollution. These bioswales are part of Milwaukee's Green Built Environment Roadway Projects.

The new bioswales function as filtration/infiltration devices. Runoff from the roadway enters the facilities through curb cuts and filtrates/infiltrates through two layers of engineered soil and crushed stone. The runoff receives its initial treatment through the salt tolerant plant combinations in the landscaped area before it infiltrates through the amended engineered soil. A portion of the treated runoff then makes its way to the sewer system through installed perforated pipes in the crushed stone layer, while the other portion evaporates and evapotranspirates through the planting system.

In each project, the conventional landscaped medians were redesigned to capture, slow, treat, and infiltrate street runoff. In addition to providing direct environmental benefits, the project also provides a visual amenity for the neighborhood and is aesthetically integrated into the urban streetscape. The project consists of installing bioretention facilities to replace the conventional medians. The facilities are designed to provide a removal rate up to 90% of total suspended solids from roadways.

Things to Consider Before Installing a Bioswale

1. Plant site-tolerant (drought, wet, salt), low maintenance, aesthetically pleasing vegetation (including trees).
2. Topsoil **must** be a specially engineered mix from a reputable supplier.

Bioswales replacing conventional medians in Milwaukee • Photo by Scott Baran

3. Existing conditions and utilities must be located prior to placement of bioswales.
4. Trees can be installed outside of swales to further enhance the effect of reducing stormwater without having an adverse effect on long-term root growth.
5. Hold an educational session before, during, and after the installation to explain the project to local residents.
6. Place bioswales in areas that have a dramatic effect on reducing/treating stormwater and also can be installed cost effectively.
7. Long-term maintenance contracts for the facilities should be in place prior to installation.

—Scott Baran, Landscape Designer, and Emad Nadi, Stormwater Engineer, City of Milwaukee, Wisconsin Department of Public Works

Bioswales in Milwaukee are designed to provide a removal rate up to 90% of total suspended solids from roadways. Photo by Scott Baran

Bioswales are part of Milwaukee's Green Built Environment Roadway projects. Photo by Scott Baran

In Milwaukee, Wisconsin, runoff from the roadway enters the bioswales through curb cuts and filtrates through two layers of engineered soil and crushed stone. Photo by Scott Baran

In 2010, the Cincinnati Park Board (CPB) signed a memorandum of understanding with the Cincinnati Metropolitan Sewer District (MSD) to help design, install, and maintain stormwater source control measures using green infrastructure in various key watersheds in Cincinnati.

MSD has a consent decree to remove 2 billion gallons of stormwater from the combined sewer overflows (CSO) in the Lower Mill Creek in Cincinnati by 2018. There are three strategies in handling the CSO problem in Cincinnati, which rates in the top five worst cities in the country in overflow events. One is a "gray" solution to build a 1.5 mile (2.4 km), 30-foot (9.1 m) diameter concrete tunnel to hold the excess water. Another is to build more and bigger underground pipes to convey all the storm water. The third is to find green solutions to absorb or slow water before it reaches the combined sewer system. This third solution is the most environmentally sustainable because it improves water quality and does not have as many long term operational costs.

CPB is caretaker of 5,000 acres of park forests and 85,000 street trees. In 2010, the CPB formed two key partnerships; the agreement with MSD, and secondly, a partnership with the State of Ohio Department of Natural Resources and Hamilton County, to leverage a U.S. Forest Service Grant that funded an urban tree canopy study. The study used high resolution imagery to generate geographic information system (GIS) layers for tree canopy and impervious services, and a CITYgreen analysis measured the benefits provided by our forest canopy for all trees in the urban forest and within parks larger than 20 acres (8 ha).

The study found that the overall city canopy has increased over the past decade from 37% to 38.8% and that the urban forest annually abates a volume of stormwater that would require 108,700,000 cubic feet of infrastructure to store and manage and that would cost $28,450,000 annually over a 20-year period to construct. The tree canopy and impervious surface data produced by the study was captured at a 6-inch (15-cm) resolution and its quality is far superior to the imagery used ten years ago. The high quality data allows more accurate modeling and evaluation of best management practices for stormwater control.

Most cities are limited to planting trees in rights-of-way and parks. The partnership with MSD has allowed the CPB to look at many more opportunities for reforestation. Because the MSD has an obligation to reduce source runoff, it has the ability to commit both capital and operational funds to meet the short and long term goals. The CPB is using aerial photography and GIS data to explore reforestation opportunities on surplus city lots and private property to achieve the synergistic goals of beautification, increased tree canopy and associated environmental benefits, and stormwater reduction on blighted urban vacant lots. CPB staff, contractors, and volunteers work together to clear invasive honeysuckle, remove trash, and plant thousands of native tree seedlings that will serve to improve forest quality and absorb and slow down rainwater.

Trees and landscaping can also be incorporated into construction of best management practices. In 2010 the CPB completed two bioinfiltration projects on private property. The largest is the St. Francis Court Apartments property, an assisted-living apartment complex. Two large parking lots were removed from a hillside setting and replaced with two 3,800 square foot (353 sq m) bio-infiltration gardens. This serves to absorb and hold water draining from the

New bioinfiltration garden in action during heavy November rains at St. Francis Court Apartments in South Fairmount, Cincinnati. Photo Courtesy Cincinnati Park Board

hillside and upper parking lot. Water is captured and slowed to infiltrate instead of reaching the combined sewer. Shade trees were planted on the hillside and the front parking lot. A handicap-friendly walking path and two community gardens were created for the residents' use.

The other completed project is at Immanuel Church. Water from the large building's downspouts is directed to a bioswale to filter, absorb, and hold water before it reaches the storm sewers in the streets.

Trees are a cost effective solution to reducing stormwater runoff and improving stormwater quality. Studies such as that of the urban tree canopy allow cities to calculate those benefits, communicate them, and to leverage dollars for reforestation projects.

—Dave Gamstetter, Natural Resource Manager, Cincinnati Park Board, and Dave Boutelle, Supervisor, Public Greenspace Program, Cincinnati Park Board, Cincinnati, Ohio

Bioswales and raingardens are a relatively new concept for us. Like other cities, Upper Arlington, Ohio is working to adopt greener standards and retrofit our suburb to comply with modern federal and EPA standards for stormwater management. At present, six of our newest gardens (over 20,600 sq. ft/1913.8 sq m) are EPA mandated raingardens. More are expected as future redevelopment triggers additional stormwater treatment requirements.

Adopting these principles has been a methodical process by design. Plant selection and planning should focus on tough low maintenance species that can tolerate brief periods of inundation but also survive extended dry spells. Proper garden installation is critical for successful drainage and filtration. Additionally, our greatest concern is always long-term maintenance. Installation is the birth of any garden, and its success depends on how well it's maintained for a lifetime. Adding raingardens without the accompanying resources for ongoing maintenance is a big mistake.

It will take us much longer to evaluate tree growth as trees take longer to establish. Not surprisingly, we are currently having success with the usual culprits that don't mind wet feet, including London planetree (*Platanus* x *acerifolia*), swamp white oak (*Quercus bicolor*), and baldcypress (*Taxodium distichum*). I also wouldn't hesitate to plant ginkgo (*Ginkgo biloba*), river birch (*Betula nigra*), serviceberry (*Amelanchier* sp.), alder (*Alnus* sp.), red maple cultivars (*Acer rubrum*), willow (*Salix* sp.), and black locust (*Robinia pseudoacacia*).

—Lisa Metcalf, Horticulturist, City of Upper Arlington, Ohio, Parks & Forestry Division

Shown here is an Upper Arlington, Ohio rain garden in a newly re-developed parking lot during a heavy drenching rain. Run-off from the parking lot drains into the garden from curb cut-outs in either end and multiple inlets on the sides. Skyline honeylocust (*Gleditsia triacanthos* var. *inermis* 'Skyline') is under planted with Virginia sweetspire (*Itea virginica*). Photo by Lisa Metcalf