MAINE STORMWATER MANAGEMENT DESIGN MANUAL

Stormwater Management Manual
Volume I

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MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
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Table of Contents

Volume I – Stormwater Management Manual

Chapter 1 - Introduction

Maine's inland and coastal waterbodies are among the state's most valuable resources and have historically been a source of pride for Maine's residents and visitors. Rivers, streams, lakes, wetlands, and coastal waterbodies complement our natural environment and provide a valuable resource for human use and enjoyment. Development opens up the landscape and increases impervious area, which in turn increases the amount of stormwater and degrades its quality. The increased runoff contributes to flash flooding and reduces the amount of rainfall that would normally recharge groundwater to maintain base flows. Development also increases pollutant concentrations in runoff. Such pollutants include sediment, suspended solids, nutrients, pesticides, herbicides, heavy metals, chlorides, hydrocarbons, other organics, and bacteria.

EPA has identified stormwater as a major contributor of pollution to surface waters and has established regulations to control its impacts.

Mount Katahdin is one of Maine's many natural areas available for recreation and enjoyment. Valuable resources such as these must be protected from the negative impacts of human activities to ensure their availability and use for future generations.

Proper stormwater management addresses the following common impacts of development:

- Altered site hydrology
- Increased stormwater runoff
- Increased flooding of rivers and streams
- Warming of water resources by heated runoff
- Reduced groundwater recharge and base flow to rivers and streams
- Increased pollutant loadings to receiving waters

Regulatory Overview

Since the early 1970's, point sources of discharge (i.e., direct discharges of wastewater from municipal and industrial facilities) have become generally regulated under the National Pollution Discharge Elimination System (NPDES) by the U.S. Environmental Protection Agency (EPA). Since 2003, this program has been administered by the Department of Environmental Protection in Maine. Point source discharges have measurably improved over the past 30 years; but the continued degradation of waterways led EPA to examine nonpoint sources of pollution (landscape-based runoff, including stormwater). The 1987 Section 319 amendments to the Clean Water Act directed EPA to focus on the contribution of nonpoint sources of pollution and begin regulation of stormwater. Section 6217 of the Coastal Zone Act Reauthorization amendments of 1990 calls for states to develop and implement nonpoint source pollution control plans for the coastal watershed. Other federal efforts to control nonpoint source pollution include:

- The National Estuary Program (Clean Water Act Section 320),
- Groundwater Protection programs (Safe Drinking Water Act Amendments and others),
- The Wetland Protection Program,
- The NOAA Coastal Zone Management Program (also Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990).

The '303d' Section of the Clean Water Act requires states to develop a list of all waterbodies that do not meet water quality standards. States are then required to develop a 'TMDL Report' (Total Maximum Daily Load) for all waterbodies on the 303d list. A TMDL analyzes the source of the degradation, defines pollution limits and describes a path to achieve compliance with water quality standards. Stormwater is the cause of pollution for many waterbodies on Maine's '303d' list. Maine DEP expects the implementation of the stormwater management Best Management Practices (BMPs) described in this document will help prevent future problems and reverse past degradation.

BMP DEVELOPMENT & PERFORMANCE:
The information included in this handbook is drawn from state-of-the-art technology or currently recognized practices. The purpose of estimating removal efficiencies is to provide both designers and reviewers with consistency in developing stormwater plans. Also, new BMPs may be approved as applicable new technologies are developed.

A BMP is a structure or practice designed to minimize the flushing by stormwater and the discharge of pollutants to waterbodies by temporarily storing and treating urban runoff.

Objective of This Manual

Maine DEP has developed this manual to provide Professional Engineers, developers, and municipalities with information to improve the management of stormwater and its impacts. The manual provides information on selecting, designing, and installing **Best Management Practices (BMPs)** for stormwater management in the State of Maine. The manual has three volumes:

Volume I - Stormwater Management Manual: This volume provides general information on the impacts of development, common problems with standard BMP designs and what can be done to control stormwater runoff and associated pollutants. It is intended for the general public, municipalities, watershed groups, developers, engineers, and designers.

Volume II - Phosphorus Design Manual: This volume outlines Maine's phosphorus standards, which limit the amount of phosphorus that new development can add to a lake. It also outlines methods for reducing phosphorus loadings to meet the established standards.

Volume III - BMPs Technical Design Manual: This volume provides technical information to assist in the selection and design of BMPs to control stormwater runoff and its impacts. Engineers and designers are encouraged to use the information contained in this manual in developing stormwater management plans. All practices should be based on sound engineering and environmental judgment, and should be specifically adapted to the sites to which they are applied.

DISCLAIMER:
This manual is intended to be a guidance document for the design and implementation of sound technical stormwater management systems and to assist developers and the regulated community in complying with existing state laws and regulations. The information outlined in this guidance manual supplement the requirements stated in the Maine Department of Environmental Protection Stormwater Management Rules, Chapter 500 and cannot overrule regulatory requirements.

This manual is not intended to be an all-inclusive source of information, as stormwater management is an evolving and developing science, and each site is unique. However, to provide satisfactory and consistent results, all designers should adhere to the basic principles and guidelines of stormwater management.

The Department reserves the right and discretion to vary from this guidance and approve on a case-by-case basis, other systems or designs that are warranted by site conditions or are based on new techniques or procedures if the proposed system or design meets the requirements of Chapter 500 for pollutant removal, cooling, or channel protection.

Chapter 2 - Stormwater Impacts

Stormwater runoff has been identified as a leading cause of pollution to surface waterbodies. As precipitation falls onto the land, some of it infiltrates into the ground to recharge groundwater, while a portion of it flows across the land (runoff) where it is directly discharged into surface waterbodies. With greater imperviousness comes greater stormwater runoff, and urban pollutants are carried by the stormwater runoff into nearby surface waters.

The Maine Department of Environmental Protection (DEP) recognizes the importance of controlling stormwater to preserve the State's natural resources. This manual was developed to assist communities, watershed groups, individuals, engineers, and developers in understanding stormwater impacts and to select appropriate Best Management Practices (BMPs) to control stormwater from development in accordance with Maine DEP's Stormwater Management regulations, Chapter 500.

Health risks associated with stormwater pollution have forced the closure of many beaches and waterways like this one.

Past Stormwater Management Practices

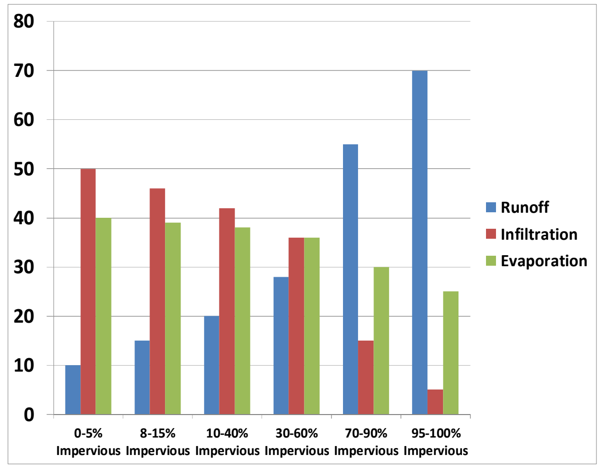
The design of stormwater management has evolved over the last 100 years. The first efforts at controlling stormwater, often previously called drainage, were made by engineers and farmers with the goal of draining wet areas and make them useable. While it was practical at the time, these activities created the current dilemma of excess stormwater and flooding. Fill affected floodplains and flood storage volume, pushing higher flows downstream. As flooding increased, early piped drainage systems simply collected and routed runoff downstream. And as development occurred, larger and larger pipes, canals, and lined concrete channels were needed to move the water out as quickly as possible.

Increased streamflow volumes and velocities associated with urban development have resulted in significant erosion of stream banks.

Under the authority of the Clean Water Act, industrial discharges and municipal waste treatment plants were increasingly regulated (yet fishable/swimmable water quality goals set in 1972 were not met within the original twenty year timeframe). In the late 1980s, the water quality problems created by drainage and land use practices were finally understood and named as 'nonpoint source pollution'. Flooding, declining groundwater levels, and lowered stream base-flows were also finally recognized as side effects from poor stormwater management.

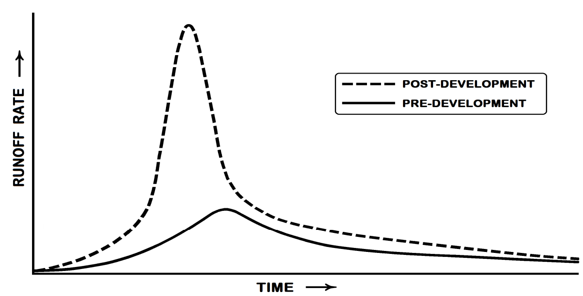
Water Quantity

Development interferes with the natural hydrologic cycle. In a natural hydrologic cycle, a portion of the precipitation goes back into the atmosphere through evaporation and transpiration (evapotranspiration); a portion infiltrates into the ground, where it is able to recharge groundwater flows and provide base flows for streams, and lastly a portion runs off over the surface of the land and is discharged into surface waters. In urbanized areas, these three components still occur; but the runoff portion is greatly increased at the expense of the infiltration portion. This graph illustrates the effects of development on the water budget. Impervious surfaces also reduce evapotranspiration, as trees and vegetation that contribute to this process are removed and replaced with paved surfaces.



As urbanization increases, major changes in stormwater quantity and quality occur. Impervious surfaces prevent water from infiltrating into the groundwater, and cause water to rapidly flow off surfaces, picking up pollutants as it travels to the nearest surface water.

As urban areas develop, natural drainage patterns are modified, with runoff channeled into road drainage ditches, storm sewers, and paved channels. These modifications increase the velocity of runoff, and decrease the time required to convey it to the nearest surface water. Greater volumes of water reach streams and rivers faster, resulting in excessive peak volumes and floods. This figure shows typical pre- and post-development hydrographs. Natural pre-development runoff slowly seeps into the ground with a slow release to surface waters. The post-development peak is much higher since the runoff is channeled to the receiving water body at once.



In addition to flooding, increased runoff taxes the hydraulic capacity and stability of downstream channels and structures, and lowers the groundwater table. The stream channel is exposed to erosive and destabilizing flows much more frequently, resulting in loss of bottom dwelling organisms with longer life cycles. The groundwater table decline affects the yield of drinking water supplies, and reduces the discharge of base-flow to streams during summer periods, when there is less precipitation. These changes in hydrology, combined with increased pollutant loading, can have a dramatic effect on the aquatic ecosystem of urban streams.

Runoff from a developed area can overwhelm a storm drain during a large rain storm. With more development, runoff can flood roads and waterways. The capacity of drainage structures and natural channels become inadequate relative to the amount of runoff that is

Water Quality

In a forested or other undeveloped area, several interacting physical, chemical, and biological processes trap, immobilize, decompose or otherwise alter most of the dissolved and suspended materials found in the runoff. As human land use intensifies, more pollutants are added to the land surface (i.e., pesticides, fertilizers, animal wastes, oil, grease, heavy metals, etc.), and are washed off by rain and runoff. The increasing pollutant load disrupts the natural biochemistry of receiving waters.

An algae bloom from too much nutrient input.

Nutrients: Nutrient inputs, particularly nitrogen and phosphorus are responsible for the eutrophication of waterbodies from excessive plant growth (algae). The increased algal growth can also contribute to greater turbidity and lower dissolved oxygen concentrations (lower dissolved oxygen can promote the release of other substances into the water column). In some cases, algal blooms may cause the growth of billions of algae, coloring the water green and releasing strong odors while decaying. Phosphorus is the primary nutrient of concern while; nitrogen is secondary (nitrogen is more important in saltwater systems). Phosphorus can be readily removed by filtration through soils; but if carried by stormwater either in a dissolved form or attached to small particles and released, it will accelerate the degradation of water quality via eutrophication.

Sediment contains many pollutants that are deposited through air pollution or directly from cars, providing a substrate for aquatic weed growth that have an adverse effect on fish and other organisms.

Solids, Sediment and Floatables: Solid contaminants include sediment and floatable wastes. Large deposits of sediment are often seen where permanent stabilization or erosion controls measures were not properly installed at construction sites. Sediment deposits can fill a waterbody, increase turbidity (which in turn affects fish and other organisms), smother benthic invertebrates, and contribute other pollutants which may stick to sediment particles. The best approach to control sedimentation is to implement erosion control measures that prevent the production and transport of sediment to waterways. Floatables derived from street litter can also be deposited into waterbodies.

Oil left by parked vehicles will eventually drain to a storm drain network and surface water, where it will degrade fisheries habitats.

Pathogens: Pathogens are responsible for many beach closures, shellfish bed closures, and the contamination of drinking water. Pathogens are often associated with overland runoff that dislodges bacteria from pet and livestock wastes, septic overflows, and sewer discharges or exfiltration. Pathogens can cause human diseases, including gastroenteritis, giardiasis, and cryptosporidiosis. Filtration through soils is generally an effective method to remove pathogens from stormwater.

Thermal Impacts: Pavement and other impervious surfaces tend to heat up in summer due to their dark coloring and lack of shade; and some BMPs, such as shallow ponds and swales, can also increase

Summary of Urban Nonpoint Source Pollutants			
	Contaminants	**Sources**	**Impacts**
Nutrients	Phosphorus, Nitrogen	Urban landscape runoff (fertilizers, detergents, plant debris, sediment, dust, gasoline, septic system effluent, etc.) Agricultural runoff (fertilizers, animal waste)	Increased algal growth & turbidity Decreased dissolved oxygen (DO) Limited recreational values Reduction of animal habitat
Solids	Sediment, Floatables	Construction sites & other disturbed/non-vegetated lands Road & parking lot sanding Agricultural lands Eroding stream banks Animal waste	Decreased storage capacity Destruction of benthic habitat Interference with animal respiration & digestion Reduced aesthetic value
Pathogens	Bacteria, Viruses	Septic systems Illicit sewage connections	Shellfish bed closures Beach closures Contamination of drinking water
Thermal Impacts	Temperature changes from urbanization	Paved areas absorbing heat Reduction of shade trees BMPs (shallow ponds and swales)	Reduced sensitive stream habitat for insects and fish species
Hydrocarbons	Oil & grease, Polycyclic aromatic hydrocarbons (PAHs)	Parking lots & roadways Spills, Oil leaks & auto emissions Illicit sewage connections Illegal dumping of waste oil	Degraded appearance of water surfaces Lowered DO Degradation of fisheries
Toxic Organics	Pesticides, Polychlorinated biphenyls	Indoor & outdoor use Industrial activities Illicit sewage connections	Loss of sensitive animal species and fisheries Reproductive & behavioral problems from accumulation in food chain
Acids	Nitrate (NO3), Sulfite (SO2), Anions (HNO3, HSO2, H2SO4) that form in the air	Incomplete combustion process coupled with atmospheric reactions (acid rain)	Loss of sensitive animal species and fisheries May affect mobility, availability & toxicity of metals & other toxins
Organic Substances	Plant materials (brush, leaves, grass clipping)	Urban & suburban landscapes	Degraded fisheries
Salt	Sodium Chloride	Road salt storage areas Roadway & parking areas, sidewalks or pedestrian areas	Contaminated surface and ground waters Loss of sensitive animal species and fisheries
Metals	Heavy metals (lead, copper, cadmium, zinc, mercury & chromium)	Industrial activities & waste Illicit sewage connections Asphalt & atmospheric deposition Automobile wear, exhaust, fluid leaks Leaching water supply and stormwater delivery systems	Accumulation in animal tissue that could be ingested by humans

the temperature of runoff. Temperature changes can be stressful and even lethal to cold water organisms. A rise in water temperature of just a few degrees Celsius over ambient conditions can reduce or eliminate sensitive stream insects and fish species such as stoneflies, mayflies and trout.

Hydrocarbons: Hydrocarbons are common contaminants associated with development. They are generally washed off roadways, parking lots and other impervious surfaces after being deposited from auto emissions, oil leaks, and spills. Hydrocarbons are toxic to many organisms at low concentrations and can degrade fisheries habitats.

Toxic Organics: Toxic organics, such as pesticides and polychlorinated biphenyls (PCBs), may be found in stormwater due to industrial activities and illicit sewage connections. Toxic organics may cause the loss of sensitive organisms and fishery resources. These substances often accumulate in the food chain through bio-magnification causing reproductive and behavioral problems that can ultimately affect human health through ingestion of the fish and animal species.

Acids: Acids may enter stormwater through incomplete combustion processes coupled with atmospheric deposition (acid rain). Acidic contamination can cause loss of sensitive animal species and fishery resources, and may increase the mobility, availability, and toxicity of metals and other toxins.

Organic Materials: Organic or humic substances include plant materials such as grass clippings and leaves. They can be picked up by stormwater, carried into a waterbody, and use oxygen for their decomposition. This, in turn, lowers dissolved oxygen levels, and causes the release of other substances (phosphorus) into the water column. Oxygen concentrations may ultimately be reduced below levels needed to support aquatic life, degrading fishery habitats and reducing fish populations.

Leaves that enter the storm drain networks are carried into receiving waters, where they use oxygen to decompose. Reduced dissolved oxygen in the water is toxic to aquatic life.

Salt: Salt content of stormwater is often due to winter road maintenance practices and road salt storage. Salt is toxic to freshwater organisms and can reduce fishery resources. Applications of salt to roads, parking lots and sidewalks for deicing can create toxic conditions from the elevated chlorides; and contamination of wells from road salt is well documented. Plus, there have been numerous cases of surface and groundwater contamination caused by runoff from inadequately protected stockpiles of salt and sand-salt mixtures.

The runoff from uncovered road salt piles can be carried to surface waters, where it will be toxic to freshwater organisms.

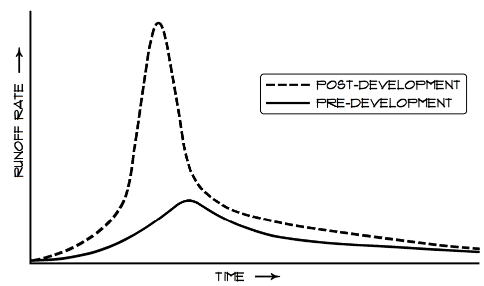
Metals: Metals from industrial activities, atmospheric deposition, or from transportation-related sources (i.e., asphalt, automobile wear or exhaust) are commonly found in stormwater. The most abundant heavy metals in stormwater are lead, zinc and copper, which together account for about 90% of the dissolved heavy metals and 90-98% of the total metal concentrations. Metals increase toxicity of runoff and accumulate in the food chain. Many metals tend to stick to sediments and can be removed from stormwater through settling.

Chapter 3 - DEP Stormwater Management Objectives

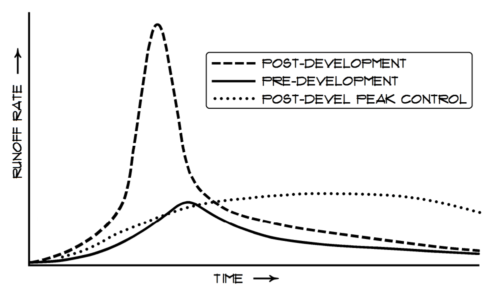
The Department's current philosophy is built around insuring that stormwater management systems for new developments meet the following four objectives: effective pollutant removal, cooling, channel protection, and flood control. In some instances, the latter three objectives are not necessary, such as for direct discharges to lakes, large rivers or some tidal waters; but stormwater management systems should always provide pollutant removal. Here are some of the shortcomings of traditional stormwater management.

Inadequate Pollutant Removal: The principal focus of traditional stormwater management has been the avoidance of downstream flooding by using detention basins that truncate peak flows during large infrequent storms. These detention basins provide little pollutant removal because the majority of the smaller storm flows pass quickly through with no loss of sediment. In Maine, the exception to this has been in lake watersheds where, for several decades, many developers have been required to incorporate measures such as wooded buffers or wet ponds to reduce phosphorus export from the developed site. In most stream and coastal watersheds, the requirements have either been absent or limited to a total suspended solids (TSS) removal requirement that in most situations results in the removal of only coarser, sand-sized particles that are easily settled. Unfortunately, the majority of nutrients, heavy metals and hydrocarbons in urban stormwater are either dissolved or associated with the finer, silt-sized particles suspended in the stormwater; and traditional management of stormwater has done little to prevent these pollutants from reaching streams and coastal waters, where they can be harmful to the biological communities. These pollutants can be effectively removed only if filtration, infiltration, long term sedimentation and/or biological processes are incorporated in all stormwater management systems.

Failure to Protect Stream Channel Integrity: As an urban area develops; the volume of runoff rises from more impervious area and modifications to natural drainage patterns (runoff channeled into road drainage ditches or storm sewers). These modifications increase the velocity of runoff and decrease the travel time required for runoff to reach the receiving surface water. Stormwater runoff rises more rapidly to higher peak discharges resulting in higher flood stages.



Pre and Post-development hydrograph



Pre and Post-development hydrograph with detention

These figures show typical pre-and post-development hydrographs. The hydrographs represent the flow rates of stormwater discharges from the site before and after development. The area below each hydrograph represents the volume of runoff for that particular storm event. As shown, the peak discharge flow rate and the volume are lower under natural predevelopment conditions since stormwater slowly seeps into the ground and releases to surface water over a long period. Under post-development conditions, precipitation turns into surface runoff and rapidly enters the receiving waterbody.

As a result, a stream experiences higher and more frequent flows which will erode the stream banks, widen the channel, and deposit the eroded sediment in slower downstream reaches. With more frequent channel disturbance, the quality of stream habitat for organisms with a longer life cycle is limited.

Peak flow attenuation and flooding control is usually applied only to infrequent storms (i.e. 2-year, 10-year, 25-year or greater), and has little or no effect on the exaggerated post-development hydrographs from the smaller, more frequent storms (i.e. 3-month, 6-month and 1-yr) that can produce flows large enough to cause significant channel degradation. Also, since peak flow attenuation does not reduce the total volume of runoff, the peak flow is sustained over a much longer timeframe, exposing the stream channel to highly erosive flows for a longer period than it would have been without the peak attenuation. This is illustrated in the second figure, which shows a typical hydrograph for a developed site where peak attenuation controls are used compared with hydrographs for undeveloped and uncontrolled developed sites. Studies have shown that peak attenuation alone can result in an increase in stream flows from pre-developed conditions. Due to a shift in the timing and duration of the flow out of a detention structure located low in the watershed can coincide with the unregulated peak streamflow from the upper part of the watershed.

Inadequate Shading: Elevated runoff temperatures are caused by reduced shading in developed riparian areas, warming of stormwater as it runs over hot roofs and pavements; and the heating of water stored in stormwater management ponds. Traditional peak reduction outlet structures and simple spillway outlets do nothing to cool the water before discharge. Many of the organisms that are native to Maine streams cannot tolerate the high summer temperatures common in urban settings. BMPs, such as buffers, infiltration, or under-drained filters can be used, or if ponds are required, under-drained outlet structures can provide the desired cooling effects. Equally important to maintaining cool stream temperatures is the preservation and/or restoration of riparian trees and shrubs that provide shade.

These culverts have filled in with sediment and require maintenance. Improvements to increase the detention area upgradient could easily be made; however, periodic maintenance is crucial to the performance of the BMP.

Lack of Maintenance: Stormwater treatment systems work well as long as they are maintained appropriately; and maintenance needs to be incorporated into every design to ensure long-term operational success. If BMPs are not sized adequately to hold winter sand sediments or maintenance is not provided, the BMP may fail prematurely. Some BMPs are designed with a bypass feature that allows water to pass through the system untreated without any outside indication that the system is failing. This will result in the lack of treatment until a costly repair is implemented. Instead of a bypass, BMPs should cause flooding or exhibit some indication that they need attention. Systems need to be designed with realistic maintenance goals (i.e. annual maintenance) and must be easily accessible for inspection and maintenance activities.

Subsurface detention and infiltration galleries under a parking lot save space. With visible and adequate pretreatment and frequent maintenance, they can work well and will help recharge groundwater. Without pretreatment and maintenance, they quickly fill with sediment and may fail.

Failures and Replacement: Pretreatment and maintenance are essential to extend the life of a BMP; however all drainage structures will eventually fail with some needing replacement within10-20 years. Some BMPs such as wetponds may not need outright replacement, but reconstruction can be costly.

The Four Stormwater Management Objectives

The objectives for most stormwater management systems: effective pollutant removal, cooling, channel protection, and flood control may be met either directly by providing BMPs that manage and treat the runoff after it has been created, or indirectly by incorporating low impact development site planning concepts that minimize production and contamination of runoff by maximizing infiltration and evapotranspiration.

Effective Pollutant Removal: Since all natural surface waters are vulnerable to the harmful effects of stormwater pollution; and most are also vulnerable to sedimentation, pollutant removal is important for all urban stormwater discharges; and stormwater management systems should provide the following:

- Site planning and operation that minimizes the contamination of stormwater;
- Stormwater BMPs that remove the fine particles carrying nutrient and a heavy-metal load;
- Stormwater BMPs that remove dissolved pollutants (phosphorus and metals); and
- Stormwater BMPs that remove hydrocarbons.

Traditional wet ponds collect heated runoff from paved surfaces and heat it further in the sun before its discharge to a stream. A spillway that discharges through an underdrained gravel trench will cool and slow the release, while offering better pollutant removal efficiencies. The pond can also control peak flows, meeting all four of Maine DEP's objectives.

Cooling: Unless the receiving water is a lake, major river or tidal water, stormwater systems should either prevent heating stormwater runoff or effectively cool it down (22°C or cooler) with the following:

- Site planning and operation that minimizes impervious areas and maximizes shading;
- BMP systems that provide cooling of runoff from hot pavement and roofs; and
- Ponds that discharge through under-drained gravel trenches or otherwise provide cooling.

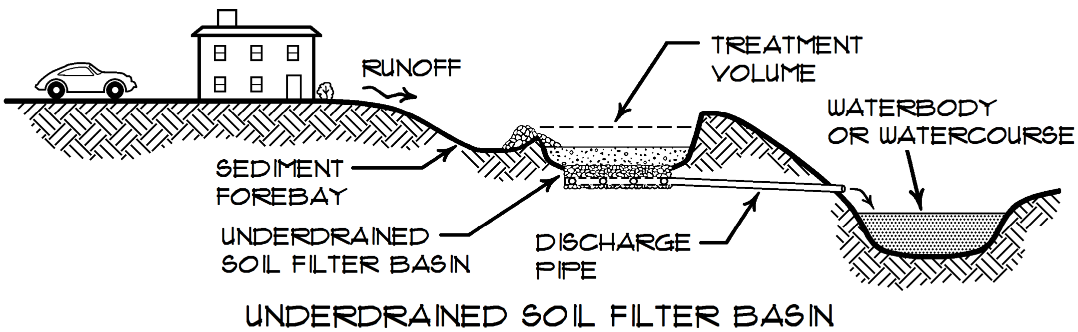
Channel Protection: Unless the receiving water is a lake, major river or tidal water, stormwater management systems should minimize the magnitude and duration of stormwater discharge from a developed site to prevent stream bank erosion and the sedimentation of downgradient stream channels. These systems should incorporate the following:

- Site planning and operation that minimizes the volume of stormwater and its rate of discharge by minimizing impervious area, maximizing infiltration and evapotranspiration, maximizing time of concentration of runoff; and
- BMP systems that provide storage and slow release of not only the very large, infrequent storms, but, more importantly, the relatively frequent small sized storms that happen many times each year and have the potential to cause stream channel erosion and sedimentation.

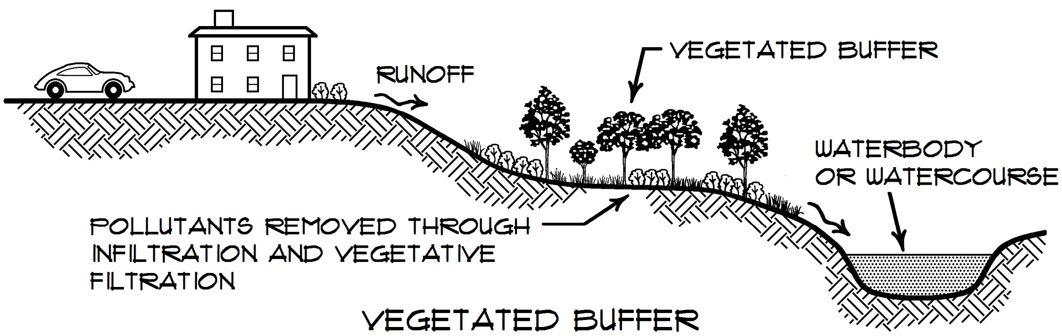
Flood Control: For some projects, controlling large, infrequent storms will still be necessary to avoid flooding of downstream infrastructures. But, traditional flood control is generally unnecessary when projects discharge directly to large water bodies such as lakes, major rivers or tidal waters; and may also be unnecessary or actually harmful for developments near the bottom of a stream's watershed (where peak flow control may delay the peak to coincide with the peak from the upper watershed, thus exacerbating rather than avoiding flooding). A comprehensive analysis of the contributing watershed and the detention structures contained within is the most accurate analysis of downstream impacts; but this analysis requires a significant amount of information.

BMPs to Achieve Objectives

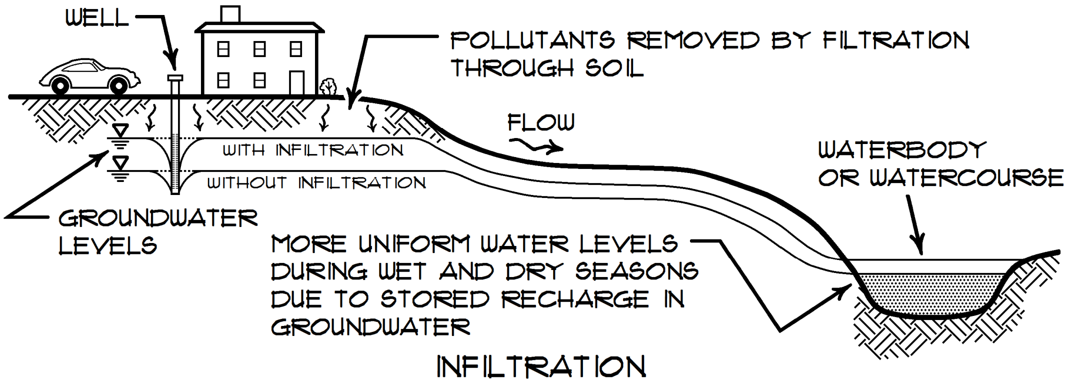
DEP is recommending four types of Best Management Practices (BMPs) that will provide pollutant removal, cooling, and channel protection. In some instances they may also provide flood control benefits without the need for a pond structure. These four types of BMPs can also be adapted and sized to handle peak discharge for flooding control; thus meeting all four of DEP's objectives. Other alternatives that provide equivalent pollutant removal, cooling, and channel protection can be used if they are designed, sized, and maintained properly.



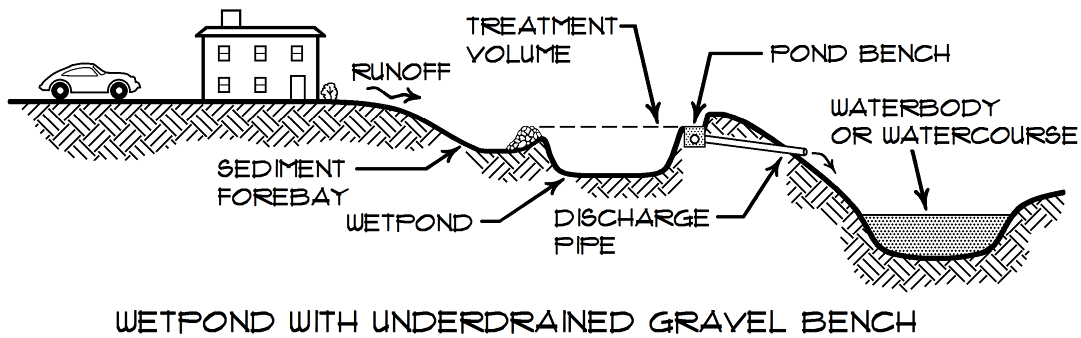
Underdrained soil filters consist of a detention structure with a bottom of loamy, coarse sand mix underlain by a gravel bedding and perforated pipe. Stormwater runoff is stored above the soil filter, where the runoff passes through the soil filter and discharges through the underdrain piping. The soil media traps particles and filters out pollutants that bind to the particles, while also cooling the runoff. The soil media can also act to absorb and release water through evapotranspiration when combined with vegetation. Underdrained soil filters are typically incorporated into a detention structure (a proprietary filter system approved by the department may be used).



Vegetated buffers located adjacent to and downgradient from a developed area allow pollutants to filter out of the stormwater runoff traveling as a sheet flow across the buffer and through the vegetation. The vegetative canopy also helps cool the runoff and contributes to the natural cycle of evapotranspiration that minimizes the amount of stormwater runoff reaching the stream or lake. Buffers also provide some infiltration and retention in the natural depressions found across the buffer. Buffers are typically used to treat runoff from smaller developments; and they require minimal maintenance. DEP has established acceptable buffer lengths for various applications to meet the objectives previously outlined.



Infiltration filters and cleanses the stormwater runoff of certain pollutants as it percolates through natural soils before reaching the groundwater table. It also reduces flooding issues by imitating natural, pre-developed conditions. Infiltration minimizes the volume of surface water reaching surface waterbodies and provides a source of water to maintain stream base flows during the dry summer months. It is critical that adequate pretreatment be provided prior to discharge to an infiltration area to prevent the clogging of the basin and contamination of the groundwater.



A traditional wetpond has a permanent pool with storage above the pool for stormwater runoff. Although wetponds can be beneficial in removing pollutants from stormwater, the pool itself heats in the warm summer sun and discharges warm water. A modification to the traditional design incorporates an underdrained gravel filter that forces the stormwater runoff to pass through the gravel filter to a perforated discharge pipe. This helps to remove the finer particles in the runoff and cools the stormwater before it is discharged.

Chapter 4 - Low Impact Development

Low Impact Development, known as "LID", is the process of developing land while minimizing impacts on water resources and infrastructure. It is a site-based process unlike 'Smart Growth' which is a community or regionally based program that is intended to minimize sprawl and make developments more people-friendly. LID replicates the natural hydrology of the site.

In the past, it wasn't intentional, but it was cheaper and easier to clear cut large swaths of land for new developments, which left little shade and large impervious areas or poor soils with grass baking in the sun. Meanwhile, runoff from these new developments was significantly increased from pre-development conditions. Today, LID should be applied to new and existing developments. How? By routing the runoff from paved areas or buildings to many small infiltration or detention systems! Dispersed structures are better than a single large end-of-pipe treatment basin to reestablish some natural hydrology to the site. While more costly, the benefits of LID outweigh the expense, since repeated flooding events and groundwater decline can be alleviated.

Increased flooding is one of the most obvious problems caused by older development practices. The water that is lost downstream might have recharged an aquifer; and the groundwater levels may now be lower - a less obvious problem but that is still related to increased imperviousness.

Some communities have reduced the total stormwater load by disconnecting the impervious areas and by building raingardens. These projects are reducing flooding problems and become an attractive part of the landscape.

THE CONCEPTS OF LID: There are several land planning and design practices that help mitigate potential environmental impacts. Ideally, these should be incorporated at the design phase to be most cost-effective; but they can also be effective when redeveloping an existing site. Specific technologies that can be used to implement these practices are discussed later in this section.

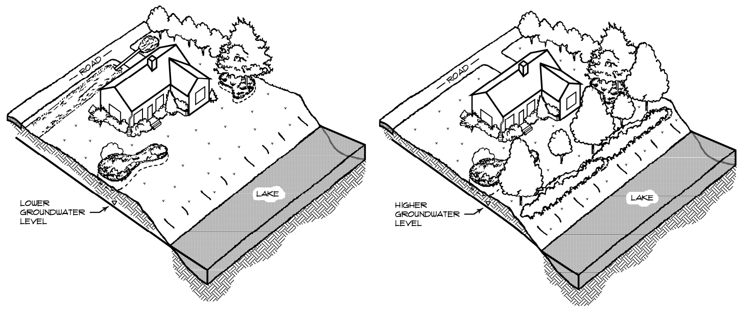
- *Minimize Impervious Areas:* Impervious areas increase the amount of runoff as vegetation is replaced with impervious surfaces. Less impervious area equals less runoff from the site.
- *Limit Areas of Clearing and Grading:* One way to preserve pre-development conditions is to minimize land disturbance activities. At a minimum, areas that are sensitive to disturbance (wetlands, steep slopes, flood plains, streams, lake fronts, etc.) should be protected with undisturbed buffers. The preserved areas need clear identification on development plans, recorded in the deeds and marked in the field.
- *Minimize Directly Connected Impervious Areas:* Some impervious area is unavoidable, but the impervious areas can be separated from the discharge point by using low impact techniques such as dry wells, raingardens, level spreaders, etc. Multiple low-flow discharge points are also preferred to one end-of-pipe discharge.

- *Manage Stormwater at the Source:* Although end-of-pipe treatment structures with a single outlet can be used to control peak-flows, they cannot mimic the natural hydrologic conditions of a site. To reproduce the natural functions of the landscape, stormwater should be handled with numerous smaller systems that fit in with the site's topography and drainage conditions as close as possible to the source. Breaking up the drainage results in the overall control of the runoff during smaller storms (first flush) when most of the pollution occurs.

Traditional Development	Results of Traditional Development	LID Development	Benefit of LID
Commercial developments with large continuous impervious areas	• Less clean recharge and lower groundwater levels • Surface water thermal impact • Groundwater degradation	• Pervious overflow parking and sidewalks • Reduced parking areas and aisle/street widths • Vertical construction	• More attractive and diverse
Unaddressed erosion during construction continues to cause problem	• Impacted surface water and receiving waterbody	• Sheet flow from impervious areas to natural vegetated buffers	• Protected surface quality
Undersized or absent stormwater systems in older developments lack maintenance or may cause erosion	• Altered stormwater flows and enlarged stream channels	• Collect runoff in dry wells or raingardens	• Protected stream flows
Detention structures controlling peak flows pass smaller, more frequent storms which cause stream bank erosion.	• Higher peak flows or flooding and lower stream base flows	• Disconnect impervious areas and manage stormwater at the source • Break up flows for treatment of smaller flows.	• Reduced flooding and property damage • Increased property value and lower maintenance cost
Compacted lawns and playing fields have more runoff than undisturbed areas.	• Polluted runoff from fertilizers, herbicides and pesticides	• Limit areas of clearing and grading • Minimize impervious area and compacted areas	• Preserved hydrologic cycle • Landscaping adding property value • Forest buffers with a beneficial duff layer
New homes in suburban areas have large lawns and a sprinkler system with a high water demand and high runoff	• High pesticides and herbicides use • Loss of wildlife habitat and damage to fisheries	• Incorporate 'smart growth' concepts such as clustering	• Fish and wildlife benefits • Aesthetic value

LID Techniques

LID is a natural evolution of stormwater management; some of the techniques are not new as they have been used for years. For example, drywells for roof runoff are not new; but they have been repurposed. All LID methods have one characteristic in common: keeping the rainfall or runoff as close to its point of generation as possible. The LID approach emphasizes multiple, dispersed on-site systems that mimic natural conditions as closely as possible. These are attractive, cost-effective solutions designed to retain and treat stormwater runoff at the source.



Extensive clearing will affect the groundwater recharge and aesthetics of the overall development. Leaving mature trees has been shown to increase the value of the home. Building contractors who may see it as a major inconvenience; however, it is a major benefit to the community and environment.

Vegetated Buffers: A healthy and mature forest floor has an irregular topography that encourages infiltration, and well-vegetated areas between developed areas and sensitive areas such as wetlands and waterways should be retained. Naturally, the several layers of vegetation (tree canopy, shrubs, possibly a herbaceous layer and groundcovers, mixed root zones of trees, etc.) absorb precipitation, disperse runoff, and provide better uptake of pollutants. The duff layer is very important and consists of leaves, pine needles, and other plant materials in various stages of decomposition. The duff layer acts as a sponge, absorbing water and filtering pollutants as well as providing habitat for microorganisms that help treat runoff. In manmade vegetated buffers, some type of mulch may be used for the duff layer until it naturally develops. Native site-specific vegetation should be used to duplicate natural site conditions if planting is necessary due to disturbances.

Filters/Bioretention Cells/Raingardens: A basin within a shallow depression area can collect, infiltrate, and treat moderate amounts of stormwater runoff using conditioned planting soil or a filter, a gravel underdrain, and vegetation. These are placed close to the runoff source, such as within a residential development or alongside parking pavements. The vegetation should consist of native or naturalized species to the area that are capable of handling periodic wet conditions such as the ponding that occurs during storm events. The plants, soils, and mulch layer each play an important role in treating runoff by breaking down the pollutants and retaining the sediments.

As vegetation is converted to rooftops and pavement, runoff is magnified, and becomes more toxic to the resource from the increase in pollutants, sediments, and temperature.

Infiltration Basins/Roofline Filters/Trenches/Dry Wells: An infiltration trench is an in-ground stone bed that will capture and infiltrate stormwater in urban settings. All subsurface structures should have pretreatment to remove sediments from stormwater before it enters the structure, or they can quickly clog. Appropriate pretreatment can include grass swales, deep sump catch basins, grassed areas after level spreaders, plunge pools or sediment forebays. Following the pre-sedimentation step, infiltration into the trench allows for the removal of most remaining pollutants. Rooftops, particularly in urban areas, contribute to the amount of impervious surfaces causing significant increase in runoff amounts; and roof runoff is usually free from clogging materials that shortens a structure's life-cycle. Diverting the rainfall into drywells diminishes the amount of runoff, and minimizes downstream flooding conditions. As with other filtration BMPs, dry wells require soils with a good infiltration rate and adequate separation from bedrock and groundwater.

Porous Pavement: Porous or permeable pavements are designed to allow some amount of rainfall to infiltrate through the road surface into the underlying gravel beds and soils. However in a high permeable soil (sand and gravel), pervious pavement could cause the contamination of the aquifer. There are basically three types of porous pavement, including:

- *porous asphalt (or concrete)* resembles typical pavement with many void spaces throughout the surface material that allow water to pass through.
- *block pavers* are interlocking blocks of material resembling a grid that are usually made out of concrete allowing runoff to infiltrate through exposed areas that can be vegetated.
- *plastic grid pavers* generally come in a honeycomb pattern and the voids are filled with stone, or loamed and seeded. The grid provides strength to allow parked vehicles or traffic without compaction of the soils within the structure.

All three types of pavements are susceptible to clogging from winter sanding applications and can be problematic for plowing if not installed properly. A different approach to winter maintenance is necessary. The use of these pervious pavements is particularly suited to overflow parking, emergency access ways, unplowed lots and areas where pretreatment or regular maintenance can be incorporated to eliminate the need for winter sand application. However, over-use of sodium chloride could cause the contamination of the groundwater.

Rain Collection Cisterns: Rain cisterns and barrels are simple collection devices, usually made out of plastic, that are designed to capture roof runoff. Rainwater is stored for later reuse in the building or the landscape.

Rooftop Greening: Rooftop greening is an innovative approach designed to temporarily store rainfall within vegetation on rooftops while simultaneously lowering the air temperature. It is particularly useful in urban settings with extensive roof surface areas that are heat sinks from high summer temperatures, and that cause an unhealthy microclimate. Green roof systems are generally installed on flat or shallow sloped roof tops that are engineered to withstand the added weight of vegetation and temporary water storage. A vegetated roof reduces solar damage to the roofing materials, lowers temperature control costs within the building, provides additional green space for the building occupants, and reduces stormwater runoff.

The Implementation of LID

LID is a great concept that can be implemented by communities, commercial developers, and by individuals as well. A collective effort is needed to preserve and protect streams, lakes and water supplies. Every project makes a difference. The following tips are provided to help with LID implementation.

- *Municipalities*: existing bylaws, subdivision association guidance and plans should include design criteria and standards that promote the retention of more runoff on each site (minimized site disturbance, clustering, and defined clearing limits). A good example on municipally owned properties with demonstration sites and a public education program can promote a behavior change by landowners.
- *Landowners:* Individuals should inspect their property's drainage pattern and try to retain more runoff! Roof leaders can be disconnected from city stormdrain and rerouted to drywells or rain gardens. Lawn size should be reduced and replaced with plant shrubs and trees that are hardy Maine natives.

LID Measure	Techniques and Benefits	Design
Protect natural drainage system	• Break up or disconnect the flow of runoff over/from impervious surfaces	Design practices developed and implemented at the planning phase that will help mitigate environmental impacts. Ideally, these are cost-effective and environmentally friendly.
Minimize impervious area	• Sheet flow over pavement that is less than 100 feet • Pervious pavement incorporated into at least 25% of the pavement area. All pedestrian walkways are pavers or pervious pavement	
Minimize soil compaction	• Minimize the construction window • Add organic matter and rototilling all areas to be revegetated	
Minimizes lawns and maximize landscaping to encourage runoff retention	• Low maintenance Maine native plants • No invasive plants, pesticides or fertilizers	
Provide vegetated open-channel conveyance systems	• No street curb/gutters nor roof gutters • Level spreaders to buffers if feasible • Underdrained swales	
Rain Collection Cisterns	• Rainwater is stored for reuse in the building or landscape	
Buffers	• Maintain green space • Allow for evaporation and infiltration	Volume III, Chapter 5
Infiltration (basins, trenches, dry wells, etc.)	• Provide for groundwater recharge and reduction of discharge to natural waterbodies	Volume III, Chapter 6
Underdrained grass filters	• Reduce heat island effect • More natural landscape and habitat	Volume III, Chapter 7.1
Underdrained filter bioretention	• Design for small disconnected areas • Natural landscape and habitat	Volume III, Chapter 7.2
Roofline filtration	• Simplify design for stormwater management • Reduce heat island effect	Volume III, Chapter 7.5
Roof Greening	• Reduce heating/cooling in building • Reduce heat island effect	Volume III, Chapter 7.5
Pervious Pavement	• Reduce salt/sand use • Provide cooling of stormwater runoff	Volume III, Chapter 7.7

Chapter 5 - Housekeeping

A combination of preventative and structural measures are important factors in the optimal reduction of stormwater impacts. Preventative measures or housekeeping practices focus on preventing pollutants from getting into the stormwater. Structural measures, the topic of Volume III, focus on the removal of pollutants from stormwater. Once pollutants reach a waterbody, it is much more difficult and expensive to restore its pre-impacted conditions. This section focuses on housekeeping practices intended to minimize or prevent the release of pollutants into runoff. These measures are not given any credit for stormwater management or pollutant removal; but they should be considered in all stormwater management plans.

Maintenance of Conveyance Structures: Structural stormwater management systems (catchbasins, swales, culverts, etc.) have been used for many years to manage runoff before it is released to surface waters; but the failure to maintain them properly can reduce their efficiency and function, and can impair the hydraulic capacity of the whole system. Also, the lack of maintenance of vegetative structures can cause erosion and sedimentation. Some devices are also designed with bypasses to prevent flooding when the system is clogged. In these cases, the owner has no physical indication that the device has failed and stormwater runoff flows through the system untreated.

Conveyance Structures Maintenance Guidelines

- *Size stormwater management BMPs to hold one year's worth of sediment to account for sand deposits from winter storm applications.*
- *Calculate a sediment load using a sand application rate of 500 lbs/acre for sanding of parking areas and access drives, a sand density of 90 lbs/ft and assuming a minimum frequency of 10 events per year.*
- *Bypasses or overflows should not be used when public health or safety is at risk. Design BMPs to alert the owner when maintenance is recommended (ponding on pavement when the structure is full).*
- *The BMP should be easily accessible, and inspections should be conducted by a person experienced with stormwater management.*
- *Maintain in accordance with the approved inspection and maintenance plan for the site. Detailed descriptions of maintenance activities for design purposes can be found in Volume III of this manual.*

Street Sweeping: Street sweeping removes grit, debris, and trash from streets, parking lots, and sidewalks (particularly from curb gutters) to improve aesthetics and reduce the export of sand to stormwater structures and/or to receiving waters. The street cleaning equipment that removes fine particles (less than 246 microns) will be most effective for nonpoint source pollution control as the majority of nutrient, oxygen demanding and toxic substances are attached to fine particles. New data shows that dry vacuum sweepers can reduce nonpoint pollution by 35-80% compared to the 5-30% efficiency of conventional mechanical broom and vacuum-assisted wet sweepers. Also, more frequent sweeping and sweeping heavily traveled roads with on-street parking is most effective.

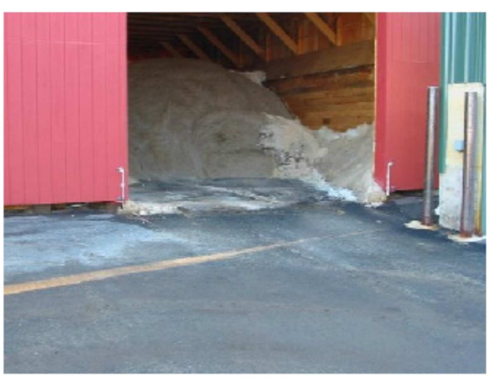
- *Mechanical sweepers:* Mechanical sweepers consist of a gutter broom and a main broom rotating at high speeds, forcing the debris from the pavement surface into a conveyer belt and hopper. Water is usually sprayed on the surface for dust control. The effectiveness of mechanical sweepers is variable and a function of (1) particle size distribution of the accumulated contaminants; (2) sweeping frequency; (3) number of passes; (4) equipment speed; and (5) pavement conditions.
- *Vacuum Sweepers:* These sweepers feature vacuum action over the entire path, assisted by a gutter broom. Regenerative air sweepers force air down onto the pavement to suspend the particles which are then vacuumed. If the unit is equipped with a wandering hose attachment, it can be used for sewer and catch basin cleaning.

Street Sweeping Guidelines

- *Street cleaning operations should concentrate on the curb and gutter lines for maximum pollutant removal efficiency (90% of street contaminants accumulate within 12 inches of the curb-line of guttered streets). The areas that are known to accumulate sediments should be swept several times a year. Other areas can be swept on a less regular basis.*
- *Sweeping should immediately follow spring snowmelt to remove sand and other debris.*
- *Pavement surfaces may be swept at other times for aesthetic reasons, such as in the fall after leaves have dropped.*

Sand and Salt Management: Sand and salt is often combined and applied as a sand/salt mix. The salt reduces the melting point of ice to prevent ice buildup, while the sand increases traction. Salt is very soluble in water allowing it to migrate into groundwater and surface water resources which can be contaminated from excessive salt levels. Also, salt runoff and wind-carried spray may damage or kill plants and trees. Corrosion damage to motor vehicles and pavement infrastructure is another side effect of salt use.

- *Salt and Sand/Salt Storage:* Improper storage of salt and sand/salt are responsible for the contamination of many local waterways. Because both shallow wells, and deep wells, can be polluted by salt, it is possible that a municipality could face unexpected expenses in providing clean drinking water or drilling new wells. All new sand/salt storage areas greater than or equal to 100 cubic yards of mixed sand/salt must be registered with the Maine Department of Environmental Protection (Chapter 574, Siting and Operation of Road Salt and Sand-Salt Storage Areas). A municipality should also be aware of State law Title 23 MRSA 3659 on the "protection of private water supplies". This law details the procedure for handling well damage claims.
- *Application:* The proper application of salt and sand/salt can minimize the negative impacts associated with its use. Eliminating over-spreading and excessive application save maintenance funds and minimize the impact. Ditching or stormdrains will reduce contamination of wells close to the road by allowing the runoff to flow directly and quickly away from the pavement.



Sand and Salt Management Guidelines

- *Use sand/salt spreaders that are capable of adjusting application rates, and calibration.*
- *Use weather and roadway monitoring systems to adjust de-icing to changing conditions. Minimize pretreatment (e.g., salting prior to storms).*
- *Use ice-cutting plow blades to reduce the need and/or volume of de-icing materials.*
- *Implement salt use restrictions around key waterbodies.*
- *Sweep spilt sand/salt during loading operations.*
- *Train employees.*

Vehicle Management: Spills associated with refueling vehicles or their maintenance can contaminate soil, groundwater and air; and exposure to petroleum contaminated media can be harmful to anyone's health. Keep automobiles well-tuned to prevent dripping fluids and toxic fumes.

Vehicle Management Guidelines

- *Recycle or dispose of used motor oil, used auto fluids or batteries at designated local drop-off recycling centers. Do not mix incompatible products which may chemically react and release toxic fumes.*
- *Washing a vehicle on a paved surface can flush detergents and other contaminants into the storm drain or a swale system and into a resource.*
- *Avoid spilling gas and oil on the ground or in the water. Immediately clean any spills with absorbent materials such as kitty litter or speedy dry. Do not use water to clean spills, leaks and drips.*
- *Industrial facilities should develop a spill response plan that outlines personnel responsibility for implementing the plan for product use, storage, spill clean-up, and waste management).*

Hazardous Material Management: Chemicals such as solvents, paints, cleaners, petroleum, and common household products (moth balls, drain & oven cleaners, motor oil, etc.) are toxic if released to the environment. Toxics and hazardous substances can accumulate in sediment and impact bottom-feeding organisms, and bio-accumulate in the tissue of their predators. Toxic materials may also contaminate groundwater used as drinking water.

Material Management Guidelines

- *Store in accordance with manufacturer's recommendations and for a period no longer than their maximum life limit.*
- *The storage facility should provide adequate protection against excessive heat, cold, and moisture, and not be subject to flooding.*
- *Do not place toxic chemicals on the soil where there is a danger of percolation into the ground or through rock fissures.*
- *Use natural and less toxic alternatives.*
- *Clearly label all containers.*
- *Store chemicals in sealable, spill-resistant containers.*
- *Keep materials covered to reduce evaporation and spills.*
- *Follow directions on the packaging, don't over-use.*
- *Never pour hazardous or toxic products down a storm drain, toilet, onto the ground, or in the trash.*
- *Do not mix with incompatible products (it may cause reactions and release toxic fumes).*
- *Not stocking large amount of toxic materials minimizes the problem with their disposal if unused (Limit purchases to a one-year supply).*
- *Toxic materials should never be burned or disposed of into catchbasins sewer, onto the ground or into a resource.*

Fertilizer Management: Fertilizers are a source of nutrients (nitrogen and phosphorus), and are used excessively in urban areas with unnecessary products draining into a natural resource. Excess phosphorus in lakes depletes the oxygen, stimulates algal growth, and causes fish kills. Excess nitrogen in groundwater increases nitrate levels which is harmful to human consumption. The proper management of fertilizer includes reducing its application and preventing over-spraying. Commercial applicators, concerned with costs, may be less likely than homeowners to over-fertilize. Residential homeowners often over-apply and apply during the wrong weather (before heavy rains).

Fertilizer Management Guidelines

- *Test your soil to determine fertilizer needs. Cooperative Extension Service specialists advocate a repeat test at least every three years. For instance, a soil may need nitrogen (N) but need little phosphorus (P) or potassium (K).*
- *Granular fertilizers slowly release nutrients and are less apt to wash away than sprays or slurries. Lawn maintenance companies may use liquid applications if applied correctly.*
- *The soil should be moist soils or lightly sprinkled with water following fertilizer application. Applying fertilizer immediately before a rain event can result in the loss of the fertilizer.*
- *Never apply fertilizer to frozen ground.*
- *Protect enriched soils from erosion during the establishment of vegetation. Organic fertilizers (compost, manures, etc.) are high in phosphorus and should not be allowed to erode into a waterbody.*
- *Maine native plants are well adapted to our environment and may minimize long-term fertilizer needs.*
- *Do not use phosphorus fertilizer in lake watersheds (Maine's soils have sufficient phosphorus to allow plant growth). Phosphorus is a pollutant for lake waters.*

Pesticide Management: The term 'pesticides' broadly covers all chemicals used against pests: insecticides to kill insects; herbicides to kill weeds, brush, or other unwanted vegetation; fungicides to control fungi that cause molds, rots, or plant and animal diseases; and rodenticides to kill rats and other rodents. **Pesticides are poisons!** They may be characterized by acute toxicity, or their long-term chronic effects and the collective amount reaching watercourses as runoff is significant. Pesticides are regulated by several federal and state agencies. The most significant federal statute is the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). In Maine, the Maine Board of Pesticides Control (22 MRSA Section 1471) provides for the certification and licensing of sellers and applicators.

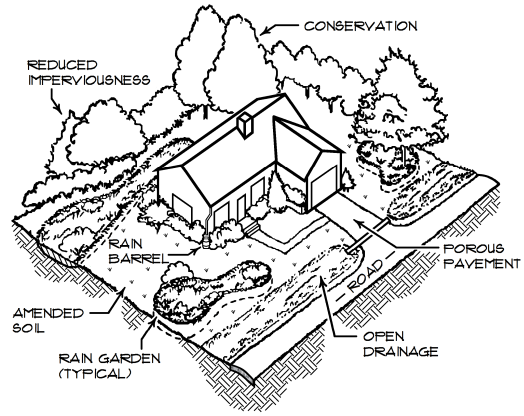
Pesticide Management Guidelines

- *Use the least toxic chemical for the purpose or use organic pesticides when possible. These substances present less contamination risk of groundwater and surface water, and fewer problems for disposal of leftover product.*
- *Follow the manufacturer's instructions for storage and application. Never exceed dosage recommendations.*
- *Use pesticides that degrade rapidly - they are less apt to become water pollutants.*
- *Use pesticides with low solubility - they are less apt to dissolve in runoff.*
- *Use granular forms over liquids - application losses are lower.*
- *Spot-spray infested areas rather than over-applying (Never apply over impervious surfaces).*
- *Apply spray formulations on windless days (less than 7 mph wind speed) - Large droplets fall faster and are less likely to contaminate non-target areas. Ground sprays followed by soil incorporation are not likely to be a source of water pollution.*
- *Apply granular formulations to moist soils (but not before heavy rain) or lightly sprinkle water on them after application.*
- *Professional applicators must be certified. Golf course superintendents, nursery and tree maintenance personnel, some industrial and institutional employees, and certain municipal employees will also need state certification.*

Chapter 6 - Stormwater Design Considerations

When sized and installed correctly, stormwater management systems will ensure that stormwater treatment objectives (channel protection, cooling, pollutant removal and flood control) are met. However, during the planning and design process, there are other stormwater design aspects that should be considered and incorporated. The following considerations should address some of the issues found in traditional site development designs.

Incorporate Low Impact Development (LID): Traditional stormwater systems do not focus on prevention of runoff and are treating the symptom rather than the source; and many existing impervious areas are directly connected with drainage systems that increase the volume and flow rate of runoff leaving a site. LID methods and techniques can be integrated to minimize that runoff by treating it at the source and to prevent the end-of-pipe effect. Designing a development that prevents stormwater concentration will reduce the magnitude of the problem instead of having to provide a costly system to deal with it.

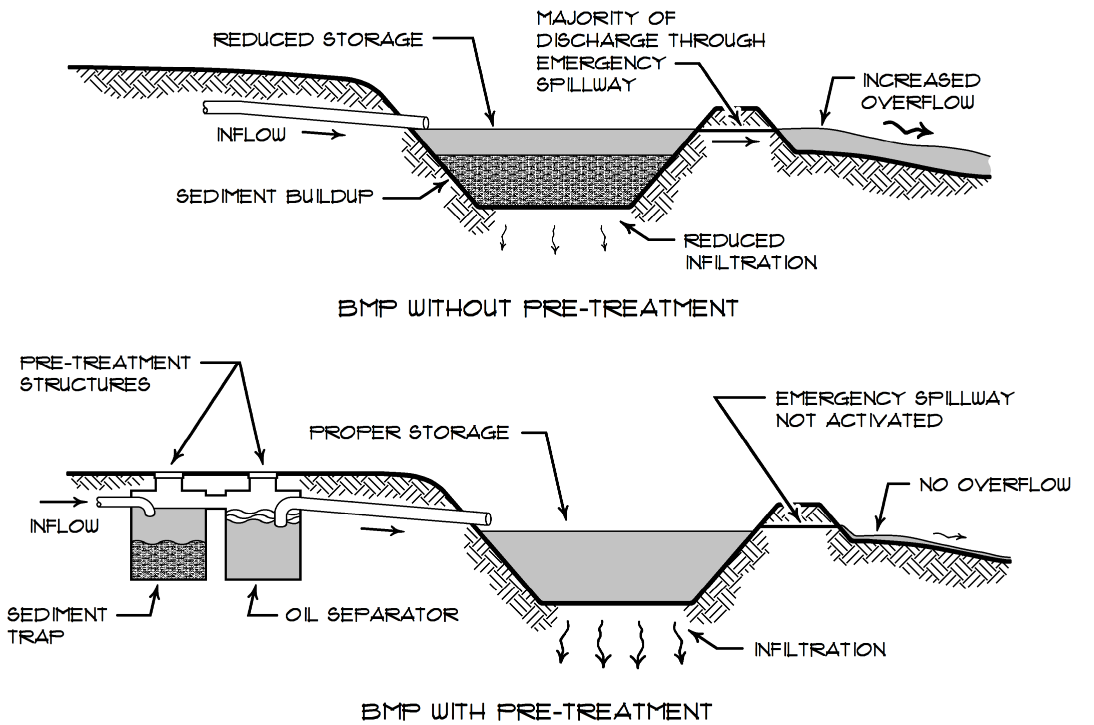


This drawing reflects how LID can be incorporated into renovations or new development projects. This example shows how multiple LID techniques can be used to minimize runoff. Ideally, LID should be incorporated at the design stage to most closely mimic predevelopment conditions, but many of the features can also be incorporated into a redevelopment project.

Sizing and Siting of Drainage Controls: The runoff calculation model TR-55 is commonly used by developers and others to estimate pre and post runoff volumes and to size drainage structures. TR-55 requires knowledge of the soil type and groundcover on the site and leaves it to the user's discretion to determine the condition of the existing and proposed cover types. In Maine, all pre-development conditions should be assumed to have good condition groundcover, and all post-development conditions should be assumed to have fair or poor condition groundcover (the property owner may not maintain their property in the best possible condition). Additionally, any wooded site that was cleared within the last five years should be considered undisturbed woods for all preconstruction runoff conditions, regardless of any restoration activities that may have occurred on the site. Furthermore, all stormwater controls should be sized assuming annual maintenance only. Sizing assumptions should not be based on more frequent maintenance since it rarely happens.

This pretreatment basin or sediment forebay has simple construction using a gabion (rock filled wire basket) berm. This helps reduce the velocity of the flows and settles out some sediments before the water is treated further.

Provide Pre-treatment on all Stormwater Management Structures: All stormwater systems should include a mechanism to remove unwanted materials from the stormwater runoff prior to its entrance into the treatment unit. Except for rooftop runoff, stormwater contains sand and silt particles that can fill a detention structure and clog the treatment devices over time. One major cause of failure is the clogging of stormwater devices that were installed to remove sediment particles. All stormwater systems should have an easily accessible, preferably visible, pre-treatment feature such as an upfront settling basin, a deep sump catch basin, a maintainable filter; or some other appropriate device. The pre-treatment unit should be designed to fail when it needs maintenance without bypassing the structure (it should stop passing water). Surface filtration devices such as raingardens and bioretention basins typically provide pretreatment in the upper layers of the structure before runoff enters the reservoir area. Regardless of the pretreatment structure, the major part of the system should be easily accessible to clean the collected sediments. In areas where petroleum byproducts or other chemical spills could occur, an appropriate measure should be added to remove the contaminants (infiltration should not be used at these sites). The pre-treatment unit should be routinely monitored for performance and regularly maintained. An O&M plan with maintenance schedules and observable triggers identifying the need for maintenance should be provided to the owner.



Pretreatment to remove coarse sediments extends the life of a stormwater treatment system (particularly infiltration and filtration systems). Without it, the system will quickly clog. This drawing shows how an infiltration system functions with and without pretreatment. Without pretreatment, sand and silt deposit in the infiltration system, causing it to clog resulting in the discharge of untreated stormwater. If pretreatment is provided, more infiltration of stormwater occurs and less water is discharged.

No Bypasses: Bypasses are used on some treatment systems to allow the device to be bypassed if not maintained. In particular, some underground units are designed with bypasses should they fill with sediment. In underground structural units, this failure is invisible so a bypass essentially renders the unit useless. Bypass capabilities should show water backing up in the unit and indicate the need for maintenance. An exception to this would be in the case of a combined sewer, in which the back up of raw sewage would not be desired.

Adapt to Site-Specific Conditions: Some special site conditions may initially seem to preclude the use of infiltration techniques, including LID practices, but there are methods that may be used to adapt infiltration or LID practices. For example, sites with shallow groundwater suggest the use of wetland treatment techniques since infiltration will not work seasonally. Similarly, an organic absorption infiltration layer can be added where bedrock is shallow. All sites can benefit from increasing the organic content of the onsite soils. In particular, the organic content of soils used in LID practices such as bioretention cells and raingardens is extremely important to the functioning of these systems. Not only do the soils promote the removal of pollutants in the water, but they also provide absorption of runoff. The organic soils act as a sponge to retain water, providing more storage capacity than would normally occur. These systems can be modified to include underdrains that will carry excess water away from the site, after it has passed through the soil media. Underdrains may also be used to route stormwater flows to an area of more native soil material or sand that can be used for infiltration.

Consider Northern Climate Issues:

Maine experiences very cold winters and the effects of our northern climate on stormwater management structures should be considered, including designing structures with a regulated overflow in the event that the unit ices completely over. Some considerations include:

- Avoidance of curbing that could cause ice jamming by plows;
- Design of infiltration systems assuming storage only with no exfiltration (as could occur under winter conditions);
- Use of traditional overflows to the municipal system in case of freezing and snow cover;
- Separation of infiltration basins from roads by more than 10 feet and only use small volume structures where infiltration might seep under the roadway;
- Fencing to protect vegetation from plow trucks.

Plowing in Maine is necessary to keep roads clear for safe passage. Stormwater treatment devices need to be designed with consideration to cold weather, snow accumulation and snow storage.

Insure Maintenance of All Stormwater Management Measures:

The maintenance of stormwater management structures is essential for their performance. Without maintenance, they will not function properly and many are difficult to recondition to restore their original function. Issues include:

- Difficulty in cleaning without overhaul;
- Lack of maintenance easement or means for access;
- Inability to see if unit is full;
- Lack of awareness and understanding of maintenance needs by owner;
- Inability to charge owner if the local municipality must do the work;
- Too frequent maintenance if unit is undersized;
- Cost of maintenance burden is too great.

The upgradient area of this wetland was not properly stabilized and maintained, causing large amounts of sediment to deposit in the wetland. The cost to retrofit this stormwater structure will be more costly than if the original specified construction and maintenance plan had been followed.

A detailed and reasonable Operations & Maintenance plan should be developed, including manpower requirements and budget needs for all stormwater management structures. It should include:

- A formally established and constructed equipment access
- Simple maintenance with minimal cleaning cost
- A permanent maintenance easement
- Easily implementable method for inspection and maintenance
- Provisions for groundwater monitoring and for the assessment of sediment removal, along with estimates of expected annual sediment quantities.

Appendix A - Landscape Designs to Enhance Stormwater Treatment

A desirable landscape is diverse and provides wildlife habitat, shade, and beauty; and it is more reflective of a natural hydrology. Also, natural landscapes tend to require less maintenance and chemical input if they have a variety of vegetation (over-story with large shade trees, understory trees with shrubs; and groundcover which provides absorption and natural uptake of rainfall). A healthy vegetative landscape will absorb and cleanse runoff; and its vegetation will thrive with little pesticide and fertilizer use. Landscape areas should include all areas on the site that are not covered by buildings, structures, paving or impervious surface.

Retention of Existing Vegetation: The boundary of areas to be retained and protected should be well defined with tree markings, construction fencing or silt fencing to avoid unnecessary cutting or removal. Care should be taken to protect root systems from damage from excavation or compaction. Individual trees, rock formations and other landscape features to be retained should also be clearly marked and bounded in the field.

- Existing trees and shrubs to be retained may be substituted for any compatible required plantings.
- Existing natural vegetation should be retained where possible and lawns should be kept to a minimum.

Neighboring Properties: Landscape Design Plans should mitigate the impact to neighboring properties.

Site Features and Layout: Landscaping should be designed to remain functional and attractive during all seasons of the year through a thoughtful selection of deciduous, evergreen, flowering and non-flowering plant varieties.

- Prominent natural or man-made features of the landscape such as mature trees, surface waters, natural rock outcrops, roadways or stonewalls should be retained and incorporated into the landscape plan where possible. The addition of ornamental rocks, fencing and other features new to the landscape is encouraged.
- Natural re-growth, mulched planting beds and alternative groundcover plant varieties are preferred. Lawn areas should not be planted in strips of less than six feet in width, especially adjacent to roads or parking areas, since such areas require watering but have little utility and are less likely to thrive.
- Plant varieties selected should be hardy, drought and salt resistant, and require minimal maintenance. Native plant species that have naturalized in the area or the surrounding region should be used when possible. Less hardy, exotic or higher maintenance plant varieties may be used to supplement minimum landscaping requirements where appropriate, but are not encouraged. Species listed on the current Invasive Species List for Maine should not be used.

Low Impact Development Landscaping: Landscaping that incorporates Low Impact Development (LID) strategies for stormwater management should absorb and treat stormwater runoff to the greatest extent possible. Low Impact Development landscaping includes the use of biofilters, raingardens, shallow swales, drywells; and other features that use soil and landscaping to mimic natural hydrologic features and functions. High organic soils encourage healthy growth and absorb and retain rainwater, minimizing irrigation needs. The selection and location of turf, trees, ground cover (including shrubs, grasses, perennials, flowerbeds and slope retention), pedestrian paving and other landscaping elements should be used to absorb rainfall, and visually integrate all structures with the landscape. Where possible, the landscaping design should combine form and function, incorporating drainage features invisibly into the landscape such as through shallow detention areas and swales that provide for infiltration of runoff.

Parking Lots: Parking lots with more than fifty (50) parking spaces should have planting islands that are placed at each end of a parking row with no parking row containing more than 30 contiguous parking spaces without a planting area. If necessary, curbs for a parking lot should have a shallow descending cut that is a minimum of five feet wide to allow drainage to flow from the parking lot into a curbed planting area. Such planting areas should be underlain by a suitable layer of crushed stone or other water-holding reservoir.

Informal, Re-growth and Peripheral Landscape Areas: Disturbed areas intended to be revegetated should be loamed and seeded with flowers, perennial grasses, or with native trees, shrubs (blueberry, rhododendron, winterberry, bayberry, shrub dogwoods, cranberry bush, spicebush, native viburnums, etc.). Hardy shrubs along the edge of cleared woodlands provide an attractive transition between natural woodland and landscaped portions of a site. Where woodland areas are intended to serve as buffers, such plantings can fill in voids by rapidly reestablishing undergrowth.

Soil Preparation: Soil compaction should be avoided as compacted soils restrict root penetration, impede water infiltration and have a higher runoff coefficient. Limiting construction activities in landscaped areas to specific area will help minimize compaction. Compacted areas that are to become landscaped should be deeply tilled (at least 12 inches) to facilitate deep water penetration and soil oxygenation. Soil amendments such as highly decomposed organic matter (compost, sewer bio-solids, and forestry by-products) will improve water drainage, moisture penetration, soil oxygenation, and/or water holding capacity. For newly landscaped areas where topsoil is limited or nonexistent, or where soil drainage is impeded due to subsurface hardpan or bedrock, 6 to 7 inches of good quality loam should be spread in all planting and turf areas to increase the subsoil depth. Soil analysis of new or renovated turf areas should include a determination of soil texture, including percentage of organic matter; an approximated soil infiltration rate; and a measure of pH value.

Compost: Incorporation of organic matter such as compost improves the structure, aeration and health of micro-organisms of any soil types. In sandy soils, compost increases the water holding capacity and nutrient retention. Compost should be a stable, humus-like organic material produced by the biological and biochemical decomposition of compostable materials (manure and/or other agricultural residuals are not recommended as they are high in phosphorus). The pH of compost should be in the range of 5.5 - 8.0. The soluble salt content of compost should not exceed 4.0 mmhos/cm (determined by using a dilution of 1 part compost to 1 part distilled water). The quantity of compost to be incorporated into a site is determined by the organic content goal for the soil and is dependent on its existing organic content. Organic content of landscaped soils should not be less than 18% by volume in the top six inches of the finished topsoil. Organic matter (three to four cubic yards of organic matter per 1,000 square feet of landscape area) should be incorporated to a depth of four to six inches.

Mulching: Mulch retains moisture, reduces weed growth, and minimizes erosion. Mulches include organic materials such as wood chips, compost and shredded bark and inert non-organic materials such as decomposed lava rock, cobble, and gravel. If weed barrier mats are used, the use of inert non-organic mulches is recommended. Mulches should be applied to the following depths: three inches over bare soil, and two inches where non-herbaceous plant materials will be used. Mulches for stormwater management areas should be heavier and not of a type that will float away.

Vegetation: All areas to be landscaped should be mulched or planted with hardy groundcover plant varieties rather than planted as lawn areas. Where landscape areas are used as part of the drainage system, plantings should be tolerant of periodic wet conditions and be sloped to allow infiltration and storage. Wheel stops should be provided in all parking areas abutting landscaped strips to avoid accidental damage. Where larger shade trees may interfere with overhead utilities, minor shade or ornamental tree varieties should be used. Any landscape element that dies, damaged or is removed, should be replaced with plants similar in height or texture element as originally intended.

Plant Specifications: Areas intended as planting beds for shrubs or hedges should be cultivated as deeply as possible.

- Pits for planting trees or shrubs should be generally circular with vertical sides. Pits for trees or shrubs should be deep enough to allow only one-eighth of the ball of the roots at the existing grade. Pits for trees should be wide enough to allow for at least 9 inches between the ball of the tree and the sides of the pit on all sides.
- The bed area should be covered with a two to three inch deep layer of mulch between plants and with a well formed at each root ball area.
- All trees and shrubs should be appropriately pruned after planting with all broken or damaged branches removed.
- All plants should be nursery grown.
- Consult the Maine Cooperative Extension from the University of Maine when selecting plants. The chosen plants should be suitable for your environment (sun exposure, moisture, soil type, zone, height of plant, etc.) and not be invasive **http://umaine.edu/gardening/home-gardening/plants-for-the-maine-landscape/ .**

Maintenance: Low maintenance, drought, insect, and disease-resistant plant varieties are encouraged for buffers and landscaping areas. Native species and species that have long thrived within the region are preferred since such plant species are well adapted to the local environment. To avoid maintenance problems, soil testing should be conducted prior to planting to ensure that the appropriate plant varieties are selected. Where used, irrigation systems should be installed with a moisture meter or other device designed to avoid unnecessary or excessive watering.