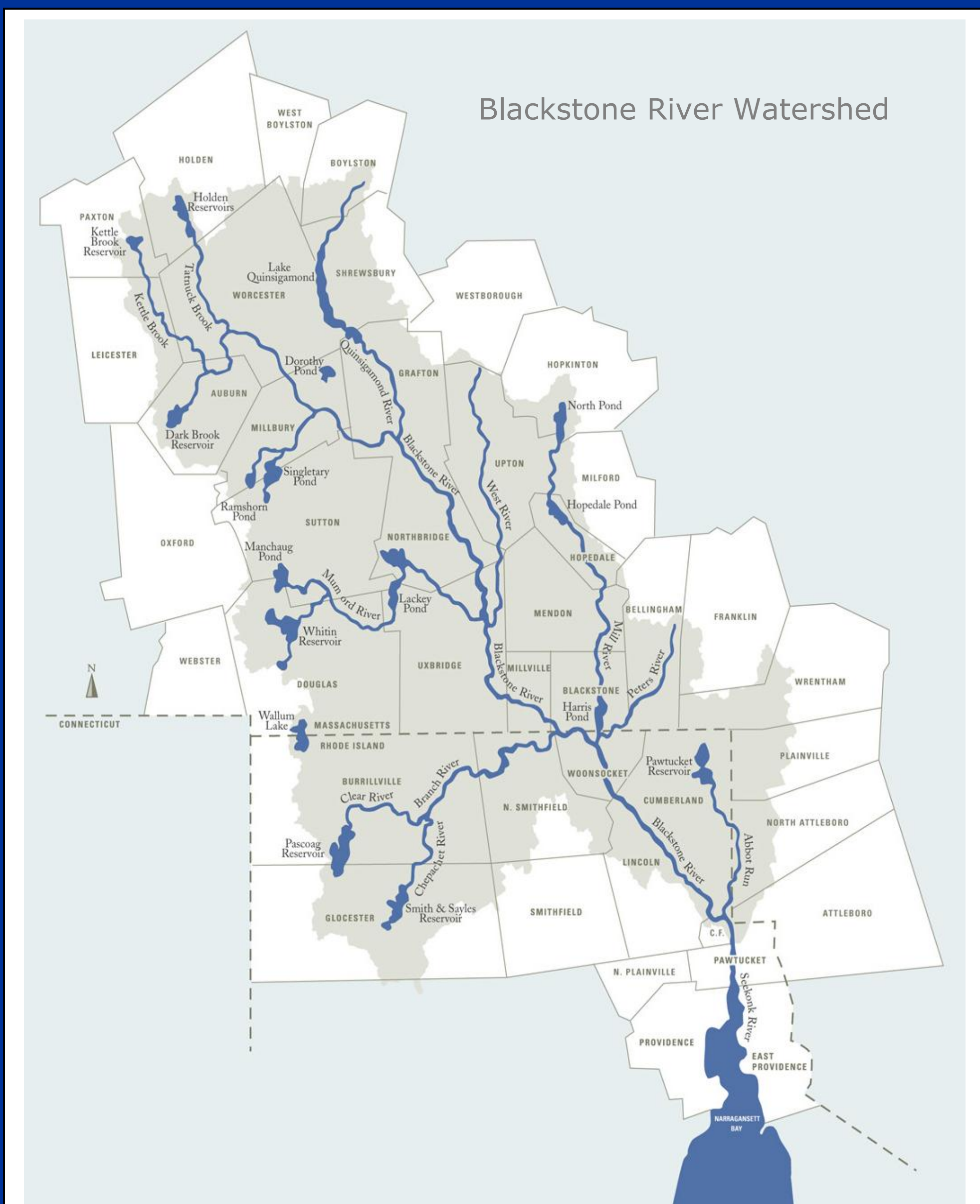
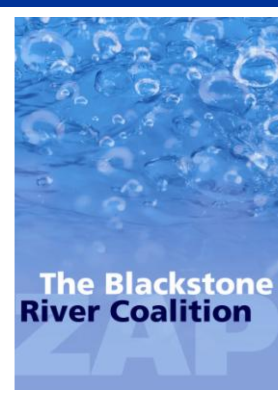
Campaign for a Fishable/Swimmable Blackstone River by 2015

Blackstone Valley Guide to Low Impact Development Practices



New development can minimize the impacts on Blackstone Valley water resources through careful site planning that maximizes infiltration, reduces paved surfaces, and uses decentralized stormwater management techniques to handle runoff.



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Introduction

We have come a long way in restoring the Blackstone River, but there is still more to do to help make the Blackstone River "Clean by 2015". To further implement the Campaign for a Fishable/Swimmable Blackstone River by 2015, the Blackstone River Coalition is targeting polluted runoff and stormwater volume as the major issue impacting water quality. If you are planning a construction project in the Blackstone watershed, a cleaner river can begin with the runoff from your site. Small changes in design and maintenance can greatly reduce polluted runoff, while increasing critical groundwater and drinking water supplies.

Polluted stormwater runoff is the most significant, unaddressed cause of water quality problems today. Rain and melting snow travel over paved surfaces and collect contaminants such as chemicals, nutrients, oil, metals, litter and debris. These contaminants are then carried to the storm drain, which often discharges directly into local streams and lakes that drain to the Blackstone. By including stormwater management in the site design, simple modifications can greatly improve the quality of our drinking water and protect rivers and lakes that are used for recreational purposes while providing important habitats for the fish, birds, turtles and other wildlife that call the Blackstone Valley their home.

The Blackstone Valley Guide to Low Impact Development Practices is a set of guidelines for developers, designers and project reviewers intended to improve the quality of development in the Blackstone Valley. This guidance manual describes the preferred design and construction practices related to site planning, stormwater management, erosion and sedimentation control and landscape design. The three major components of Stormwater Management include:

- **Site Planning:** Design the development using environmentally sensitive site design and low impact development techniques to preserve natural vegetation, minimize impervious surfaces, slow down times of concentration, and reduce runoff;
- **Source Controls, Pollution Prevention, and Construction Period Erosion and Sediment Control**: implement nonstructural measures to prevent pollution or control it at its source; and
- **Structural BMPs:** Design, construct and maintain structural BMPs to attenuate peak flows, capture and treat runoff, and provide recharge to groundwater.

None of the practices in this Guidebook are new, and many have already been used extensively in Massachusetts and Rhode Island. The Guidebook codifies these practices, thus taking some of the "guesswork" out of project design and review. The Guidebook also provides a single-source reference book for designers and reviewers working in the Blackstone Valley. Recognizing that many best development practices are site-dependent, the Guidebook identifies a range of practices that are relevant to development and redevelopment projects on a variety of sites. Thanks to Richard Vacca and the Town of Franklin for allowing the use of their Best Development Practices Guidebook. Thanks also to the Town Planners throughout the Valley who spent time reviewing the document and suggesting examples of good development.

Thank you for taking the time to read this Guidebook. With your participation, the Blackstone Valley will become a model for attractive and environmentally responsible community development.

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I. Site Planning

> **PRINCIPLE:** Subdivision plans and site plans for all forms of development should adhere to the principles of *environmental compatibility*, *aesthetic compatibility*, and *energy-efficient design*.

This Guidebook recommends that site plans and subdivision applications consider the presence of natural, cultural, and aesthetic features on any proposed development or redevelopment site. Designers should utilize the four-step planning process known as Conservation Subdivision Design to identify and plan for these site features.[1] This process can help expedite the project review and approval process and minimize the need for re-designs.

Under the four-step process, the applicant first prepares an "environmental constraints and opportunities plan" for an initial Planning Board meeting. At this meeting, the applicant and the Planning Board identify those portions of the site that should be conserved (e.g., wetlands, view-sheds, specimen trees, historic sites), and those portions that are most suitable for development. This analysis should consider natural and visual features, as well as the site's orientation with respect to the sun and wind. With this input, the designer then identifies building sites and lays out the internal circulation network in a way that minimizes clearing, vegetation disturbance and re-grading, and situates the buildings within the natural topography. The last step is to draw in the lot-lines, if applicable. The goal of this process is not to reduce the overall development program, but rather to lay it out in a less expensive and more environmentally and aesthetically compatible fashion.

The four site planning steps are described below.

1. Constraints and Opportunities Plan

Site planning should begin with the preparation of a **Constraints and Opportunities Plan** to understand the site's features and its context. The plan should identify water resources (wetlands, streams, ponds, vernal pools, floodplains, and springs or seeps), site conditions (steep slopes, significant rock outcroppings, landforms such as knolls and hollows, hydric soils, and prime aquifer recharge areas), ecological features (woodlands, wildlife habitat, and rare species), scenic/visual features (specimen trees, farmland and meadows, and views both into and out from the site), and historic and archaeological resources. The constraints and opportunities plan may be prepared in conjunction with the site survey, but will require more investigation and analysis than a survey usually provides. Ideally a multidisciplinary team with an engineer, scientist, and landscape architect will visit the site and prepare the constraints and opportunities plan. During this step, the designer should also consider the locational context, including surrounding land uses, water resources, historic sites, and other features. The constraints and opportunities plan can either be a single plan or a series of layers of clear plastic or tracing paper, each representing one set of site features.

2. Identify the Conservation and Development Areas

Once all of the existing conditions information has been combined on the constraints and opportunities plan, the most suitable areas for development and conservation will become apparent. Conserved lands should include *primary conservation areas* (areas such as wetlands, floodplains, and steep slopes that are generally unbuildable due to environmental regulations or site conditions) as well as *secondary* *conservation areas* (unique or attractive site features, or areas that are important for environmental protection but not otherwise regulated). Working within the zoning guidelines, the designer should identify areas that will be conserved and areas that will be developed. The designer should be creative in trying to site the desired development program outside of the identified conservation areas, using flexible development options if appropriate.

3. Locate the Building Sites and Lay Out the Roads and Trails

Building pads should be sited within the identified development areas to the maximum extent possible. In addition, the site will need to be designed carefully, with the site's constraints and opportunities in mind. Sensitive features in the conservation areas (e.g., vernal pools) should be buffered from the development areas, while scenic or historic features (e.g., knolls, meadows, or rock outcroppings) could be "showcased" by providing an open view to see them. In residential projects, natural vegetation will often need to be retained on individual house lots so that the total development program can fit into a development area that is only a fraction of the site's total land area. Finally, buildings should be sited with consideration to the view from the public way as well as the view out from the buildings. In suburban and rural sections of the Valley, developments should generally be as naturally camouflaged as possible.

Buildings should also be oriented to the sun and wind for maximum efficiency. Protection from cold winter winds can be achieved by retaining natural vegetation along a building's northwest edge or by planting evergreen species such as white pine (*Pinus strobus*) in this location. For summer shading and winter heating, deciduous species can be planted close to the building, along the east, south and west exposures. Winter sunlight will penetrate the empty branches and provide heat. Home interiors should be laid out with time-of-day occupancy in mind. Living and high-activity rooms should be placed on the south side where they are heated by the low winter sun and shaded from the high summer sun. Garages, utility rooms and closets can be positioned to provide insulating barriers on the north and west sides.

During this step, the system of roads and pedestrian network (if any) should be laid out based on the most efficient way to access the building sites with a minimum of environmental and aesthetic impacts. From an engineering standpoint, it is important to consider the topography to minimize cuts and fills; from an environmental approach, to consider mature tree stands, wildlife habitat areas, wetlands; from a water quality perspective to minimize the amount of impervious surfaces; and from an aesthetic and speed control perspective to build "slow" roads. "Slow" roads are naturally curving, or have short straight segments connected with relatively tight bends that force drivers to go slowly. As with the siting of buildings, preserving vistas should be a prime consideration.

4. Draw in the Lot Lines

Once steps 1 through 3 have been completed, the lot lines (if any) can be drawn in based on the building locations. The location of the buildings may necessitate a subdivision plan that takes advantage of any flexible development options.

Appropriate site planning will further the goals of:

- **Protecting the environment**, including wildlife habitat, water resources, and "ecosystem services" such as groundwater recharge, flood attenuation and pollutant removal;
- **Creating a visually appealing community**;

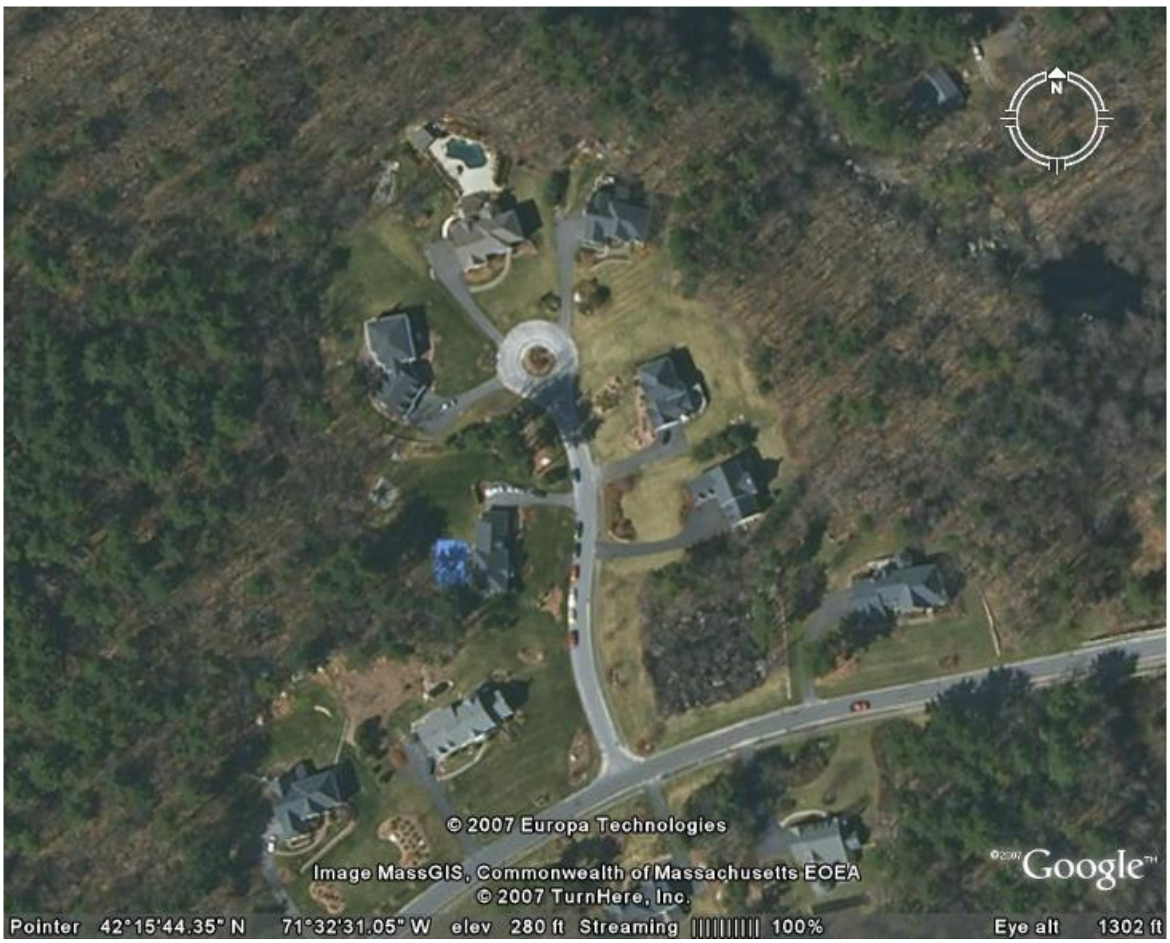
- **Preserving the Valley's cultural heritage**, including historic sites, view corridors, trees and other noteworthy features;
- **Stabilizing and increasing property values**; and
- **Encouraging sustainable development** that minimizes energy use and pollution.

In order to minimize costs related to design and engineering (as well as construction), it is recommended that applicants follow the **four-step planning process** described above. Creative designers will usually be able to find many cost savings by reductions in clearing, paving widths, cut and fill, replanting, and stormwater management needs.

Guidelines and criteria for site planning include the following:

- **Avoid, minimize and mitigate impacts to wetlands.** Low Impact Development (LID) measures mimic natural hydrology and in order to do so must be dispersed through a site and not rely on "end-of-pipe" treatment systems.
- **Refrain from disturbing unique natural features of the site to the maximum extent possible.** Depending on the site, such features could include wooded areas, specimen trees (e.g. larger than 10" diameter at breast height), knolls, and rock outcroppings as well as the more typically conserved streams, wetlands and ponds. These features should be identified early in the site planning process (for example, in the survey or an early site visit) and incorporated into the site plan either as "focal points" for the development or as protected areas, whichever is more appropriate. In general, clearing of vegetation and alteration of topography should be limited as much as possible. Native vegetation should be planted in disturbed areas as needed to enhance or restore wildlife habitat. Disturbance should be limited to construction areas only. Preservation of groups of trees (e.g., beech, oak, hickory, etc.) is encouraged.
- **Refrain from disturbing sites of historic and/or cultural significance.** Significant sites could include old buildings, cellar holes or graveyards, as well as historic trees that have a diameter at breast height of 20" or greater.
- **Preserve views and vistas both into and out of the site.** A visual analysis should be conducted to identify any scenic "windows" into the site and preserve the aesthetic value of these views whenever possible.
- **Minimize cut and fill.** Roads should follow the natural contours whenever possible, taking a steeper path only if necessary. Steep areas on individual house lots should generally be left as natural vegetation, not regraded to allow for a sloping lawn. This approach can reduce grading costs and stormwater control costs because it often results in less land being disturbed, thereby creating fewer erosion or runoff problems. In addition, future homeowners will have fewer expenses and hassles related to maintaining steep lawns and landscaped areas, which are often costly to maintain and have low utility as yards.
- **Locate houses and buildings in a way that blends into the natural topography.** Buildings should not be set high up on a hill where they will be an eyesore or a focus of attention. Generally buildings should be situated near the grade of the road, unless this would require extensive regrading, in which case they may be higher or lower. For buildings located much above the road, an extra effort should be made to recess these buildings into the treeline to reduce their visual impact.
- **Reduce the amount of impervious surfaces.** Reduced roadway widths and smaller front yard setbacks lessen the amount of impervious surfaces, while directing rooftop and roadway runoff to Qualifying Pervious Areas can increase infiltration and help recharge groundwater.

- **Conserve energy by orienting buildings to the sun and wind for maximum efficiency.** Buildings should be aligned to be protected from cold winter winds, shaded from summer sun, and open to winter sun. Protection from cold winter winds can be achieved by retaining natural vegetation at a building's northwest edge or by planting evergreen species such as white pine (*Pinus strobus*) in this location. For summer shading and winter heating, deciduous species can be planted close to the building, along the east, south and west exposures. Winter sunlight will penetrate the empty branches and provide heat. Home interiors should be laid out with time-of-day occupancy in mind.[2] Living and high-activity rooms should be placed on the south side where they are heated by the low winter sun and shaded from the high summer sun. Garages, utility rooms and closets can be positioned to provide insulating barriers on the northeast and northwest sides.



The Highland Park Subdivisions in Hopkinton were planned using Open Space Residential Design. Large, expensive homes are built on 30,000 square foot lots, with the majority of land set aside as permanent open space. A Landscape Architect laid out the roads, with waivers for grade requirements to minimize cut & fill. A simple thing as grassing the center of the cul-de-sac helps reduce paving.

II. Stormwater Management

a. Overview and Principles

The need for a strong and innovative stormwater management policy is based on an attempt to address several challenges:

- The Blackstone Valley has numerous wetlands and water bodies, all of which drain to the Blackstone River, which is affected by polluted runoff.
- Many Towns rely on local groundwater aquifers for their public water supply. With the Valley facing seasonal water shortages, groundwater recharge is an essential function.
- The U.S. Environmental Protection Agency (EPA) has recently promulgated the so-called "Stormwater Phase II Requirements," which require communities in the Blackstone Valley to manage polluted runoff effectively.[3] (Notes and references are provided in the endnotes.)

In order to ensure a minimum level of stormwater management for development and redevelopment projects, Towns are urged to adopt the following stormwater management performance standards.[4] The adoption of performance standards allows the design engineer to select one or more stormwater management systems that are most appropriate and cost-effective for the particular site.

PRINCIPLE: All new development projects should meet the following three stormwater management performance standards. All redevelopment projects should meet the standards and if they fail to meet the standards, should retrofit or expand existing stormwater management systems to improve existing conditions.

1. Post-development peak discharge rates and volume of runoff from the site should not exceed pre-development peak discharge rates and volume of runoff.
2. Annual groundwater recharge from the post-development site should approximate annual recharge from the pre-development site.
3. The stormwater management system should remove at least 80% of the average annual post-construction load of total suspended solids (TSS).

There is a growing realization among water resource professionals that conventional systems of stormwater collection, conveyance, and end-of-the-pipe dry-basin detention are no longer sufficient to improve the water quality of surface water bodies. Therefore, the general preference is that stormwater be conveyed and treated in natural and vegetated systems such as vegetated swales, filter strips, constructed wetlands, and bioretention cells. While some of these practices may be new to local developers, they have been used successfully in other towns and states and have gained support from the EPA because of their generally superior performance in attenuating peak runoff rates, filtering pollutants, recharging groundwater, and allowing retention of the natural landscape. Recognizing that non-structural systems are not appropriate in all situations, the Guidebook also discusses other practices.

PRINCIPLE: Non-structural stormwater management systems should be used wherever site conditions allow, as outlined in the Guidebook. Drain pipe/catch basin systems should be used, in part or in whole, only if the applicant can demonstrate that other systems are not feasible due to site conditions.

This section of the Guidebook discusses nine stormwater management practices that can be used, alone or in combination, to meet the performance standards. Other systems not discussed in this guidebook may also be acceptable if the applicant can demonstrate their fulfillment of the above standards. Table 2-1 provides a summary of the practices discussed in this chapter and when each practice is encouraged or allowed.

Table 2-1: Use of Stormwater Management Practices

Practice	Advisability	Appropriate Uses
Vegetated Swales	Strongly encouraged	Roadsides, parking lots
Vegetated Filter Strips	Strongly encouraged	Roadsides, residential frontage areas, parking lots, perimeter protection
Constructed Wetlands	Strongly encouraged	Commercial and industrial sites, office campuses, subdivisions
Bioretention Cells (Rain Gardens)	Strongly encouraged	Residential lots, parking lot islands
Pervious Paving Surfaces	Encouraged	Parking overflow areas
Roof Gardens/Green Roofs	Encouraged	Office/industrial buildings
Retention Basins/Wet Basins	Neutral	Subdivisions, office developments
Detention Basins	Allowed in combination with other practices	All areas of development, if necessary
Drain Pipe/Catch Basin System	Allowed when other systems are not practical due to site constraints	All areas of development, if necessary

There are several factors to consider when deciding on which practice(s) to implement in any given project. Among these factors are the space required, soils and slopes on site, depth to the water table, maintenance requirements, pollutant removal efficiencies, cost, and the ability to meet stormwater performance standards.

Rebekah Drive in Sutton is a good example of “country drainage”. It is a small residential cul-de-sac, with narrow widths of pavement, no sidewalks, and grass swales to handle stormwater. No curbs, no catch basins.

b. Summary of Practices

Table 2-2 provides a summary of design and site considerations for the various stormwater management systems.

Table 2-2: Design and Site Considerations for Stormwater Practices[5]

	Vegetated Swales	Vegetated Filter Strips	Constructed Wetlands	Bioretention Cells	Pervious Paving	Retention Basins	Detention Basins	Catch Basins
Space Required	Bottom width: 2 ft. min. 6 ft. max.	Recommended minimum width: 10-20 ft.	5% of drainage area	Min width: 5-10 ft Min length: 10-20 ft Min. depth: 2-4 ft	Not a factor	Min. pool surface: 0.25 acres recom'd	1 acre foot per 4 acres drainage area	Not a factor
Soils	Permeable soils perform better, but wet swales can be used in less permeable soils	Permeable soils perform better, but soils are not a limitation	Soils are not a limitation	Permeable soils recom'd (infilt. rates >0.27 in/hr). Underdrains allow for less permeable soils.	Permeable soils perform better	Not a factor	Not a factor	Not a factor
Slope of Catchment Area	A design consideration, but usually not a limitation	A design consideration, but usually not a limitation	Max. 15% for forested; 5% for shrubs/ herbs	A design consideration, but usually not a limitation	Usually not a limitation	Maximum 15%	Maximum 15%	Not a factor
Water Table and Bedrock	Generally not a constraint	Generally not a constraint	Water table should be at or near soil surface, or else a liner can be used	2-4 ft above water table/bedrock recommended	2-5 ft above water table/ bedrock recom'd	Not a factor	Generally not a constraint	Not a factor
Proximity to Building Foundations	Min. 10 ft. down-gradient from buildings & foundations recom'd	Min. 10 ft. downgradient from buildings & foundations recom'd	Minimum distance of 10 ft.	Min. 10 ft. downgradient from buildings & foundations recom'd	Not a factor	Minimum distance of 10 ft	Minimum distance of 10 ft.	Not a factor
Max. Depth	N/A	N/A	4-6 ft.	2-4 ft., depending on soil type	N/A	3-6 ft.	3-12 ft.	N/A
Maintenance Requirement	Low: routine landscape maintenance	Low: routine landscape maintenance	Moderate; depends on sedimentation rate	Low: property owner can include in normal site landscape maintenance	Low: routine landscape maintenance	Moderate; depends on sedimentation rate	Moderate: routine sediment removal	Moderate: routine sediment removal

Table 2-3 (below) should be used in determining compliance with the 80% TSS removal standard. TSS removal efficiency for each of the various stormwater management systems shall be presumed to be the value shown in Table 2-3 unless the applicant can provide additional satisfactory information or documentation that the system has a greater TSS removal efficiency. Other systems not discussed in this Guidebook may also be acceptable if the applicant can demonstrate their fulfillment of the stormwater management performance standards.

If more than one practice is used to achieve the required 80% TSS removal, the removal efficiency rates must be multiplied together, not added. For example, if the first practice has a 60% TSS removal rate and the second practice has a 20% removal rate, a total of only 68% of TSS would be removed. (60% of the total, plus 20% of the remaining 40% of TSS.)

Table 2-3: TSS Removal Rates for Stormwater Management Practices[6]

Practice	**Design Rate for TSS Removal** (use this number to calculate compliance with the 80% TSS removal requirement)	**Range of Average TSS Removal Rates**
Water Quality Swale	70%	60-80%
Vegetated filter strip	10% for 25’ & 45% for >50’	10-50%,
Constructed wetland[b]	80%	65-80%
Bioretention cell	90%[c]	65-80%
Retention basin/Wet basin[b]	70%	60-80%
Detention basin[d]	60%	60-80%
Deep sump and hooded catch basin	25%	25% w/cleanout

[b] Must have a sediment forebay or pre-treatment.

[c] If an underdrain is used, the water must be conveyed to a secondary treatment device such as a constructed wetland or a retention basin.

[d] Post-treatment is required (e.g., by a constructed wetland or retention basin).

c. Discussion of Practices

Each of the nine stormwater management practices is discussed in more detail below. References in the endnotes provide additional information on the use, design, and construction of these practices.

1. Water Quality Swales

Swales are earthen channels most commonly covered with a dense growth of grass or other vegetation, and are designed primarily to control water quantity and quality.[7] The design of vegetated swales has improved over the years, enabling engineers and hydrologists to implement them for a variety of different purposes. Depending on hydrological conditions and design, swales can be dry, wet, or grassed:

- **Dry swales** are channels filled with approximately 30 inches of soil (50% sand and 50% loam) that allows full infiltration of the stormwater.
- **Wet swales** are generally used when the water table is at or near the soil surface or when soils are poorly drained. Theses swales have a ponding area that should be planted with moist-tolerant species to enhance nutrient uptake and sediment retention.
- **Grassed swales** are planted with grass species that provide a dense cover and serve to provide sediment retention, nutrient uptake and filtration. They are suitable for sandy loam soils. Pollutants are removed from stormwater by the filtering action of the grass, sediment deposition, and/or infiltration into the soil. Grass swales are designed to remain dry most of the time and are specifically planted with species to enhance nutrient uptake and filtration.

Design Considerations

Swales are easily implemented on large lot residential sites (½ to 1 acre or larger), office and industrial campuses, roadways where right-of-way widths are adequate, and parking lot medians and edges (see photo below). Ideally, stormwater should flow from the impervious surface through a vegetated filter strip before entering the swales. Typically, dry and grass swales are used for low density residential projects or very small impervious areas and require soils that have infiltration rates of 0.27-0.50 inches per hour. Wet swales, on the other hand, are convenient for treating highway runoff in low lying or flat terrain areas and need to be planted with water tolerant vegetation. Swales should be built at a gentle slope so that water flows at a relatively low velocity. The minimum allowable slope is ½%, while the maximum slope is based on velocity. Water velocity in the swale should generally not exceed 3 feet per second, which typically corresponds to a maximum slope of about 5%. If necessary, the swale may be steeper in places, provided that riprap or other stabilization is used to prevent scouring and erosion within the swale. The side slopes should be at a maximum of 3:1, and the length of the swale should be calculated to accommodate the entire calculated runoff volume from a 10-year storm. Regular maintenance such as mowing, sodding, and repair of eroded areas is necessary for swales. In addition, the accumulated sediment may need to be periodically removed during construction until the site is stabilized.

Grassed swale around a parking lot in Franklin, MA

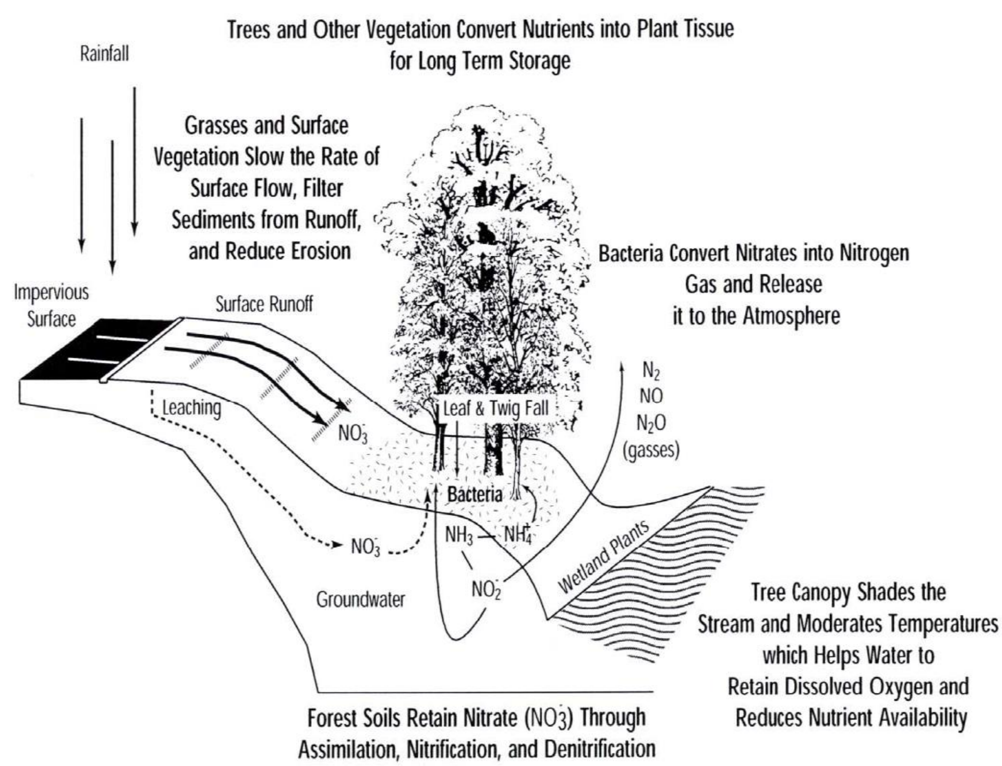
2. Vegetated Filter Strips

Filter strips are typically bands of close-growing vegetation, placed between pollutant source areas and the receiving water body (either a natural water body or a constructed swale). To protect natural water bodies (e.g., streams or wetlands), filter strips should consist of natural buffer strips already existing on the site. Not only do filter strips protect sensitive areas such as wetlands, woodlands and erodible soils; they also reduce runoff impacts by trapping sediment and sediment-bound pollutants, provide some infiltration, and slow and disperse stormwater flow over a wide area.[8] The Figure below illustrates some of the biochemical processes by which filter strips remove pollutants.[9]

Design Considerations

Treatment of stormwater in filter strips is accomplished physically by a combination of filtration through the standing vegetation and infiltration into the underlying soils. In order to treat stormwater effectively, filter strips must be designed to function as overland flow systems where stormwater is evenly distributed. Because there is a high potential for short-circuiting of the filter strips and reduced pollutant removal, grading must be designed carefully to provide uniform flow into the filter strips.

If filter strips are wide enough and planted with appropriate plant species, they will provide wildlife habitat as well as visual amenities in the landscape. It is important to note that filter strips are usually implemented in combination with other stormwater management facilities that specifically control stormwater volume. Finally, for a filter strip to be efficient, a minimum width of 10-20 feet is recommended. Upkeep of filter strips should be incorporated into routine landscape maintenance, which would include raking the filter strip, removing large trash or debris that has accumulated, and regularly cleaning up sediment.



Processes by which vegetated filters remove pollutants

3. Constructed Wetlands

Constructed wetlands (or stormwater wetlands) are shallow pools that create growing conditions suitable for marsh plants. These systems are designed to maximize pollutant removal through retention, settling, and uptake by wetland plants.[10] Stormwater wetlands serve several benefits simultaneously. The primary purpose of constructed wetlands is to improve water quality by removing sediment and pollutants. However, these wetlands can also provide excellent habitat for wildlife and waterfowl. In general, a constructed wetland would be a suitable stormwater management practice for residential subdivisions and commercial developments.

Design Considerations

Constructed wetlands must be designed with consideration to the size of the contributing watershed area, amount of baseflow, soil type, and available space. The contributing watershed may be as small as 5 acres; however, the smaller the watershed area, the more difficult it is to create sufficient drainage and runoff to keep the wetland perpetually wet. Since wetlands need to maintain soil moisture throughout the year, it is important to have a dry-weather baseflow or a groundwater supply. The preferred soil types for constructed wetlands are less-permeable soils that have relatively small pores and are less prone to evaporation.

The surface area of constructed wetlands should be at least 1% of the contributing drainage area, and the wetlands should have a length to width ratio of at least 1.5:1.[11] In order to increase the efficiency of the retention pond, a sediment forebay must be incorporated as a pretreatment device.

As with all other stormwater management practices, stormwater wetlands also require ongoing maintenance to retain their maximum effectiveness. However, several design features can decrease the amount of maintenance that a wetland needs. For example, a reverse-slope pipe or a weir outlet with a trash rack should be used to prevent clogging of the outlet; orifices should have diameters no less than 3"; and direct maintenance access should be provided to the forebay to allow for sediment removal. Selection of plant species is one of the most important parts of creating a stormwater wetland, as the plants are largely responsible for the pollutant and sediment retention and uptake. Please refer to **Section IV** for a list of plant species suitable for planting in constructed wetlands.

A constructed wetland in Franklin, MA

4. Bioretention Cells (Rain Gardens)

Bioretention cells (otherwise known as rain gardens) are landscaped areas that mimic upland vegetation systems. These systems are designed to trap stormwater, infiltrate it, and treat it by means of vegetational uptake (uptake of certain minerals and nutrients by vegetation), biological degradation (microbial/bacterial metabolic activities), and/or gravitational sediment removal. Depending on the choice of plant materials, they can provide cover and forage for wildlife, while increasing the beauty of the site.

Completed Rain Garden @ Broad Meadow Brook Wildlife Sanctuary, Worcester, MA.
A good soil mix for rain gardens is 50-60% sand, 20-30% topsoil & 20-30% compost. Shredded hardwood as mulch keeps the soil moist and ready to soak up rain and reduces maintenance needs.

Runoff is conveyed by downspouts or as sheet flow to the treatment area, which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants [12]. Runoff passes first over or through a sand bed, which slows the runoff and distributes it evenly along the ponding area. The ponding area is made up of a surface organic layer, ground cover and the underlying planting soil. The ponding area is graded such that there is a depression in the middle where water remains until it infiltrates or evaporates. The depression should be designed to hold up to 6 inches of water.[13] An overflow structure should be provided for situations where the ponding area is not sufficient. The infiltrated water may also be collected through an underdrain and outlet, which would drain water to a constructed wetland or retention pond for further treatment.

Bioretention cells can be used in both residential and commercial projects. In residential subdivisions, bioretention cells are used to retain and infiltrate stormwater locally so that it does not need to be conveyed and treated by means of a more extensive stormwater management system. Each residential lot would typically have one or more bioretention cells (which are essentially landscaped gardens) that receive stormwater from the roof and driveway and infiltrate it to the ground. Each homeowner is responsible for maintaining the bioretention cell(s) on their property, just as they would maintain their garden. In commercial projects, bioretention cells are installed as depressed islands in the parking lot. Stormwater is directed to these islands, where it is treated and infiltrates into the ground.

Construction photos show how gutter downspouts dump to a stone-lined channel then through a mulched swale to a depressed planting bed.

Design Considerations

The design of bioretention cells must consider the site area, slope, soils, groundwater, and maintenance needs. Bioretention cells should be designed to occupy 5 to 7 percent of the drainage area multiplied by the rational method runoff coefficient ("c") determined for the site.[14] Recommended minimum dimensions are 15 feet by 40 feet for bioretention cells receiving parking lot runoff. Bioretention cells on individual house lots can be much smaller.

The site should have shallow slopes (approximately 5% or less) so that water flow is guaranteed but velocity is not too high. An underdrain should be used in situations where soils are tight and there is a concern about the cell backing up or flooding. (In areas of less pervious soils, bioretention cells may be constructed by importing more permeable soils for the cell itself, in combination with an underdrain which prevents water from ponding above a less permeable natural soil layer.) An underdrain should also be used where the water table is close to the surface and there is a concern about groundwater pollution. In other situations, an underdrain generally is not needed.

Bioretention cells need to be maintained regularly to ensure the presence of mulch and good soil, attend to any diseased or dead plants, and remove collected sediment, litter and debris.

5. Pervious Paving Surfaces

Pervious paving surfaces typically consist of a permeable surface with an underlying crushed/broken stone reservoir to temporarily store runoff before it infiltrates into the ground. The main purposes of this application are to reduce the amount of stormwater runoff from paved areas and to infiltrate stormwater into the underlying soils. By reducing the amount of stormwater runoff, pervious paving surfaces reduce the cost of stormwater management.

Pervious paving surfaces that are now available include porous asphalt, pervious concrete and grass pavers. Porous asphalt and pervious concrete appear to be the same as traditional pavement from the surface, but incorporate void spaces to allow infiltration. These systems have been applied successfully in a few locations in New England where soils consist of particularly well-drained sands and gravels that allow the pores to drain rapidly. However, in areas of tighter soils, porous asphalt and pervious concrete are generally not recommended in this region because water remaining in the void areas is subject to the freeze-thaw cycle which stresses and weakens the pavement. Grass pavers are a viable option in New England's climate.[15] Grass pavers consist of concrete interlocking blocks or a synthetic fibrous gridded system with open areas designed to allow grass to grow. The design should allow for infiltration into the underlying soils so that stormwater does not pond near the surface.

Design Considerations

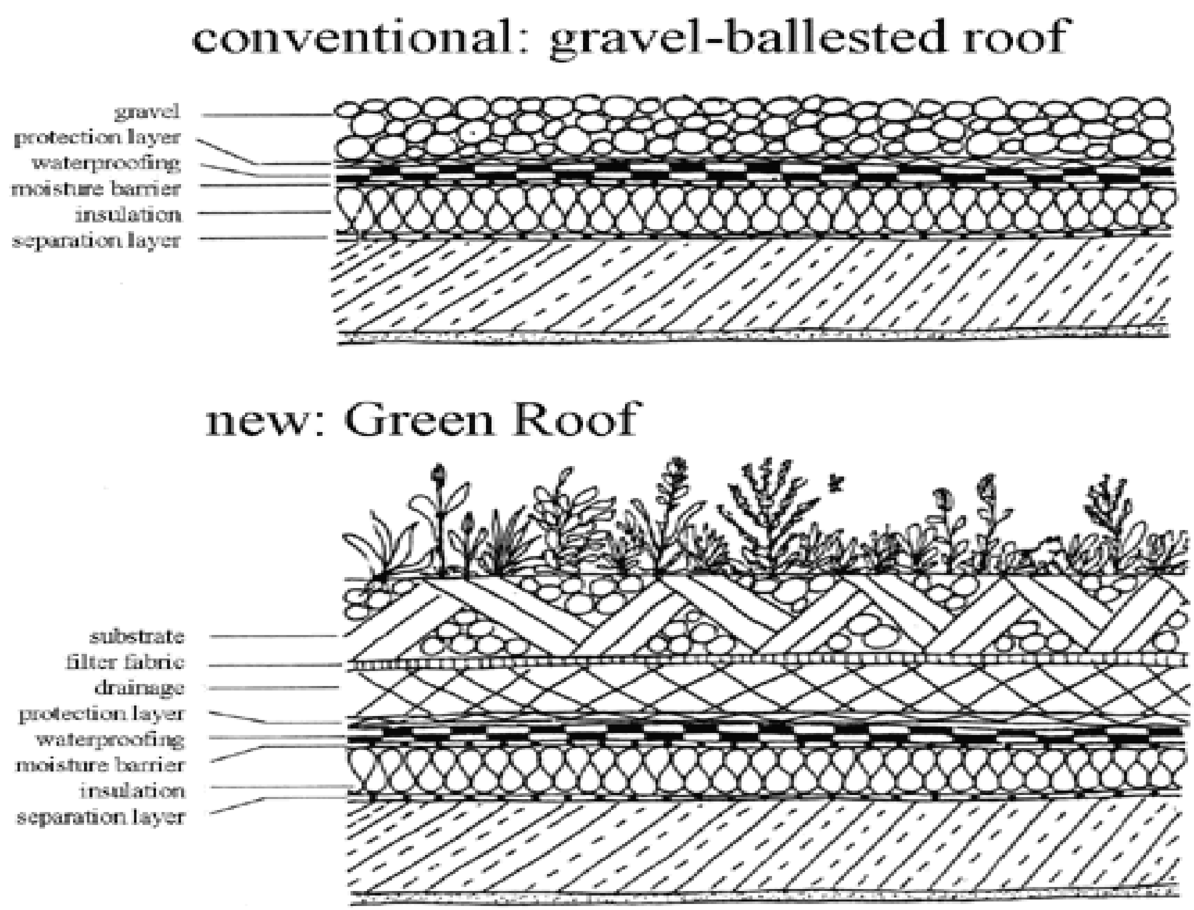
Grass pavers are most suitable for low-traffic areas such as the overflow areas of commercial or office parking lots, residential driveways, and service areas that will be subject to light traffic. If these systems are used, stormwater calculations should account for the reduced amount of runoff generated by areas with grass pavers. In general, grass paver systems should not be salted in the winter because this will threaten the viability of the plants. However, salting will not typically be required in the low-traffic areas where grass pavers are recommended. Concerns regarding clogging should be noted. Asphalt can be drawn into the voids, clogging the pore space and reducing exfiltration. Clogging can also occur due to sand and finer materials carried in on car tires, blown to the site via wind, from winter sanding, or through unstable land surfaces adjacent to the porous pavement. Some need to be maintained by monthly vacuum sweeping.

A section of the parking lot at WPI in Worcester, MA has been paved with porous concrete. The melting snow goes right through the concrete!

6. Roof Gardens/Green Roofs

Roof gardens are precultivated vegetation mats placed on several layers including a fertilizer layer, a substrate mat, a protective fleece and an impervious membrane. Roof gardens provide several functional benefits such as reducing stormwater runoff volume and pollutant load, increasing the energy efficiency of buildings, improving air quality by removing particles in the air and by photosynthesis, and increasing the aesthetic value of the area. Roof gardens can be built on almost any rooftop, from a residential building to a commercial or industrial building. The Figure below shows a typical application.[16] Roof gardens are recommended for use in large commercial, office, and institutional buildings that have flat roofs.

Once established, roof gardens do not need extensive maintenance other than occasional fertilization and weeding. During the initial stage some watering might be required; however, usually within six months the plants are able to sustain themselves.
Since the soil layer is not deep, it will not support tall vertical growth or large plants; therefore, cutting or mowing is not required. Load reserves of at least 15 pounds per square feet beyond snow load requirements are needed to install a roof garden.[17] If properly built over a suitable roofing membrane, roof gardens do not present a leaking problem.



Typical roof garden design

7. Retention Basins/Wet Basins

Retention basins are constructed to have a permanent pool of water to treat stormwater. The pool allows settling of sediments, removal of soluble pollutants by algal uptake, and some groundwater recharge[18]. The basins are designed to include additional storage capacity to control peak discharge rates. The primary component of a retention basin is a deep, permanent pool, but the basin may also include a shallow marsh or a sediment forebay to increase sediment and nutrient removal.[19] In general, it is not recommended that retention basins be used as the primary means of attenuating peak runoff rates or removing pollutants. Wet Basins are generally a preferred system since they have greater pollutant uptake functions. However, retention basins may be used in subdivisions as well as commercial and industrial areas when other stormwater management systems are not feasible or sufficient because of site conditions or the nature of the development program. Retention basins may also be used in series with constructed wetlands as a sediment trap, particularly during construction.

Design Considerations

Retention basins must drain a sufficiently large area to maintain a permanent pool of water. The minimum recommended area is typically around 20 acres, assuming impervious surface percentages typical of suburban developments.[20] Within the watershed area that drains to the retention basin, the slopes and the stormwater conveyance system must result in a measured flow of stormwater that does not flood the basin all at once. The use of filter strips and swales can help slow and infiltrate water on its way to the basin.

Retention basins can be constructed in a wide range of soil types. However, when native soils have a rapid percolation rate, soils should be compacted or supplemented sufficiently so that the pond does not dry up during the dry season. The soils should retain sufficient infiltration potential so that the pond also continues to play a role in groundwater recharge. In order to increase the efficiency of the retention basin, a sediment forebay must be incorporated as a pretreatment device. As with constructed wetlands, retention basins should use non-clogging outlets and provide easy dredging access to reduce long-term maintenance requirements and difficulties. Design of the outlet control needs to be an iterative process with thought given to both retaining the water quality volume to get gravity separation and designing an outlet that is less likely to clog.

Retention Basin

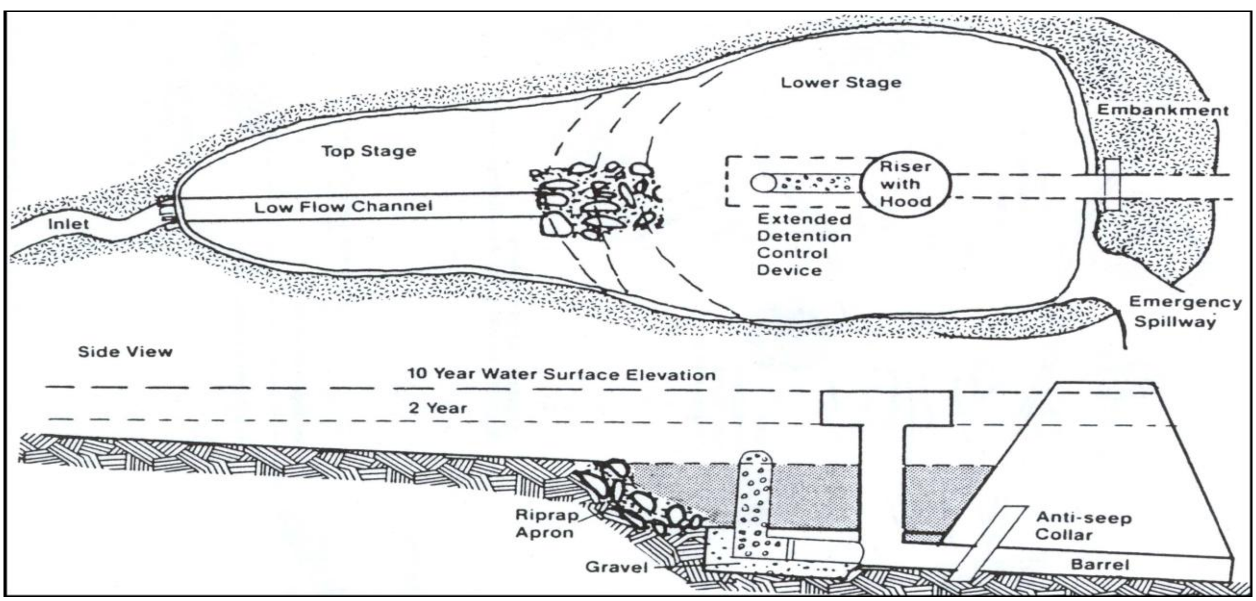
8. Detention Basins

Detention basins are depressed areas whose outlets have been designed to detain stormwater runoff for some minimum time to allow particles and associated pollutants to settle. Since the aim of detention basins is mainly to control flooding and remove sediments, they do need not to have a permanent pool and therefore can be dry during non-flood conditions. Typically, they are used in conjunction with other stormwater management systems such as retention basins or constructed wetlands as a primary treatment.

Good design discourages the use of detention basins as the primary means of flood control. Instead, vegetated swales and filter strips should be used whenever possible to attenuate peak runoff rates. When site characteristics do not allow use of such practices, however, detention basins may be considered as part of the stormwater management system. In addition, detention basins may be used as a pre-treatment device to settle out particulates prior to discharge to a constructed wetland or retention basin, where additional treatment and infiltration will occur.

Design Considerations

Detention basins are most practical for use on sites that are at least 10 acres, which allows for the use of larger outlet orifices that are less likely to clog. Detention basins can be used on sites with a slope of up to about 15 percent. There is no minimum slope requirement, provided that there is enough change in elevation to ensure flow. Soil type is not a factor except in areas with rapidly percolating soils such as sand. In these areas, an impermeable liner should be used to prevent groundwater contamination from untreated runoff. Detention basins should be designed with sediment forebays, which allows sediment to be trapped prior to entering the detention basin. This feature also reduces maintenance requirements for the detention basin. Extended Detentions Basins must include sediment forebays to achieve 50% TSS removal credit. As with constructed wetlands, detention basins should use non-clogging outlets and large orifices and should provide easy dredging access to reduce long-term maintenance requirements and difficulties. Any detention basin should provide landscaping and planting to minimize its visual impacts. The plants selected for the ponding area should be able to withstand both wet and dry periods. Along the perimeter of the basin, however, the plants should be adapted to dry conditions and should create a visual vegetated buffer.



Schematic design of a dry extended detention pond

9. Catch Basins and Drain Pipes

Catch basins are storm drains that capture and roughly filter stormwater through a grate or curb inlet and capture sediment, debris and associated pollutants in a deep sump [21]. In most cases a hood is also included to separate oil and grease from the stormwater. The essential function of a catch basin is to act as a pretreatment device for other structures incorporated into a storm sewer system. The performance of a catch basin in removing sediment and pollutants will depend greatly on the size of the drainage area, the size of the sump, and the amount of maintenance it receives. Although catch basins are currently used in virtually all circumstances, they typically cannot remove pollutants as well as most of the other practices mentioned in this section and require frequent maintenance. Catch basins should only be used when the other practices mentioned in this section prove unfeasible. The designer must document the reason(s) why the other practices are not feasible before the use of catch basins may be approved.

When catch basins are used, it is preferable if they discharge individually or in pairs to nearby swales, constructed wetlands, or bioretention cells, rather than carrying runoff further to a larger retention/infiltration system. Lengthy catch basin-piped drain-manhole networks are discouraged. In general, the goal is to use vegetated, low-velocity channels to hold and infiltrate stormwater locally, not to efficiently capture and deliver stormwater to watercourses.

Design Considerations

Catch basins should be designed to hold a combined volume of at least 400 cubic feet per acre of contributing impervious area and have sumps that are at least four feet deep. Flow from the catch basin/drain pipe system should be directed to another stormwater management device, such as a constructed wetland, for further treatment. Catch basin inlets should be cleaned regularly (at least twice a year) and after large storms. Removed sediment should be disposed of in accordance with applicable local, state and federal guidelines and regulations.

A Boardwalk replaces a decrepit building along the Branch River in Burrillville, RI. Drainage from the abutting new parking lot flows through a VorTek separator before discharging to the Branch River.

III. Erosion and Sedimentation Control

Erosion and sedimentation control practices should be incorporated into the planning, construction, and operation of any project. Specific measures should be presented for review prior to construction.

a. Site Planning

The most important erosion control practice is to minimize clearing and regrading, as discussed in **Section I**, Site Planning.

PRINCIPLE: Any proposed project on a previously undeveloped site should accommodate the development program in a way that minimizes clearing and regrading, especially in areas of steep slopes, erosion-prone soils, or sensitive vegetation. For redevelopment projects, the site plan should concentrate development in previously disturbed areas to the extent possible.

The initial step to control erosion and sedimentation is to develop a plan that is appropriate to the site features including topography, soils, drainage ways, and natural vegetation. The site planning process should begin with a thorough evaluation of sensitive areas requiring protection as well as less sensitive areas suitable for development. The site plan should delineate a limit of work that limits clearing and regrading and protects the most sensitive areas, based on the criteria in Table 3-1. For example, in residential subdivisions, native vegetation should be retained on individual houselots to the extent possible, rather than creating larger lawns.

Table 3-1: Guidelines for identifying sensitive site features[22]

Topography	Drainage	Soils	Natural vegetation
Slopes that are steeper and/or longer typically create more erosion. Slopes that exceed the following thresholds are likely to be sensitive and erosion-prone: • Slopes of 5-7% longer than 300 feet • Slopes of 7-15% longer than 150 feet • Slopes of more than 15% longer than 75 feet	Where possible, retain natural drainage ways and depressions and utilize for stormwater conveyance	Consider factors such as erodibility, permeability, depth to water table and bedrock, and soils with shrink/swell potential or slippage tendencies. The most erodible soils contain high proportions of silt and very fine sand. The presence of clay or organic matter tends to decrease erodibility.	This is the most important factor in preventing erosion. Vegetated buffers filter runoff, decreasing runoff velocity, and increase infiltration capacity.

b. Construction Period Impacts

Prior to the commencement of construction, the limit of clearing and limit of work identified on the site plan and approved by the Town must be suitably marked. Acceptable markers include survey tape or plastic fences. These markers are in addition to any silt-fences or hay-bales that the Conservation Commission may require for sensitive areas such as wetlands, streams and their buffers. Construction activities and construction traffic must be limited to the area identified on the site plan, and no stockpiling of materials, soils, or debris or other activity may occur outside of the limit of work.

PRINCIPLE: As a condition of approval, every proposed project should submit and adhere to a construction management plan that addresses soil stabilization, sediment retention, perimeter protection, construction scheduling, traffic area stabilization and dust control.

For any land disturbance of 1-acre or more, coverage must be obtained under the EPA National Pollution Discharge Elimination System (NPDES) Construction General Permit. A Stormwater Pollution Prevention Plan (SWPPP) must be prepared as part of receiving coverage under the Permit. Please keep in mind that sediment traps used for construction are designed differently than sediment forebays used for pretreatment of post construction runoff. In addition to controlling erosion, the Stormwater Pollution Prevention Plan must include addressing contamination of runoff during the construction and land disturbance phases of a project. For example, fueling of vehicles needs to be addressed in the plan.

1. Soil Stabilization

The construction management plan should outline a plan for cover and/or stabilization of erodible surfaces that are not the immediate focus of construction activity. Towns require covering and stabilization as a way of minimizing soil erosion as well as sedimentation in the Town's water bodies and storm sewer system. Cover measures must be implemented on areas that have already been disturbed but will not be worked on during the next 7 days during dry conditions or next 2 days during wet conditions. Acceptable cover methods include, but are not limited to, the use of mulch, erosion control nets and blankets, plastic covering, seeding and sodding. These are described in the following paragraphs.

Mulching is generally considered to be a suitable short-term protective measure. The main purpose of mulching is to protect the site from erosion by stabilizing soils and reducing stormwater runoff velocity. Mulch can also enhance plant establishment by conserving moisture, holding fertilizer, seed and topsoil in place, and moderating soil temperature. The most commonly used mulches include straw, wood fiber or cellulose, compost and wood chips. The effectiveness of mulching depends on site characteristics and maintenance: if the site is prone to high winds or has steep slopes, additional steps should be taken to anchor the mulch, such as planting vegetation or providing netting or blanketing. The thickness of the cover should be maintained at all times and any area that has eroded should be remulched and anchored until it has been stabilized.

Similar to mulching, plastic covering is also acceptable as a short-term protective measure. This technique simply involves covering the area of concern with a plastic sheet and using tires or sandbags to weight the plastic down. Plastic covering is generally used on cut and fill slopes and stockpiles. Plastic covering should not be used if there is a sensitive area located downslope, because of the rapid runoff created by the plastic covering. Although this is a fairly easy technique to apply, it requires careful maintenance. The plastic cover can easily be torn or damaged by the sun and can clog drainage systems if not removed properly. Therefore, regular maintenance should be provided to ensure that the plastic is undamaged at all times and fully removed after it is no longer needed.

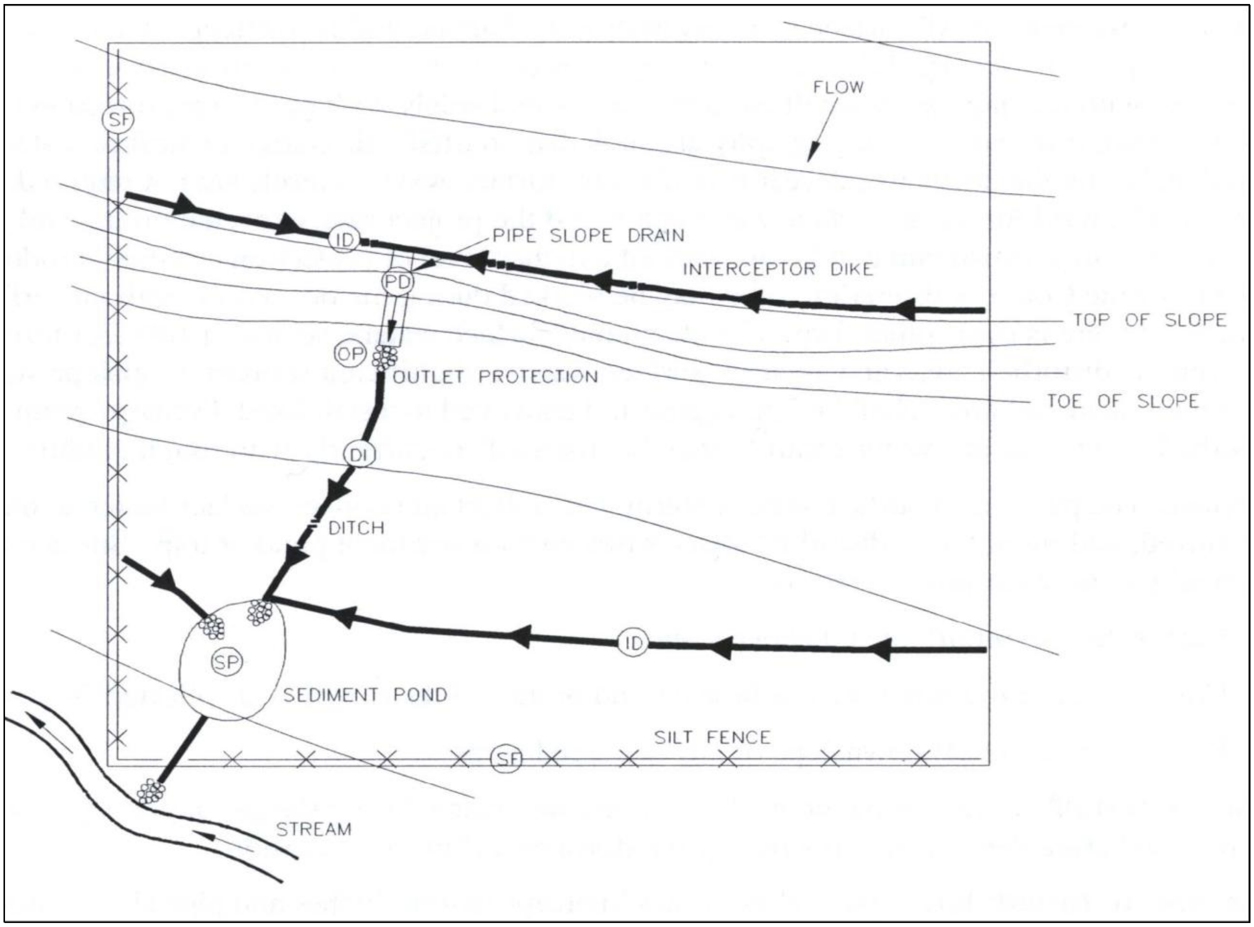
Seeding, sodding and erosion nets and blankets are usually more appropriate as long-term solutions for areas that will remain unworked for months. **Section IV** lists recommended species to plant for erosion control purposes. A well-designed landscaping plan can easily incorporate areas of planting for permanent erosion control. If the area must be stabilized immediately, then the use of sodding is more appropriate since it can provide immediate erosion protection. Sodding is appropriate for use on residential or commercial lawns, steeply-sloped areas, waterways and channels carrying intermittent flow, and areas around drop inlets that require stabilization.[23] Sod maintenance is essential during the establishment period. Sod should be provided with adequate moisture and fertilizer. If the sod does not root and stay healthy, it should be replaced by new sodding or a different technique.

Erosion control nets or blankets, also referred to as geotextiles, are another suitable long-term stabilization technique [24]. Geotextiles are used for preventing erosion and holding seed and mulch in place on steep slopes, as well as in channels to aid vegetation establishment. Geotextiles can be made of synthetic materials such as polypropylene, polyester, polyethylene, nylon, and polyvinyl chloride as well as biodegradable materials such as mulch matting, jute, coconut fiber and other wood fibers. For effective stabilization, good contact with the ground must be maintained and no erosion should occur beneath the net or blanket. Synthetic geotextiles can be sensitive to light and wind; therefore, they should be inspected regularly and any problematic areas should be repaired immediately.

2. Sediment Retention

Sediment retention from construction sites is a three-step process. First, all surface runoff from disturbed areas must be intercepted since this runoff contains high sediment loads. Second, the runoff must be conveyed to a sediment trap or pond where sediment removal will occur. Finally, the cleaned runoff must be discharged downslope of any disturbed areas. Typically, interceptor dikes and swales are used to intercept runoff; check dams are used to reduce flow velocity and remove sediment; ditches and pipes are used to convey the runoff; and riprap or level spreaders are used to dissipate runoff velocity in a non-erosive manner. As shown below[25], interceptor dikes can collect the runoff and direct it to pipes and/or ditches which can convey the runoff to a sediment pond. The outflow from the pond can be connected to a stream (as shown in this case) or to a vegetated area. Riprap may be used to stabilize outlets. Check dams can be incorporated into the design to reduce the velocity of the runoff. Typically, check dams are installed in swales or ditches and consist of small gravel, rock, sandbag, log or straw dams.

As mentioned above, sediment must be conveyed to sediment traps or ponds prior to being discharged. Sediment traps should be used for areas less than about three acres, and sediment ponds should be used for larger areas. Stormwater runoff is conveyed through these structures, where sediment is settled (mostly small particles of 0.02 mm or so) and turbidity is slightly reduced.[26] When sediment reaches one foot in depth, the trap or the pond should be cleaned. Any embankments or slopes should also be routinely checked and any damage properly repaired. The construction management plan must state how surface runoff will be intercepted and settled before it is released into the ground or off-site.



Sample sediment retention plan

3. Perimeter Protection

While interceptors and sediment traps/ponds discussed above will provide the primary sediment retention on construction sites, perimeter protection is also required to prevent residual sedimentation of adjacent lands and waters. The construction management plan should identify measures to prevent sediment from being transported off of the site. Again, the purpose of this requirement is to minimize sedimentation in the Town's water bodies, storm sewer system, and adjacent properties. Measures such as vegetated filter strips, silt fences, or brush barriers should be provided at the limit of work to filter runoff and capture sediment. In places where the limit of work is not near the edge of the site, a natural vegetation buffer of 40 feet is generally considered to be an acceptable retention system, except where the natural vegetation is a wetland, a wetland buffer or otherwise sensitive landscape feature, in which case a silt fence or similar device should generally be used. The Figure below[27] illustrates proper installation of hay bales for sediment retention purposes.

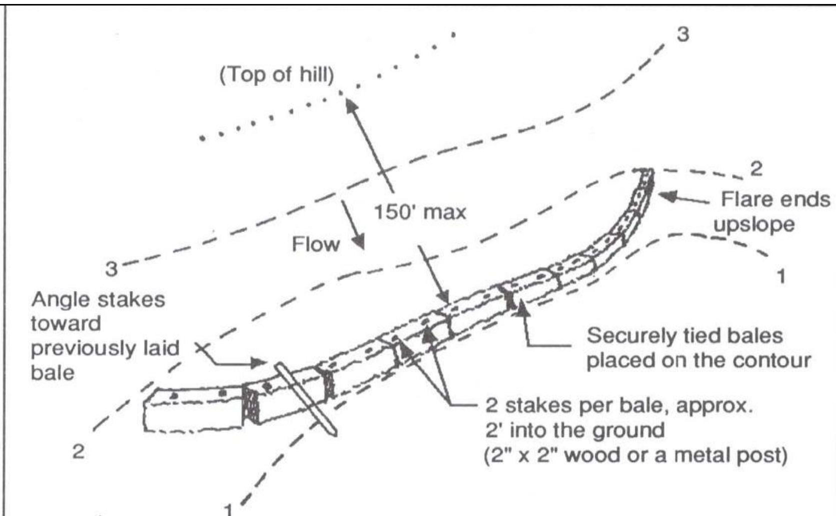


Figure 6.4-1: Placement and anchoring detail for straw bale sediment trap

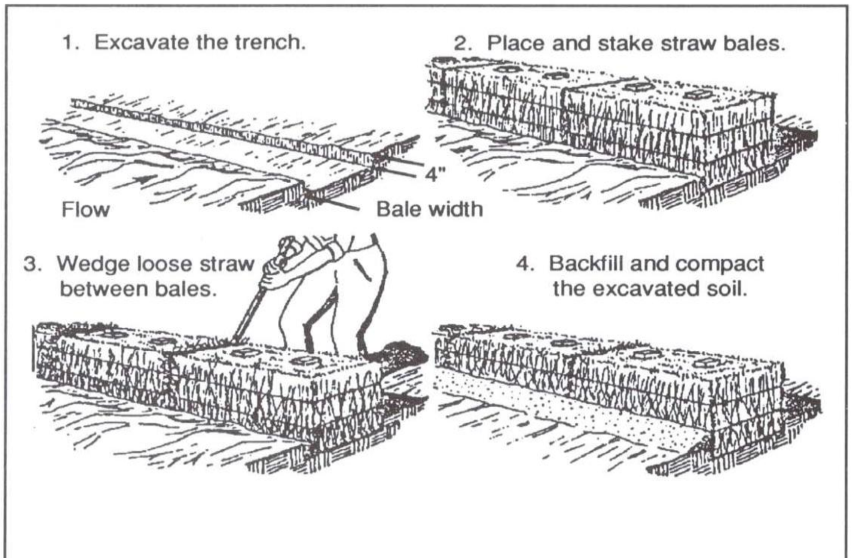


Figure 6.4-2: Construction of a straw bale barrier

Installation of hay-bales for sediment retention purposes

4. Other Practices

Scheduling of Operations

The construction management plan should state when clearing, grubbing, grading, construction, and replanting will occur on each section of the site. If construction phasing has not been determined at the time of the initial permitting, this section of the construction management plan may be submitted later, but must be submitted at least 60 days prior to the desired commencement of construction. Construction must be phased by area so that the smallest practical area of land is exposed for the shortest possible time.

Traffic Area Stabilization

To reduce the amount of sediment transported off site by construction vehicles and to reduce the erosion of areas disturbed by vehicle traffic, roads and parking areas should be stabilized immediately after initial grading. Not only will this stabilization reduce amount of sediment transported out of the site; it will also reduce the amount of easily erodible mud that forms on site. Stabilization can be achieved by use of a 6 inch deep layer of crushed rock, gravel base, or crushed surfacing base on the area of construction entrances or roads and parking areas. For any area that will be subject to long-term or high-volume construction vehicle traffic, a truck wash should be implemented, with dirty water channeled through sediment traps or ponds prior to discharge.

Dust Control

The construction management plan should commit to minimizing wind transport of dust from exposed soil surfaces onto roadways, drainage ways, and surfaces waters by spraying exposed soils with water until they are sufficiently damp so as to not produce dust, but not so wet as to produce runoff, whenever weather conditions are dry and windy.

IV. Landscape Design

This section of the Guidebook addresses three critical goals for the Towns in the Blackstone Valley: stabilizing water use at a sustainable level; creating landscapes that minimize natural habitat destruction and maximize habitat value; and encouraging the development of landscapes that provide environmental quality and visual relief.

a. Water-Sensitive Landscaping

The Blackstone Valley currently suffers from a seasonal water supply shortage due in large part to lawn and garden watering. At the same time, development and the attendant rise in impervious surfaces is altering the natural hydrological cycle and reducing recharge to the aquifers. Without careful attention to water use and hydrologic systems, the Valley could face continued water shortages as well as large future expenditures related to public water supply.

PRINCIPLE: Site plans and landscape plans for all proposed projects should take appropriate steps, as outlined in this section, to minimize water use for irrigation and to allow for natural recharge of groundwater.

On previously undeveloped ("greenfield") sites, the most important water-sensitive practice is to minimize the disturbance and clearing of natural vegetation. Guidelines to meet this objective are provided in **Section I** and **Section III** of this Guidebook. Typically, this will mean preserving some portion of the site as open space, plus reducing the area of lawn and garden in favor of native vegetation in both residential and commercial/industrial projects. In places where native vegetation is cleared, at least some of the area should function as a groundwater recharge system. For example, a landscaped garden could function as a bioretention cell through appropriate subsurface design and selection of species, or portions of a lawn could serve as a vegetated filter strips for driveway runoff if properly graded. In general, the landscape design should aim to:

- Retain and recharge water onsite;
- Preserve existing vegetation to the maximum extent possible;
- Preserve soil permeability during development; and
- Minimize the use of turf grass in landscaping, opting instead for a variety of native species.

To keep the water onsite, impervious areas need to be reduced to the maximum extent practical. Planting beds should be designed to conserve the water they receive. This can be achieved by grading the beds so that slope is gradual and stormwater runoff will have more time to percolate into the soil, and by using plant species that do not require large amounts of water.

To meet water conservation objectives, in-ground irrigation systems are discouraged. However, if irrigation systems are proposed, they should be water-efficient drip systems or soil soakers equipped with automatic sensors that prevent watering when soils are already wet, or when it is raining. Drip irrigation is defined as the frequent slow application of water to a very small area in the root zone of the plant. Water slowly drips through either porous plastic pipes or emitters located below the soil surface. Drip systems have been found to reduce water use by 20-50%.[28] Soil soakers consist of long plastic or canvas tubes perforated with tiny holes through which the water seeps as a fine mist. Soil soakers are connected to a garden hose and can be left in place on the surface of the planting bed or buried under the mulch.

For garden areas, landscape plans should specify the use of a suitable mulch. Use of mulch is beneficial for several reasons. Mulch layers:

- Help capture moisture for vegetation that would normally be lost through evaporation;
- Prevent erosion by protecting the soil surface from raindrop impacts and by reducing the velocity of overland flow;
- Help prevent crusting, sealing and compaction of the surface, thereby preserving the infiltration rate;
- Protect seeds by forming an insulating layer against extreme heat and cold and by creating a suitable microclimate for seed germination; and
- Reduce weed growth and the need for herbicide application.[29]

Good mulching materials include compost, pine bark, pine straw (pine needle bales), leaf mold, rotted manure, lawn clippings, aged and shredded hardwood bark, aged wood chips, and straw or chopped hay.

b. Plant Species

In the interest of striking an appropriate balance between community development and conservation, Towns in the Blackstone Valley are committed to retaining natural habitats and habitat functions on developed sites to the maximum extent possible. In addition, to further water conservation goals, drought-tolerant species should be used in appropriate situations.

PRINCIPLE: Landscape plans should follow the guidelines in this section for selecting species that are most appropriate to the site conditions. Native species and habitat-creating species should be used in all landscape plans to the maximum extent possible. Invasive species identified in this section should not be planted under any condition.

Landscape designers working on projects should use the following lists to select the most appropriate species for each portion of their site. Recognizing that many species are well-suited to several circumstances, there is much overlap among the nine lists of species provided below. Each list is also divided into different forms of plants, such as shade trees, ornamental trees, evergreen trees, deciduous shrubs, groundcovers, and flowers. The lists are not all-inclusive, and landscape designers may propose the use of other species not included here, provided they are not invasive species. However, these lists are intended to provide a sufficiently wide range of species that are generally acceptable under different circumstances.

1. Native Species

The following species are native to the Blackstone Valley and well-adapted to the area's climate. Many of the species also provide good wildlife habitat value.

Shade Trees

Botanical Name	Common Name
Acer rubrum	Red Maple
Acer saccharum	Sugar Maple
Betula lenta^{F}	Sweet Birch^{F}
Betula alleghaniensis^{F}	Yellow Birch^{F}
Betula papyrifera	Paper Birch
Carya ovata^{+}	Shagbark Hickory^{+}
Castanea dentate	American Chestnut
Fagus grandifolia	American Beech
Fraxinus americana	White Ash
Fraxinus pennsylvanica	Green Ash
Juglans cinerea^{+}	Butternut^{+}
Liquidambar styraciflua^{F}	Sweetgum^{F}
Liriodendron tulipifera^{F}	Tulip Tree^{F}
Nyssa sylvatica	Black Tupelo
Platanus occidentalis	American Sycamore
Quercus alba^{+F}	White Oak^{+F}
Quercus bicolor^{+F}	Swamp White Oak^{+F}
Quercus coccinea^{+F}	Scarlet Oak^{+F}
Quercus palustris^{+F}	Pin Oak^{+F}
Quercus rubra	Northern Red Oak
Salix nigra	Black Willow
Sassafras albidum	Common Sassafras
Tilia americana 'Redmond'	Redmond Linden
Ulmus americana, disease-resist. var.	American Elm

Notes:
$^{+}$ Recommended for planting on the portions of the site away from walks or roads.
^{F} These trees need extra care if they are planted during the fall season.
^ Canadian Hemlock is currently under attack by an insect that has no predator.

Evergreen Trees

Botanical Name	Common Name
Ilex opaca	American Holly
Juniperus virginiana	Eastern Red Cedar
Pinus rigida	Pitch Pine
Pinus strobus	Eastern White Pine
Thuja occidentalis	American Arborvitae
Tsuga canadensis	Canadian Hemlock^

Ornamental Trees

Botanical Name	*Common Name*
Alnus rugosa	Speckled Alder
Amelanchier canadensis	Shadblow Serviceberry
Amelanchier laevis	Allegany Serviceberry
Betula nigra[F]	River Birch[F]
Betula papyrifera[F]	Paper Birch[F]
Carpinus caroliniana[F]	American Hornbeam [F]
Cercis canadensis	Eastern Redbud
Cornus alternifolia[F]	Pagoda Dogwood[F]
Cornus florida ^[F]	Flowering Dogwood ^ [F]
Crataegus punctata	Dotted Hawthorn
Hamamelis virginiana	Common Witchhazel
Larix laracina	American Larch
Larix decidua	European Larch
Ostrya virginiana	Hop Hornbeam
Prunus pennsylvanica[F]	Pin Cherry[F]
Prunus virginiana[F]	Common Chokecherry[F]
Salix discolor	Pussy Willow
Viburnum lentago	Nannyberry Viburnum

Notes:
^ Cornus florida has been adversely affected by an anthracnose epidemic in the Northeast U.S. in the past two decades. Anthracnose spreads rapidly to other flowering dogwoods. Before using this species, check with local agricultural extensions for the status of anthracnose.
[F] These trees need extra care if they are planted during the fall season.

Deciduous Shrubs

Botanical Name	*Common Name*
Arctostaphylos uva-ursi	Bearberry
Aronia melanocarpa	Black Chokeberry
Clethra alnifolia	Summersweet Clethra
Comptonia peregrina	Sweetfern
Cornus alterniflora	Pagoda Dogwood
Cornus amomum	Silky Dogwood
Cornus racemosa	Gray Dogwood
Cornus rugosa	Redleaf Dogwood
Ilex verticillata	Common Winterberry
Lindera benzoin	Common Spicebush
Myrica pennsylvanica	Northern Bayberry
Azalea nudiflorum	Early Deciduous Pink Azalea
Rhododendron roseum	Roseshell Azalea
Rhododendron viscosum	Swamp Azalea
Rhus glabra	Smooth Sumac
Rhus typhina	Staghorn Sumac
Rosa carolina	Carolina Rose
Rubus odoratus	Flowering Raspberry
Sambucus canadensis	American Elder
Vaccinium corymbosum	Highbush Blueberry
Viburnum acerifolium	Mapleleaf Viburnum
Viburnum cassinoides	Witherod Viburnum
Viburnum dentatum	Arrowwood Viburnum
Viburnum trilobum	American Cranberrybush Viburnum

Evergreen Shrubs

Botanical Name	*Common Name*
Juniperus communis 'Compressa'	Common Juniper
Kalmia angustifolia	Sheeplaurel
Kalmia latifolia	Mountainlaurel
Taxus canadensis	Canadian Yew

Groundcovers

Botanical Name	*Common Name*
Cornus canadensis	Bunchberry Dogwood
Gaultheria procumbens	Checkerberry Wintergreen
Mitchella repens	Partridgeberry
Vaccinium angustifolium	Lowbush Blueberry
Vaccinium macrocarpum	Cranberry

Meadow Grasses/Wildflowers

Botanical Name	*Common Name*
Festuca elatior	Tall Fescue
Lolium perenne	Palmer II Perr. Ryegrass
Sorghastrum nutans	Indian Grass
Panicum	Blackwell Switchgrass
Andropogon gerardii Vitman	Big Bluestem
Schizachyrium scoparium	Little Bluestem
Calamagrostis canadensis	Blue Joint Reedgrass
Antennaria alpina	Alpine Pussy-Toes
Aristida dichotoma	Poverty Grass
Aster linariifolius	Bristly Aster
Eragrostis spectabilis	Purple Lovegrass
Houstonia caerulea	Bluets
Juncus bufonius	Toad Rush
Senecio aureus	Golden Ragwort

2. Salt Tolerant Species

These species are well-suited to roadsides and other locations that are likely to collect salty winter runoff.

Notes:
* Native Plants
+ Recommended for planting on portions of the site away from walks or roads.
[F] These trees need extra care if they are planted during the fall season.

Shade Trees

Botanical Name	Common Name
Acer campestre	Hedge Maple
Aesculus hippocastanum	Horse-chestnut
*Betula lenta**[F]	Sweet Birch*[F]
*Betula alleghaniensis**[F]	Yellow Birch*[F]
*Fraxinus americana**	White Ash*
Gleditsia triacanthos inermis	Thornless Honeylocust
*Nyssa sylvatica**	Black Tupelo*
Quercus alba+*	White Oak*+
Quercus macrocarpa+	Bur Oak+
Quercus robur+	English Oak+
Quercus rubra	Red Oak
Ulmus glabra	Scotch Elm
Ulmus pumila	Siberian Elm

Ornamental Trees

Botanical Name	Common Name
*Amelanchier canadensis**	Shadblow Serviceberry*
*Betula papyrifera**[F]	Paper Birch*[F]
*Betula populifolia**[F]	Gray Birch*[F]
*Prunus pennsylvanica**[F]	Pin Cherry*[F]
*Prunus virginiana**[F]	Common Chokecherry* [F]
Pyrus calleryana[F]	Callery Pear [F]
Pyrus calleryana 'Bradford'	Bradford Pear
*Salix discolor**	Pussy Willow*

Evergreen Trees

Botanical Name	Common Name
*Juniperus virginiana**	Eastern Red Cedar*
Picea pungens 'glauca'	Blue Colorado Spruce
Pinus nigra	Austrian Pine
Pinus ponderosa	Ponderosa Pine
*Pinus rigida**	Pitch pine*

Deciduous Shrubs

Botanical Name	Common Name
*Arctostaphylos uva-ursi**	Bearberry*
*Aronia melanocarpa**	Black Chokeberry*
*Aronia prunifolia**	Purplefruit Chokeberry*
Hippophae rhamnoides	Common Seabuckthorn
*Lindera benzoin**	Common Spicebush*
*Myrica pennsylvanica**	Northern Bayberry*
*Rhus glabra**	Smooth Sumac*
*Rhus typhina**	Staghorn Sumac*
*Salix humilis**	Prairie Willow*
*Salix lucida**	Shining Willow*
Shepherdia argentea	Buffaloberry
Tamarix ramosissima	Five Stamen Tamarisk

*Vaccinium corymbosum**	Highbush Blueberry*
*Viburnum cassinoides**	Witherod Viburnum*
*Viburnum dentatum**	Arrowwood Viburnum*

Notes:
* Native Plants
+ Recommended for planting on portions of the site away from walks or roads.
[F] These trees need extra care if they are planted during the fall season.

Evergreen Shrubs

Botanical Name	Common Name
Pinus mugo	Mugo Pine
*Taxus canadensis**	Canadian Yew*

Groundcovers

Botanical Name	Common Name
*Vaccinium angustifolium**	Late Lowbush Blueberry*
Vaccnium palladum	Early Lowbush Blueberry

3. Urban Tolerant Species

These species are suitable for planting in "high-stress" environments where there will be pavement within the tree's drip line, high levels of pedestrian or vehicular traffic, vehicle exhaust and air pollution, or other urban stressors. For example, most of these species are generally well-suited to being planted in parking lot islands or other narrow landscaped areas.

Shade Trees

Botanical Name	Common Name
Acer campestre	Hedge Maple
*Acer rubrum**	Red Maple*
*Acer saccharum**	Sugar Maple*
Carpinus betulus fastigiata[F]	Pyramidal European Hornbeam [F]
Celtis occidentalis	Hackberry
Cladastris lutea	Yellowwood
Corylus colurna	Turkish Hazelnut
Eucommia ulmoides	Hardy Rubber Tree
*Fraxinus pennsylvanica**	Green Ash*
Gingko biloba	Maidenhair Tree (female +)
Gleditsia triacanthos inermis	Thornless Honeylocust
*Liquidambar styraciflua**[F]	Sweet Gum* [F]
Maclura pomifera inermis 'Park'	Park Osage Orange
*Nyssa sylvatica**	Black Tupelo*
Platanus acerifolia[F]	London Plane Tree [F]
Sophora japonica	Scholartree
Tilia cordata	Littleleaf Linden
Zelkova serrata[F]	Japanese Zelkova [F]

Notes:
* Native Plants
+ Recommended for planting on portions of the site away from walks or roads.
[F] These trees need extra care if they are planted during the fall season.

Ornamental Trees

Botanical Name	Common Name
*Betula nigra**[F]	River Birch* [F]
Cercidiphyllum japonicum	Katsuratree
Chionanthus virginicus	White Fringetree
Cornus kousa[F]	Kousa Dogwood [F]
Crataegus phaenopyrum	Washington Hawthorn
Magnolia stellata[F]	Star Magnolia [F]
*Ostrya virginiana**	American Hophornbeam*
Oxydendron arboreum[F]	Sourwood [F]
Prunus sargentii[F]	Sargent Cherry [F]

Pyrus calleryana [F]	Callery Pear [F]
Syringa reticulata	Japanese Tree Lilac

Deciduous Shrubs

Botanical Name	*Common Name*
Cornus sericea	Red Osier Dogwood
*Ilex verticillata**	Common Winterberry*
*Ilex verticillata 'Nana'**	Dwarf Winterberry*
Rhus aromatica 'Gro-low'	Dwarf Fragrant Sumac
Spiraea bumalda varieties	Spirea
*Vaccinium angustifolium**	Lowbush Blueberry*

Groundcovers

Botanical Name	*Common Name*
Cotoneaster horizontalis	Rockspray Cotoneaster
Hedera helix	English Ivy
Juniperus chinensis sargentii	Sargent Juniper
Juniperus horizontalis varieties	Creeping Juniper
Vinca minor	Periwinkle
Pachysandra terminalis	Japanese Pachysandra

4. Species for Erosion Control

These species can be used for stabilizing the ground and preventing erosion, and should be considered for planting in areas with steep slopes or unstable, erodible soils.

Botanical Name	*Common Name*
Aegopodium podagraria ‘Variegatum’	Variegated Snow-on-the-Mountain
Celastrus scandens	American Bittersweet
Clematis paniculata	Clematis
Cornus, shrubby types	Dogwood (Silky, Gray-stemmed, Gray, Redleaf)
Cotoneaster, low types	Cotoneaster
Cytisus spp.	Scotch Broom
Erica spp.	Heath
Euonymus fortunei ‘Colorata’ and cvs.	Wintercreeper
Forsythia suspensa and cvs.	Weeping Forsythia
Genista x ‘Lydia’	Genista lydia
Hedera helix and cvs.	English Ivy
Hemerocallis, all	Daylilly
Houtuynia cordata ‘Chameleon’	Chaeleon Houtuynia
Itea spp.	Sweetspire
Juniperus, low types	Juniper
Ligustrum, all	Privet
Myrica pennsylvanica	Northern Bayberry
Parthenocissus spp.	Ivy
Polygonum aubertii	Silver-vine Fleeceflower
Rhus aromatica and cvs.	Fragrant Sumac
Rosa, most	Most roses
Salix purpurea	Purpleosier Willow
Stephanandra incisa	Cutleaf Stephanandra
Symphoricarpos x chenaultii ‘Hancock’	Chenault Coralberry
Vinca minor and cvs.	Periwinkle
Yucca filamentosa	Yucca

5. Wetland Species

This list of species is generally well-suited for planting in constructed wetlands, wet swales, and other stormwater management areas that will typically be wet. Plantings in each section of the wet area must be selected according to the hydrological conditions in that area. See Figure 2-4 for a sample wetland planting layout.

Herbaceous Plants

Botanical Name	Common Name	Water Depth (see below)
Osmunda cinnamomea	Cinnamon fern	Transitional
Osmunda regalis	Royal fern	Transitional
Symplocarpus foetidus	Skunk cabbage	Transitional
Scirpus cyperinus	Woolgrass	Shallow
Thelypteris palustri	Marsh fern	Shallow
Caltha leptosepala	Marsh Marigold	Shallow
Polygonum coccineum	Pennsylvania smartweed	Shallow
Lobelia cardinalis	Cardinal Flower	Shallow
Lobelia siphilitica	Great Lobelia	Shallow
Iris versicolor	Blue Flag Iris	Medium
Acorus calamus	Sweet flag	Medium
Calla palustris	Water arum	Medium
Sparganium eurycarpum	Burreed	Medium
Scirpus americanus	Three-square	Medium
Scirpus fluviatilis	River bulrush	Medium
Sagittaria latifolia	Arrowhead	Medium
Ponetederia cordata	Pickerelweed	Medium
Peltandra cordata	Arrow arum	Medium
Potamogeton pectinatus	Sago pondweed	Deep
Vallisneria americana	Tapegrass	Deep
Ranunculus flabellaris	Yellow water buttercup	Deep
Ranunculus aquatilis	White water buttercup	Deep
Scirpus validus	Bulrush	Deep
Nymphea odorata	Fragrant white lily	Deep
Nuphar luteum	Spatterdock	Deep
Brasenia schrebrri	Watershield	Deep

Transitional: seasonally flooded; Shallow: seasonally flooded to permanently flooded to 15 cm; Medium: 15 to 50-cm water depths; Deep: 50 to 200-cm water depths.

Shrubs

Botanical Name	Common Name
Clethra alnifolia	Summersweet Clethra
Cornus amomum	Silky Dogwood
Ilex verticillata	Winterberry
Kalmia angustifolia	Sheep Laurel
Lindera benzoin	Spicebush
Rhodendron viscosum	Swamp Azalea
Viburnum recognitum	Northern Arrowwood
Vaccinium corymbosum	Highbush Blueberry

Trees

Botanical Name	*Common Name*
Nyssa sylvatica	Black gum
Quercus bicolor	Swamp oak
Fraxinus americana+	White ash+
*Fraxinus pennsylvanica**	Green Ash*
Acer rubrum+	Red Maple+
Quercus bicolor^	Swamp oak^
Betula nigra^	River birch^

Notes:
*Species that will tolerate flooding for more than 1 year
+Species that will tolerate flooding for one growing season
^Species that will tolerate flooding for less than 30 days during the growing season

Woody Wetland Plants

Botanical Name	*Common Name*
*Salix nigra**	Black Willow*
*Cephalanthus occidentalis**	Buttonbush*
*Cornus stolonifera**	Red-osier Dogwood*
Sambucus canadensis+	Elder+
Vaccinium corymbosum+	Blueberry+
Chamaecyparis thyoides+	Atlantic white cedar+
Alnus rugosa+	Spackled Alder+
Nyssa sylvatica^	Black gum^
Ilex opaca^	American Holly^

6. Moist Tolerant Species

These species require significant moisture, and many are adapted to survive periods of standing water. In general, these species should only be planted where local soil and topography produce moist conditions. Landscape designers should not rely upon irrigation to sustain these species.

Woody Plants

Botanical Name	*Common Name*
Acer negundo	Box Elder
Acer rubrum	Red Maple
Alnus rugosa	Speckled Alder
Amelanchier	Serviceberry
Andromeda polifolia	Bog Rosemary
Aralia spinosa	Devil’s Walkingstick
Aronia arbutifolia	Chokeberry
Azalea arborescens	Sweet Azalea
Azalea vaseyi	Pinkshell Azalea
Azalea viscosum	Swamp Azalea
Betula nigra	River Birch
Calluna vulgaris	Heather
Calycanthus floridus	Common Sweetshrub
Campsis radicans	Trumpet Creeper
Cephalanthus occidentalis	Buttonbush
Chamaecyparis thyoides	Atlantic White Cedar
Clethra acuminata	Mountain Pepperbush
Clethra alnifolia	Summersweet
Cornus spp.	Dogwood (Silky, Shrub, Gray)
Erica carnea	Heath
Gymnocladus dioicus	Kentucky Coffee Tree
Halesia diptera	Two-winged Silverbell

Hamamelis virginiana	Witchhazel
Ilex spp.	Holly
Ilex verticillata	Winterberry
Kalmia latifolia	Mountain Laurel
Larix spp.	Larch
Leucothoe fontanesiana	Drooping Leucothoe
Lindera benzoin	Spicebush
Magnolia virginiana	Sweetbay Magnolia
Malus	Crabapple
Myrica pennsylvanica	Bayberry
Nyssa sylvatica	Black Gum
Rhododendron canadense	Rhodora (for bogs only)
Rhododendron maximum	Rosebay Rhododendron
Rhus aromatica	Fragrant Sumac
Salix	Willow
Sambucus canadensis	American Elder
Sassafras albidum	Common Sassafras
Vaccinium	Blueberry, Cranberry
Zenobia pulverulenta	Dusty Zenobia

Perennials

Botanic Name	Common Name
Aconitum carmichaelii	Monkshood
Amsonia hubrechtii	Star Flower
Aruncus dioicus	Goatsbeard
Clatha palustris	Marsh Marigold
Chelone lyonii	Turtlehead
Cimicifuga	Snakeroot
Epimedium	Bishops' Cap
Ferns	Ferns
Filipendula ulmaria	Meadowsweet
Gillenia trifoliate	Bowman's Root
Helleborus niger	Christmas Rose
Hemerocallis	Daylilly
Hibiscus moscheutos	Rosemallow
Iberis sempervirens	Candy Tuft
Iris ensata	Japanese Iris
Iris siberica	Siberian Iris
Kirengeshoma palmate	Yellow Waxbells
Liatris spicata	Gayfeather
Limonium latifolium	Sea Lavender (for salt marsh only)
Lobelia cardinalis	Cardinal Flower
Lobelia siphilitica	Big Blue Lobelia
Monarda didyma	Beebalm
Petasites	Butterbur
Phlox divaricata	Woodland Phlox
Platycodonj grandiflorus	Balloon flower
Polygonatum	Solomon's Seal
Tradescantia x andersonianan	Spiderwort
Trillium	Wakerobin
Trollius	Globeflower

Grasses

Botanical Name	*Common Name*
Carex muskingumensis	Palm Sedge
Miscanthus sacchariflorus Giganteus	Giant Silver Banner Grass
Pennisetum alopecuroides	Fountain Grass
Sisyrinchium	Blue-eyed Grass
Typha angustifolia	Cattail

7. Drought Tolerant Species

These species require relatively little water, can survive longer periods without water, and/or are adapted to grow in well-drained soils. In the interest of minimizing the demand for irrigation water, these species should be considered in sunny areas with well-drained soil that are likely to experience dry conditions.

Woody Plants

Botanical Name	*Common Name*
Abies concolor	White Fir
Acer truncatum	Shantung Maple
Aesculus x carnea	Ruby Horsechestnut
Aesculus pavia	Red Buckeye
Aralia spinosa	Devil’s Walkingstick
Arctostaphylos uva-ursi	Bearberry
Buddleia alternifolia	Fountain buddleia
Calluna vulgaris	Heather
Campsis radicans	Trumpet Creeper
Caragana microphylla	Littleleaf Caragana
Carpinus betulus	European Hornbeam
Carpinus caroliniana	American Hornbeam
Chaenomeles speciosa	Flowering Quince
Chamaecyparis thyoides	Atlantic White Cedar
Comptonia peregrina	Sweet Fern
Cornus racemosa	Gray Dogwood
Corylus colurna	Turkish Filbert
Cotinus coggygria	Smoke Tree
Crataegus crusgalli	Cockspur Hawthorn
Fraxinus pennsylvanica	Green Ash
Gleditsia tricanthos inermis	Honeylocust
Gymnocladus dioicus	Kentucky Coffee tree
Hamamelis	Witchhazel
Hybiscus syriacus	Rose-of-Sharon
Hydrangea	Hydrangea
Indigofera gerardiana	Himalayan Indigo
Jasminum nudiflorum	Winter Jasmine
Juniperus	Juniper
Kerria japonica	Japanese Kerria
Koelreuteria paniculata	Golden Rain Tree
Kolkwitzia amabilis	Beautybush
Microbiata decussata	Siberian Carpet Cypress
Myrica pensylvanica	Northern Barberry
Pinus banksiana	Jack Pine
Pinus mugo	Mugo Pine
Pinus nigra austriaca	Austrian Pine
Pinus strobus	Eastern White Pine

Platanus x acerfolia	London Planetree
Potentilla fruticosa	Potentilla
Prunus maritima	Beach plum (especially back and scarlet)
Quercus	Oak
Rhus	Sumac
Rosa rugosa	Rugosa Rose
Salix	Willow
Sambucus canadensis	American Elder
Sassafras albidum	Common Sassafras
Shepherdia argentea	Buffalo Berry
Sophora japonica	Scholartree
Stephanandra incisa	Cutleaf Stephanandra
Vitex agnus-castus	Chastetree

Perennials

Botanical Name	Common Name
Anthemis tinctoria	Golden Marguerite
Artemisia	Wormwood
Armeria maritime	Thrift
Asclepias tuberosa	Butterfly Milkweed
Aubrieta deltoidea	False Rock Cress
Aurinia saxatilis	Basket-of-Gold
Callirhoe involucrata	Poppy Mallow
Campanula carpatica	Carpathian Bellflower
Centaurea Montana	Mountain Bluet
Cerastium tomentosum	Snow-in-Summer
Echinacea purpurea	Coneflower
Echinops ritro	Globe Thistle
Eryngium planum	Sea Holly
Eupatorium	Hardy Ageratum
Gaillardia x grandiflora	Blanket Flower
Geranium dalmaticum	Cranesbill
Geranium macrorhizum	Bigroot
Gypsophila	Baby’s Breath
Helianthus grosse-serratus	Sawtooth Sunflower
Hemerocallis fulva	Daylilly
Lamium maculatum	Spotted Dead Nettle
Lewisia cotyledon	Bitter Root
Nepera x faassenii	Persian Catmint
Oenothera	Evening Primrose
Opuntia humifusa	Prickly Pear
Papaver orientale	Poppy
Perovskia atriplicifolia	Russian Sage
Phlox subulata	Moss Pink
Polemonium caereum	Jacob’s Ladder
Rudbeckia	Coneflower
Salvia verticillata	Purple Rain
Santolina chamaecyparissus	Lavender Cotton
Sedum	Stonecrop
Sempervivum	Houseleek
Stachys byzantina	Lamb’s Ears
Stokesia laevis	Stoke’s Aster
Thymus serpyllum	Mother-of-Thyme
Yucca	Desert Candle

Grasses

Botanical Name	*Common Name*
Bouteloua gracilis	Blue Gramma
Elymus arenarius	Blue Lyme Grass
Festuca cinerea	Blue Fescue
Schizachyrium scoparium	Little Bluestem

8. Habitat Creating Species

Habitat creating species provide food or home sites for birds and other animals. The following plants provide good habitat value for birds and animals.

Trees

Botanical Name	*Common Name*
Acer rubrum	Red Maple
Acer saccharinum	Sugar Maple
Amelanchier canadensis	Serviceberry
Betula nigra	River Birch
Betula papyrifera	White Birch
Celtic occidentalis	Hackberry
Cornus, most	Dogwoods
Crataegus, most	Hawthorn
Malus, most	Crabapple
Nyssa sylvatica	Black gum
Picea glauca	White spruce
Picea pungens	Blue Spruce
Pinus strobus	White Pine
Populus, most	Poplars
Quercus alba	White Oak
Quercus palustris	Pin Oak
Quercus rubra	Red Oak
Sorbus aucuparia	Mountain Ash
Tsuga canadensis and cvs.	Eastern Hemlock

Shrubs

Botanical Name	*Common Name*
Amelanchier canadensis and cvs.	Serviceberry
Aralia spinosa	Devil's Walking Stick
Aronia spp. And cvs.	Chokeberry
Cornus, most	Dogwoods
Cotoneaster spp. and cvs.	Cotoneaster
Ilex glabra	Inkberry
Juniperus virginiana and cvs.	Eastern Red Cedar
Myrica pensylvanica	Bayberrry
Rosa rugosa	Rugosa Rose
Salix discolor	Pussy Willow
Viburnum dentatum	Arrowwood

The following plant species provide persistent fruit that lasts into the late fall and winter, thus providing food for wildlife during the critical months when food is most difficult to find.

Trees

Botanical Name	*Common Name*
Cornus mas	Cornelian Cherry Dogwood (Golden Glory)
Crataegus phaenopyrum	Washington Hawthorn
Malus spp., most	Crabapple

Shrubs

Botanical Name	*Common Name*
Aronia arbutifolia	Red Chokeberry
Ilex glabra	Inkberry
Juniperus spp. and cvs.	Juniper
Myrica pennsylvanica	Bayberry
Pyracantha coccinea and cvs.	Firethorn
Rhodotypos scandens	Black Jetbead
Rhus spp.	Sumac
Rosa rugosa and cvs.	Rugosa Rose
Rosa wichuriana and cvs.	Memorial Rose
Viburnum dilatatum	Linden Viburnum
Viburnum setigerum	Tea Viburnum

9. Invasive Species

Invasive plants are introduced species that tend to spread into natural habitats and out-compete native species because of their superior reproductive ability, aggressive growth pattern, or (most commonly) lack of native competitors, herbivores, parasites, or diseases. In terms of maintaining native biodiversity, invasive species are a serious threat because they compete with native species for limited land, water and sunlight. Sensitive Design prohibits the planting of invasive species that appear in the following list.

Shade Trees

Botanical Name	*Common Name*
Acer ginnala	Amur Maple
Acer platanoides	Norway Maple
Acer pseudoplatanus	Sycamore Maple
Populus alba	White Cottonwood
Robinia pseudoacacia	Black Locust

Deciduous Shrubs/Vines

Botanical Name	*Common Name*
Ampelopsis brevipedunculata	Porcelain Berry
Berberis thunbergii	Japanese Barberry
Berberis vulgaris	Common Barberry
Celastrus orbiculata	Oriental Bittersweet
Cynanchum louiseae	Black Swallow-wort
Elaeagnus umbellata	Autumn Olive
Elaeagnus angustifolia	Russian Olive
Euonymus alatus	Winged Euonymus
Euphorbia cyparissias	Cypress Spurge
Hesperis natonalis	Dame's Rocket

Ligustrum obtusifolium	Blunt-leaved Privet
Ligustrum vulgare	Privet
Lonicera japonica	Japanese Honeysuckle
Lonicera maackii	Amur Honeysuckle
Lonicera morrowii	Morrow's Honeysuckle
Lonicera tatarica	Tatarian Honeysuckle
Lonicera xbella	Morrow's x Tatarian Honeysuckle
Polygonum cuspidatum	Japanese Knotweed
Pueraria lobata	Kudzu
Rhamnus cathartica	Common Buckthorn
Rhamnus frangula	Shining Buckthorn
Rosa multiflora	Multiflora Rose

Meadow Grasses/Wildflowers

Botanical Name	Common Name
Achillea millefolium var. millefolium	Common Yarrow
Aegopodium podagraria	Goutweed
Alliaria petiolata	Garlic Mustard
Cabomba caroliniana	Fanwort
Centaurea maculosa	Spotted Knapweed
Cirsium canadense	Field or Canada Thistle
Coreopsis lanceolata	Lance-leaved Coreopsis (Tickseed)
Cytisus scoparius	Scotch Broom
Daucus carota	Queen Anne's Lace
Egeria densa	Giant Waterweek
Epilobium hirsutum	Hairy Willow-herb
Euphorbia cyparissias	Cypress Spurge
Galium mollugo	Field Madder
Glaucium flavum	Sea Poppy
Glechoma hederacea	Gill-over-the-ground (Ground Ivy)
Holcus lanatus	Velvet Grass
Hypericum perforatum	Common St. John's Wort
Iris pseudacorus	Yellow Iris
Linaria vulgaris	Butter and Eggs
Lysimachia nummularia	Moneywort
Lythrum salicaria	Purple Loosestrife
Myosotis scorpioides	True Forget-me-not
Myriophyllum heterophyllum	Variable Water-milfoil
Myriophyllum spicatum	Spiked Water-milfoil
Najas minor	Lesser Naiad
Nasturtium officinale	Watercress
Phalaris arundinace	Reed Canary Grass
Phragmites australis	Phragmites
Plantago lanceolata	Ribgrass (Lance-leaved Plantain)
Poa compressa	Canada Bluegrass
Potamogeton crispus	Curly or Crisped Pondweed
Ranunculus acris	Tall Buttercup
Ranunculus bulbosus	Bulbous Buttercup
Ranunculus repens	Creeping Buttercup
Ribes rubrum	Garden Red Currant
Rumex acetosella	Sheep Sorrel
Rumex crispus	Curled Dock
Rumex obtusifolius	Bitter or Broad-leaved Dock
Solanum dulcamara	Bittersweet Nightshade
Trapa natans	Water Chestnut

Tussilago farfara	Coltsfoot
Verbascum thapsus	Flannel-leaved Mullein

Lawn Grasses

Botanical Name	*Common Name*
Agrostis gigantea	Redtop, Upland Bentgrass
Festuca longifolia	Hard Fescue
Festuca ovina	Sheep Fescue

V. Checklist for Designers

The Checklist for Designers is a summary of the best development practices that this Guidebook recommends, and when they should be used. Prior to submitting an application for review, the applicant should use this checklist to verify that he or she has complied with recommended practices that furtherthe goals discussed below. The Planning Board and/or ZBA and their technical consultants can use the checklist to evaluate whether the application complies with Best Development Practices.

Checklist for Designers - Page 1 of 4

Site Planning

GOALS and NEEDS addressed:

1. Protect the natural environment, including habitat, water resources, and ecosystem services
2. Create a visually appealing community
3. Preserve the Town's historic and cultural heritage
4. Stabilize and increase property values
5. Encourage sustainable development

POLICY:
Subdivision plans and site plans for all forms of development shall adhere to the principles of *environmental compatibility*, *aesthetic compatibility*, and *energy-efficient design*.

BEST DEVELOPMENT PRACTICES The site plan must address all of the following principles.	Incorporated into Project?
Avoid, minimize and mitigate impacts to Wetland Resource Areas *(the development program should avoid or else showcase significant natural features)*	☐
Historic and cultural resources have been preserved *(the development program should avoid or else showcase significant historic and cultural features)*	☐
Reduce impervious areas and disconnect stormwater runoff flow paths	☐
Cut and fill have been minimized	☐
Buildings blend into the natural topography	☐
Buildings are oriented to the sun and wind for maximum energy efficiency	
Vegetated protection from northwest (winter) winds is provided	☐
Deciduous species planted or retained close to the E, S and W building edges	☐

Stormwater Management

GOALS and NEEDS addressed:

1. Protect local and regional wetlands and water bodies
2. Maximize groundwater recharge to retain a viable local groundwater supply
3. Ensure that Towns comply with the EPA Stormwater Phase II Requirements

POLICIES:

(A) All new development projects shall meet the following three stormwater management performance standards. All redevelopment projects shall meet the standards to the maximum feasible extent, and, if they fail to meet the standards, shall retrofit or expand existing stormwater management systems to improve existing conditions.

1. Post-development peak discharge rates from the site shall not exceed pre-development peak discharge rates from the site.
2. Annual groundwater recharge from the post-development site shall approximate annual recharge from the pre-development site.
3. The stormwater management system shall remove at least 80% of the average annual load of total suspended solids (TSS) from the post-development stormwater created on developed site.

(B) Non-structural stormwater management systems should be used wherever site conditions allow. BMP's should be dispersed to mimic the natural hydrology. Drain pipe/catch basin systems may be used, in part or in whole, only if the applicant can demonstrate that other systems are not feasible due to site conditions.

BEST DEVELOPMENT PRACTICES One or more of the following must be used to meet the above policies.	Incorporated into Project?
Vegetated swales *(recommended to collect runoff from roadways & parking lots)*	☐
Vegetated filter strips *(recommended to filter and infiltrate runoff from roadways, parking lots, and driveways; use with (a) along roadsides and parking lots)*	☐
Constructed wetlands *(preferred method for stormwater retention & pollutant removal)*	☐
Bioretention cells *(recommended on residential lots and parking lot islands)*	☐
Pervious paving surfaces *(recommended in overflow parking and low-traffic areas)*	☐
Roof gardens *(encouraged on flat commercial and industrial rooftops)*	☐
Retention basins *(less preferred method for stormwater retention & pollutant removal)*	☐
Detention basins *(may be used in series with other practices, such as constructed wetlands, to provide pre-treatment)*	☐
Drain pipe/catch basin systems *(discouraged, unless other stormwater collection and conveyance systems have been demonstrated not to be feasible due to site conditions)* Have you documented that other systems are infeasible?	☐ ☐

Erosion and Sedimentation Control

GOALS and NEEDS addressed:

1. Minimize erosion
2. Prevent sedimentation of water bodies and its attendant environmental impacts

POLICIES:

(A) Any proposed project on a previously undeveloped site shall accommodate the development program in a way that minimizes clearing and regrading, especially in areas of steep slopes, erosion-prone soils, or sensitive vegetation. For redevelopment projects, the site plan shall concentrate development in previously-disturbed areas to the extent possible.

(B) As a condition of approval, every proposed project shall submit and adhere to a construction management plan that addresses soil stabilization, sediment retention, perimeter protection, construction scheduling, traffic area stabilization and dust control.

BEST DEVELOPMENT PRACTICES The applicant must comply with all of the following requirements.	Incorporated into Project?
Clearing and regrading have been minimized	☐
Development is focused in previously disturbed areas *(for redevelopment projects)*	☐
A construction management plan has been prepared	☐
The construction management plan addresses:	
Soil stabilization *(cover or stabilize erodible surfaces not in immediate use)*	☐
Sediment retention *(runoff interceptors and sediment traps/ponds)*	☐
Perimeter protection *(vegetated buffers or silt fences at the limit of work)*	☐
Construction scheduling *(minimize disturbed area at any given time)*	☐
Traffic area stabilization *(crushed rock or similar at construction vehicle entrance and parking areas)*	☐
Dust control *(plan for stabilizing dusty surfaces when necessary)*	☐

Landscape Design

GOALS and NEEDS addressed:

1. Minimize demand for irrigation water
2. Maximize groundwater recharge from landscaped areas
3. Preserve native biodiversity by retaining habitat and defending against invasive species
4. Maximize the value to wildlife of human-managed landscapes

POLICIES:

(A) Site plans and landscape plans for all proposed projects shall take appropriate steps, as outlined in the Guidebook, to minimize water use for irrigation and to allow for natural recharge of groundwater.

(B) Landscape plans shall follow the guidelines in the Guidebook for selecting species that are most appropriate to the site conditions. Native species and habitat-creating species shall be used in all landscape plans to the maximum extent possible while still meeting the site's landscaping needs. Invasive species identified in this Guidebook should not be planted under any condition.

BEST DEVELOPMENT PRACTICES The applicant must comply with all of the following requirements.	Incorporated into Project?
Clearing and re-grading have been minimized *(natural vegetation must be retained to the maximum extent possible, given the development program)*	☐
Irrigation, if present, is water efficient *(if an in-ground irrigation systems is proposed, it is a water efficient system with automatic sensors to prevent overwatering)*	☐
Landscaped areas retain water *(gardens are mulched and designed for water infiltration. Landscaped area qualifies for credit for disconnecting rooftop or roadway runoff)*	☐
No invasive species are used *(species from the invasive species list may not be used)*	☐
Native and habitat-creating species are used *(species from these lists have been incorporated into the landscape design whenever possible)*	☐
Species are appropriate to the soil, site, and microclimate conditions *(select appropriate species from the lists of salt-tolerant, urban-tolerant, wetland, moist-tolerant and drought-tolerant species)*	☐

Endnotes

[1] This process is the essentially the same as the planning process required for projects proposed under Franklin's Senior Village Overlay District. This process is based on the work of Randall Arendt as presented in his book *Conservation Subdivision Design*, 1996. The images used in this section of the Handbook are taken from Arendt's book.

[2] *Best Development* Practices, Reid H. Ewing *et al*., Planners Press, 1996.

[3] Overall, these practices will aid Blackstone Valley Towns in meeting the EPA Stormwater Phase II requirements. The EPA's goals are to minimize polluted stormwater entering rivers and streams by reducing the discharge of pollutants to the maximum extent practicable; to protect water quality; and to satisfy the appropriate water quality requirements of the Clean Water Act. Phase I of EPA's plans was initiated in 1990 and regulated municipal separate storm sewer systems (MS4s) that were defined as "large" and "medium." Phase II, which was recently finalized, focuses on "small" MS4s. To comply with the Phase II requirements, the EPA requires that towns set in place regulations and programs that include public education and outreach, public involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control and pollution prevention/good housekeeping.

[4] These stormwater management standards are adopted from the Massachusetts Department of Environmental Protection (DEP) Stormwater Handbook. The DEP standards already apply to any project that falls under the jurisdiction of the Wetlands Protection Act. This guidebook has adopted three of the nine DEP standards, and has incorporated by reference the relevant portions for the DEP's Stormwater Handbook that relate to the implementation of these standards. For standard #2 (DEP standard #3), engineers should consult the DEP Handbook to determine the requirement for on-site recharge and how to demonstrate compliance with this requirement. For standard #3 (DEP standard #4), engineers should also consult the DEP Handbook for additional information. The Stormwater Handbook and an accompanying Stormwater Technical Handbook may be downloaded from the DEP's website at http://mass.gov/dep/water/laws/policies.htm#storm , or purchased at the state bookstore.

[5] Adapted from the *Low Impact Development (LID) Design Strategies: An Integrated Design Approach*, Department of Environmental Resources, Prince George's County, Maryland, June 1999, www.co.pg.md.us/Government/DER/PPD/pgcounty/pdf/LID/LiDNatl.pdf. Additional information from the *DEP Stormwater Policy Handbook* and *EPA Stormwater Phase II Best Management Practices Factsheets*, www.epa.gov/npdes/menuofbmps/menu.htm.

[6] Based on the table in the *DEP Stormwater Policy Handbook*, with additional information on other systems added from *Prince George's County LID Design Strategies*.

[7] *Prince George's County LID Design Strategies.*

[8] *Prince George's County LID Design Strategies*.

[9] *Northern Virginia Planning District Commission (NVPDC) Nonstructural Urban BMP Handbook*, Department of Conservation and Recreation/Division of Soil and Water Conservation, December 1996, www.novaregion.org.

[10] *NVPDC Nonstructural Urban BMP Guidebook.*

[11] *Stormwater Management Fact Sheet: Stormwater Wetlands*, The Stormwater Center, www.stormwatercenter.net.

[12] *Bioretention: A Low Impact Stormwater Best Management Practice*, University of Maryland, www.ence.umd.edu/~apdavis/Bioret.htm.

[13] *EPA Stormwater Technology Fact Sheet – Bioretention*, EPA 832–F-99–012.

[14] EPA Stormwater Technology Fact Sheet.

[15] EPA Stormwater Phase II Best Management Practices Factsheets, www.epa.gov/npdes/menuofbmps/menu.htm.

[16] www.uncommonplants.com

[17] *Green Roofs: Stormwater Management From the Top Down*, Katrin Scholz-Brath, www.edcmag.com, January/February 2001.

[18] The University of Florida Natural Area Teaching Lab has been working on retention basin designs as part of their Stormwater Ecological Enhancement Project. See natl.ifas.ufl.edu.

[19] *DEP Stormwater Manual*.

[20] *DEP Stormwater Manual*.

[21] *EPA Stormwater Phase II Best Management Practices Factsheets*.

[22] *Prince George's County LID Design Strategies*.

[23] *EPA Stormwater Phase II Best Management Practices Factsheets*.

[24] Geotextiles and other erosion control and stormwater management products may be purchased from numerous commercial vendors. Vendors include Synthetic Industries, www.fixsoil.com; Pinelands Nursery, www.pinelandsnursery.com; North American Green, www.nagreen.com; and the American Excelsior Company, www.amerexcel.com/erosionindex.htm.

[25] *Surface Water Design Manual*, King County, Washington, Department of Natural Resources, September 1998.

[26] King County, WA, *Surface Water Design Manual*.

[27] *Best Management Practices for Minnesota: Protecting Water Quality in Urban Areas*, Minnesota Pollution Control Agency, 1991.

[28] *NVPDC Nonstructural Urban BMP Handbook*.

[29] *NVPDC Nonstructural Urban BMP Handbook*.

Other Sites

- DRAFT Rhode Island Stormwater Design & Installation Standards Manual

  http://www.dem.ri.gov/programs/benviron/water/permits/ripdes/stwater/t4guide/desman.htm

- University of New Hampshire Stormwater Center

  http://www.unh.edu/erg/cstev/