Stormwater Management

Cornell Local Roads Program

New York LTAP Center

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Preface

In this manual, we focus on understanding the issues related to stormwater and provide steps to manage and reduce the problematic issues resulting from stormwater. This manual is intended to serve as a guide for managing stormwater related to the roadway infrastructure and practices of local highway departments, from planning to maintenance. The discussion includes management and structural alternatives to give local officials a better understanding of what is available and what they can do to improve their approach to, and maintenance of, the watershed they live in.

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Acronyms

The following acronyms are found throughout this manual.

ACOE (US ACE) - Army Corps of Engineers
BMP - Best Management Practices
BOD - Biological Oxygen Demand
BSD - Better Site Design
CaCl - Calcium Chloride
CLRP - Cornell Local Roads Program
CSOs - Combined Sewer Overflows
CWA - Clean Water Act
CWP - Center for Watershed Protection
DO - Dissolved Oxygen
EPA - Environmental Protection Agency
FEMA - Federal Emergency Management Agency
GI - Green Infrastructure
HDPE - High-Density Polyethylene
IDDE - Illicit Discharge Detection and Elimination
LID - Low Impact Development
MCM - Minimum Control Measure
MgCl - Magnesium Chloride
MS4 - Municipal Separate Storm Sewer System
NaCl - Sodium Chloride
NFIP - National Flood Insurance Program
NOI - Notice of Intent
NOT - Notice of Termination
NPDES - National Pollution Discharge Elimination System
NRCS - Natural Resources Conservation Service
NURP - National Urban Runoff Program
NY OGS - New York Office of General Services
NYC DEP - New York City Department of Environmental Protection
NYDOS - New York Department of State
NYSDEC (DEC) - New York State Department of Environmental Conservation
SPCC - Spill Prevention, Control and Containment
SPDES - State Pollution Discharge Elimination System
SWCD - Soil and Water Conservation District
SWMP - Stormwater Management Plan
SWPPP - Stormwater Pollution Prevention Plan
TMLD - Total Maximum Daily Load
TSS - Total Suspended Solids
USDA - United States Department of Agriculture
USGS - United States Geological Survey
WQA - Water Quality Act
WQv - Water Quality Volume
WSS - Web Soil Survey

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1 - Managing Stormwater

> "*Stormwater is water from rain or melting snow that doesn't soak into the ground but runs off into waterways*" NYSDEC

People have been managing stormwater runoff since the changing of the landscape for human use began. Often management was an unintended consequence of another activity such as redirecting runoff flow from in and around farm fields or intentionally, as when the Romans installed gutters to remove and redirect runoff on their "paved" roadways. Today, design standards continue this tradition of collecting and directing runoff away from the road. The subject of runoff as related to drainage systems and roadways and how to address it, is covered in detail in the Cornell Local Roads Program workshop *Roadway and Roadside Drainage*. In this workbook we look to focus more on understanding and managing stormwater. It is intended that this workbook will provide a guide to follow when addressing stormwater from planning through maintenance to post flood response. This workbook also provides a discussion of management and structural alternatives available.

The key to being successful in making a management program work is to know your infrastructure. Knowing the critical infrastructure in your municipality can be done through regular inventory, inspection, and documentation of those crossings. Records related to the conditions and importance to the community are factors in understanding how stormwater will affect access to and within a community. Examples of items that should be reviewed are:

- Ditches
- Culverts and bridges
- Slopes
- Vegetation
- Municipal facilities and equipment including snow and ice material storage

In addition to the infrastructure, highway departments need to also look at how maintenance activities can effect stormwater. Common activities include:

- Repairs and maintenance for all of the infrastructure listed above
- Snow and ice control
- Equipment washing
- Gravel pit operations
- Use of fertilizers and pesticides

POTENTIAL POLLUTANTS

For all of the infrastructure and activities of the highway agency, there are a variety of potential pollutants that can be carried in stormwater and have adverse effects if not handled properly. Table 1 shows possible pollutants associated with various municipal activities. These types of pollutants are discussed in Chapter 4.

Table 1. Potential pollutants associated with specific municipal activities

Municipal Program: Maintenance & Operation	**Activities**	**Potential Pollutants**								
		Sediment	**Nutrients**	**Trash**	**Metals**	**Bacteria**	**Oil & Grease**	**Organics**	**Pesticides**	**Oxygen Demanding Substances**
Highway Maintenance	Sweeping	X		X	X		X			X
	Repair, Maintenance, Striping	X		X	X		X	X		
	Bridge Maintenance	X		X	X		X	X		
Landscape Maintenance	Mowing/Trimming & Planting	X	X	X		X			X	X
	Fertilizer & Pesticides	X	X						X	
	Landscape Wastes			X					X	X
	Erosion Control	X	X							
Drainage System	Inspection/Cleaning	X	X	X		X		X		X
	Illicit Discharge & Connections	X	X	X	X	X	X	X	X	X
	Illegal Dumping	X	X	X	X	X	X	X	X	X
	Inlet/Outlet Maintenance	X		X	X		X			X
Waste, Handling & Disposal	Solid Waste Collection		X	X	X	X	X	X		X
	Waste Reduction/Recycling			X	X					X
	Household Hazardous Waste			X	X		X	X	X	
	Litter			X	X	X		X		X
	Illegal Dumping	X		X		X	X		X	X
Sidewalk, Parking Lot Maintenance Cleaning	Surface Cleaning	X	X			X	X			X
	Graffiti Cleaning	X	X		X			X		
	Sidewalk Repair	X		X						
	Litter	X		X		X	X			X
Water/Sewer Utility Operations & Maintenance	Water Line Maintenance	X				X	X		X	
	Sanitary Sewer Maintenance	X				X	X			X
	Spill/Leak/Overflow Control Response & Containments	X	X			X		X		X
Fountain/Pool/ Pond/Lake/Lagoon Maintenance	Fountain/Pool Draining		X					X		
	Lake/Pond/Lagoon Maintenance	X	X	X		X			X	X

Table 2. Potential pollutants likely associated with specific municipal activities

	Potential Pollutants								
Municipal Facility Activities	**Sediment**	**Nutrients**	**Trash**	**Metals**	**Bacteria**	**Oil & Grease**	**Organics**	**Pesticides**	**Oxygen Demanding Substances**
Building & Grounds Maintenance & Repair	X	X	X	X	X	X	X	X	X
Parking/Storage Area Maintenance	X	X	X	X	X	X	X		X
Waste Handling and Disposal	X	X	X	X	X	X	X	X	X
Vehicle & Equipment Fueling			X	X		X	X		
Vehicle & Equipment Maintenance & Repair				X		X	X		
Vehicle & Equipment Washing and Steam Cleaning	X	X	X	X		X	X		
Outdoor Loading & Unloading of Materials	X	X	X	X		X	X	X	X
Outdoor Container Storage of Liquids		X		X		X	X	X	X
Outdoor Storage of Raw Materials	X	X	X			X	X	X	X
Outdoor Process Equipment	X		X	X		X	X		
Overwater Activities			X	X	X	X	X	X	X
Landscape Maintenance	X	X	X		X			X	X

Source for table 1 & 2: California Stormwater BMP Handbook (http://www.cabmphandbooks.com/)

Figure 1. Sediment build up adjacent to road

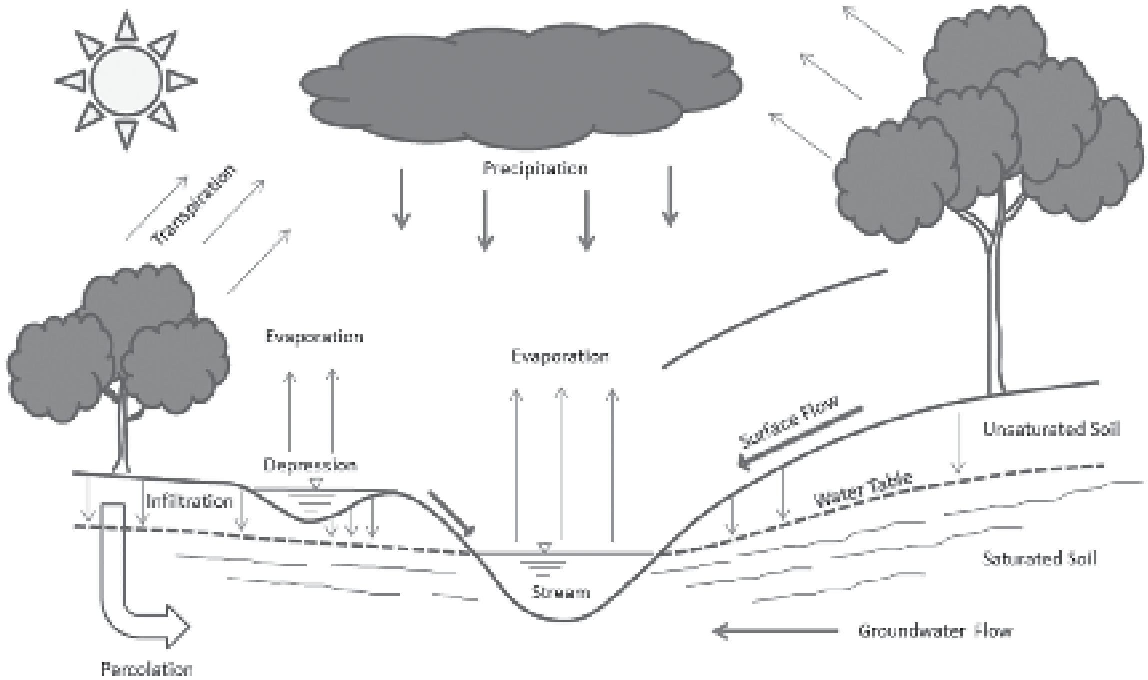


Figure 2. The water cycle

STORMWATER CYCLE

We are familiar with the water, or hydrologic, cycle that represents the "life" of water from atmospheric vapor, precipitation, to surface and ground water and back to the atmosphere through evaporation and transpiration.

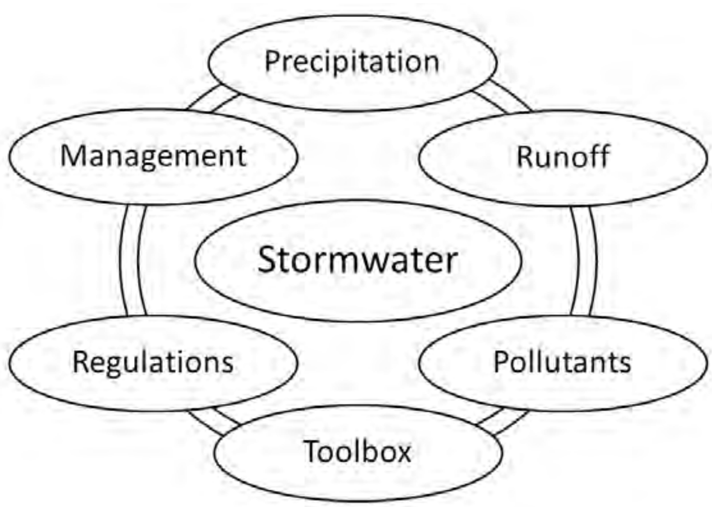


Figure 3. The stormwater cycle

Like the water cycle, stormwater can also be represented as a cycle. This cycle is influenced by the atmosphere and precipitation, but more importantly, stormwater is greatly influenced by the earth surface on which it falls. The presence of vegetation, the type of soils, the geographical configurations directly impact how stormwater is generated and what it does once it concentrates and travels over the land. To provide a means of understanding and a source guide on how to prepare for and address stormwater, we look to discuss the multiple parameters that influence the daily operations and planning within a community.

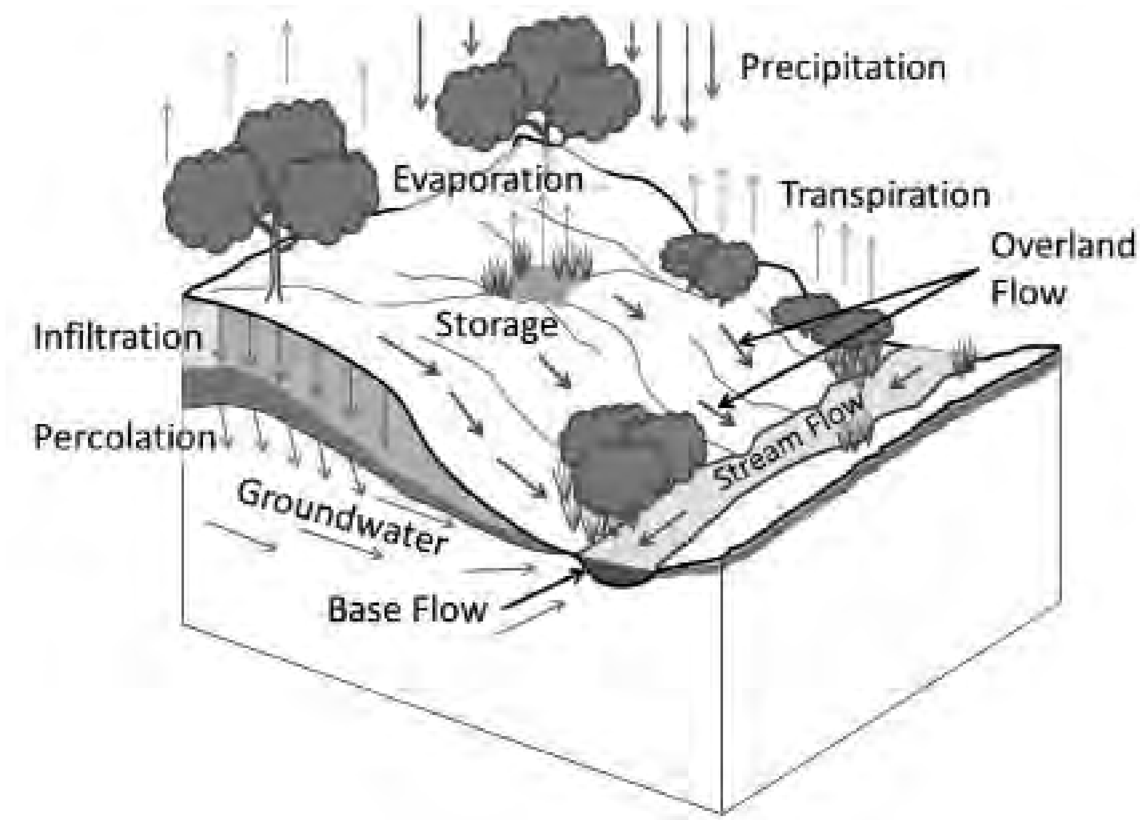


Figure 4. Stormwater and the land

2 - Precipitation

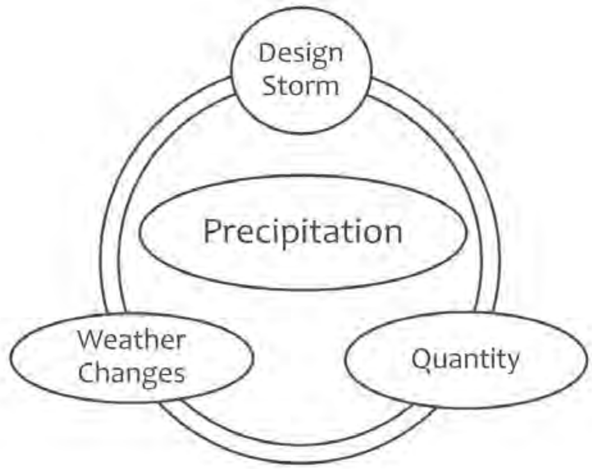


Figure 5. Precipitation concerns

WEATHER CHANGES

We can see why stormwater is becoming a serious topic by looking at the influence the atmosphere has on precipitation. Regardless of the cause, weather patterns are changing, and have been changing in New York State for quite some time.

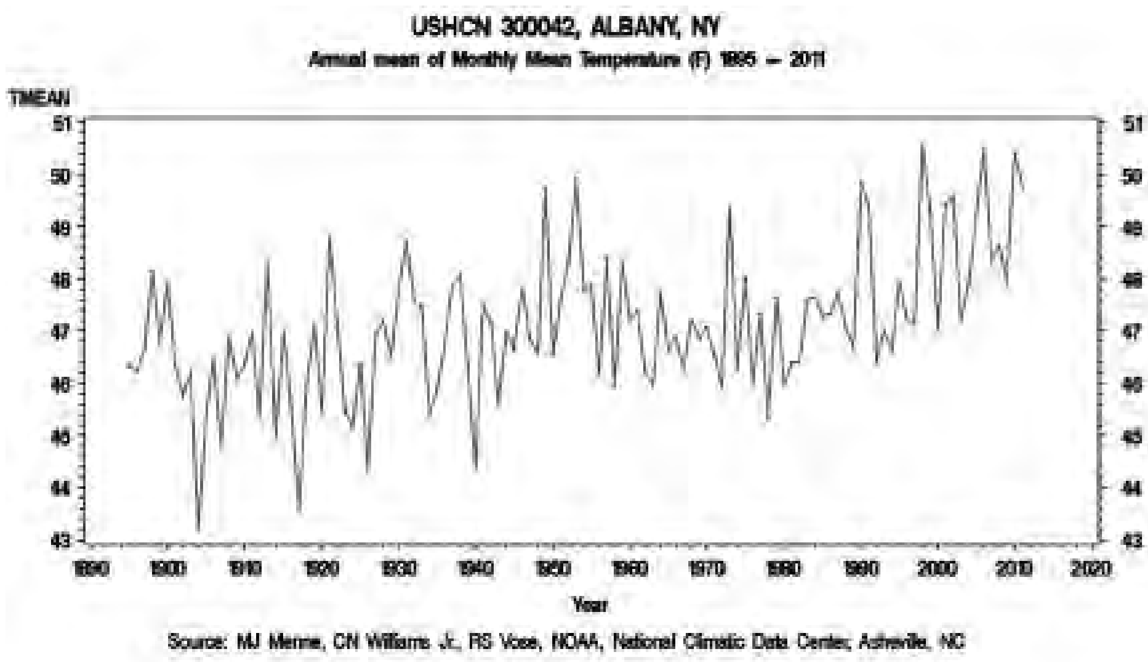


Figure 6. Annual mean monthly temperature - Albany, NY

Figure 7. Annual mean monthly precipitation - Albany, NY

From 1970 to 2000, average temperatures here in New York State have been getting warmer; summer temperatures have been increasing at a rate of 0.5°F per decade, while winter temperatures have been rising at an average rate of 1.3°F per decade. This trend is likely to continue.

What's the concern?

While many people may dream of the days when New York becomes Florida like, this scenario comes with changes that may affect the way of life to which we are currently accustomed. Climatic changes observed with this warming trend include:

- Increased short intense rainfall events
- Less precipitation as snow and more as rain
- Decreased snow pack
- Higher density snowfall (heavier and wetter)
- Hotter and dryer summers, higher number of days with temperatures greater than 99°F
- More frequent tropical storm occurrences
- Rising ocean temperatures
- Earlier snow melts
- Increased number of freeze-thaw cycles/more pavement damage

Ecological changes include:

- Longer growing seasons
- Earlier blooming of vegetation
- Changing migration patterns in Atlantic salmon
- Changes in amphibious mating cycles

The changes observed are anticipated to continue into the future as well.

DESIGN STORM

The design storm is a concept used to determine the amount of precipitation that can be anticipated for the design of a drainage system. The design storm is an average time (in years) between storms of specific volumes. However, this average is long-term and the real use is as a probability in a given year. A design storm which has 1/25 (4 percent) chance of occurring in a given year is referred to as a 25-year storm. A 50-year storm has a 1/50 chance of occurring, or 2 percent. The greater the design storm, the greater the amount of precipitation that can be expected and the less likely it will occur.

The greater the design storm value in years, the less likely a flood will occur during the life of the design. A 50-year storm is not two times the 25-year storm; it is a storm that is half as likely to occur. Table 2 shows the typical design storms used for for different road types. The objective of the design storm is to design a crossing adequate to pass most rainfall events, yet allow flooding to occur during heavy rainfall events.

Table 3. Design storms for various highways

Road type	Culvert	Driveway	Ditches
Town roads/Village streets with low traffic	10 years	5 years	5 years
Town roads/Village streets with high traffic	25 years	10 years	10 years
County roads with low traffic	25 years	10 years	10 years
County roads with high traffic	50 years	25 years	25 years
Arterials (State and very important roads)	100 years	50 years	50 years

As rainfall patterns and intensities change, the rainfall amounts used in design; specifically, the 'design storm' may need to be modified. The USDA Natural Resource Conservation Service (NRCS) 24-hour Rainfall Distribution design storm data used to prepare most culvert designs were developed and published in the early 1960s. Those NRCS 24-hour rainfall distributions in today's applications may result in insufficient capacity and an increased potential for flooding. For previously designed and installed culverts and stream crossings this is an issue that must be recognized.

To address this potential shortcoming in the data, the USGS has developed a web based source that utilizes real-time data from thousands of gauging stations across the US which are used to calculate stream flow statistics for each station. This source is known as StreamStats and can be found on the web at *http://water.usgs.gov/osw/streamstats/index.html*.

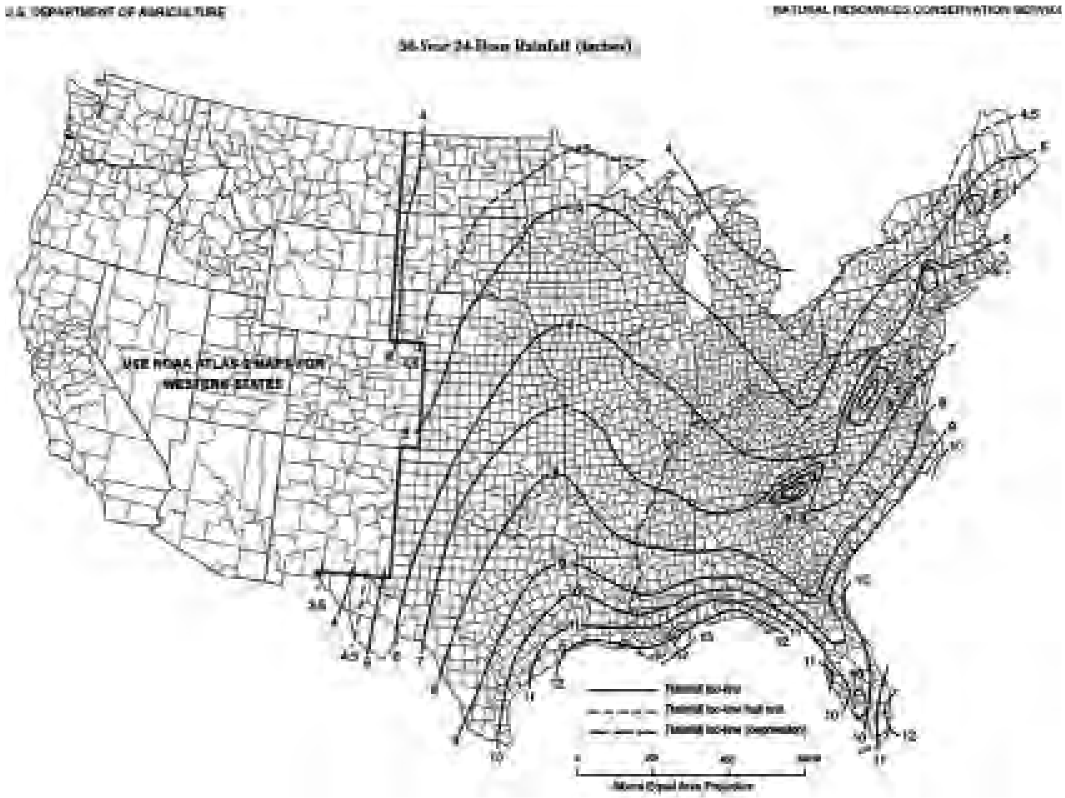


Figure 8. Amount of rainfall in 24 hours (inches) for a 50 year storm
Source: Appendix B: Synthetic Rainfall Distributions and Rainfall Data Sources; Figure B-7, 210-VI-TR-55, Second Edition, June 1986.

QUANTITY

The amount of rain for a given design storm identifies an amount that is anticipated over a 24 hour period. The NRCS refers to a 50-year design storm as “50-Year 24-Hour Rainfall (inches)”, as it does for other design storms. These amounts are the historical amount of rainfall that can be anticipated a certain percentage of time. For example, Albany can anticipate about 6 inches of rainfall in a 24-hour period for a 50-year storm. Or in other words, there is a 2 percent chance of Albany getting 6 inches of rainfall in a 24-hour period.

One of the trends that have been observed lately is that a large amount of rainfall can drop in a very short period of time. Occasionally, multiple heavy rainfall events can occur in very short periods of time at one location. Since the amount of rainfall that lands on the earth’s surface from these types of events does so in a short period of time, the ability of the soil to absorb it is severely limited. This results in a large volume of runoff travelling along the ground surface. As this runoff concentrates and flows down the watershed, the volume and velocity of the flow becomes potentially dangerous and damaging. Large volumes of runoff in streams and ditches can easily overwhelm the banks resulting in flooding. The velocity associated with the flow can carry a large force capable of eroding stream banks, ditches and occasionally roadways. These short intense high volume rainfall events are some of the more destructive factors to consider when addressing runoff.

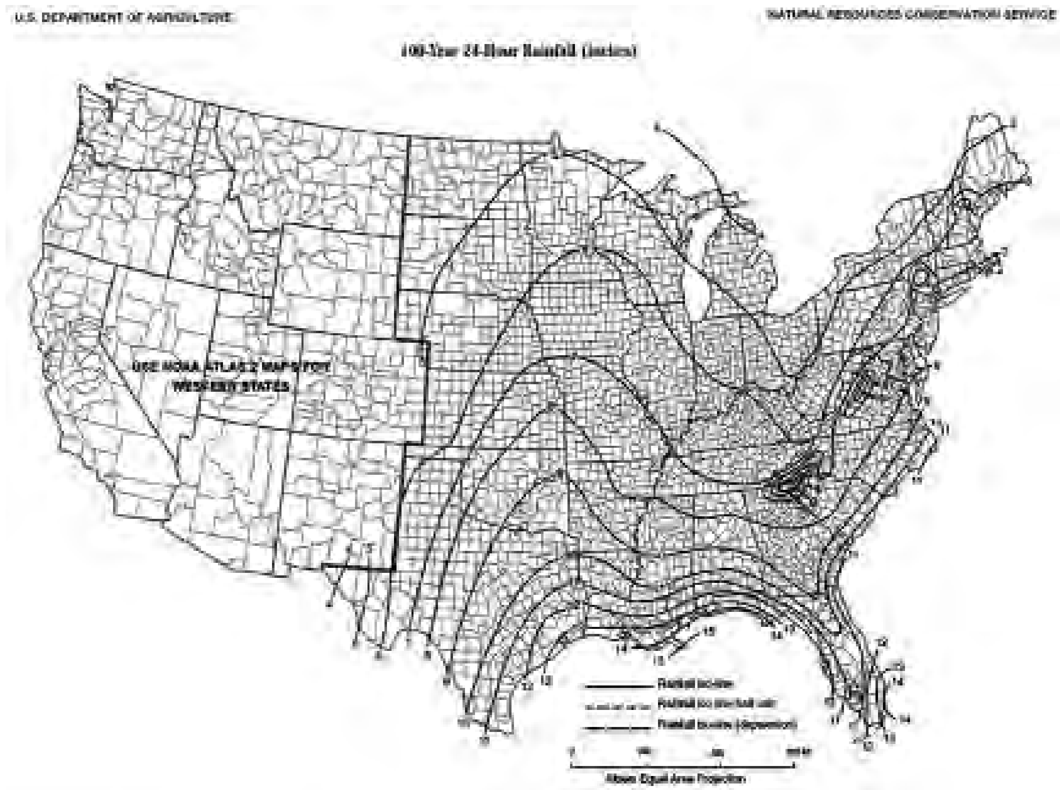


Figure 9. Amount of rainfall in 24 hours (inches) for a 100 year storm
Source: Appendix B: Synthetic Rainfall Distributions and Rainfall Data Sources; Figure B-8, 210-VI-TR-55, Second Edition, June 1986.

Rainfall Data Resources

- USDA NRCS 24-Hour Rainfall Data
- Streamstats: *http://water.usgs.gov/osw/streamstats/index.html*
- Local Soil and Water Conservation District
- Regional Watershed Authority
- Water Resources Engineer

3 - Runoff

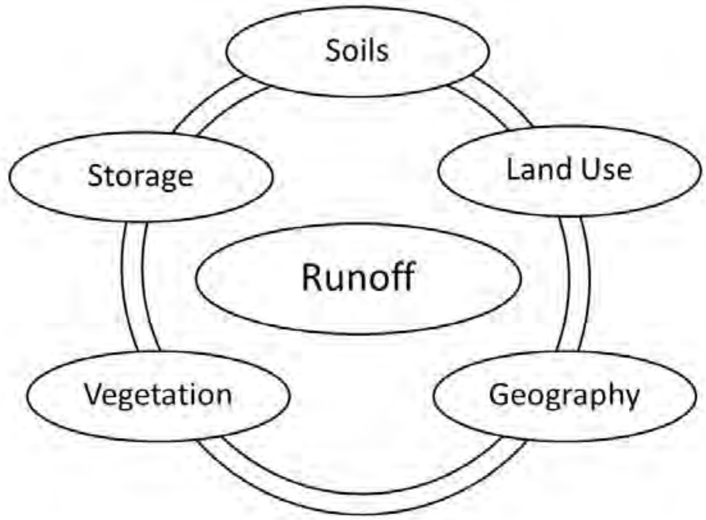


Figure 10. Runoff concerns

Runoff, simply defined, is the portion of precipitation that does not get absorbed by the soil, collected in a pond or evaporated immediately. When measuring the amount of runoff in a stream a graph known as a hydrograph is used. It is a measure of the amount of runoff added to the base stream flow over the course of a rainfall event. Figure 11 shows a hydrograph overlaying another graph known as a hyetograph. A hyetograph, represented by the light line, is a graph that represents the rainfall intensity in inches per hour over the entire rainfall event. On this graph the hydrograph, represented by the dark line rises from the base flow line, reaches a peak and then gradually descends back toward the normal base flow of the stream. For most infrastructure designs, the peak flow is the main item of concern since it represents the total amount of runoff that occurs; the greater the peak the more potential for infrastructure damage. There is a lag between the peak of the hyetograph and the hydrograph; this indicates the amount of time it takes for the precipitation to collect at the specific point at which the flow is being measured. The base flow is the normal flow level at the point of measurement; note that the hydrograph does not immediately return to its base flow, this is a result of the short term saturation and infiltration of the runoff into the soil that slowly works its way into the stream over a longer period of time.

When we discuss runoff and how the hydrograph is affected, it is important to understand that there are multiple factors that come into play. Soils, land use, geography, vegetation and available storage all influence the amount of runoff that can come from an area. Each of these factors directly impacts how much and how fast stormwater will travel through the watershed on which the precipitation is falling. In turn, the quantity and velocity directly impact the ability of that runoff to carry and/or create pollutants to be discussed later in this workbook.

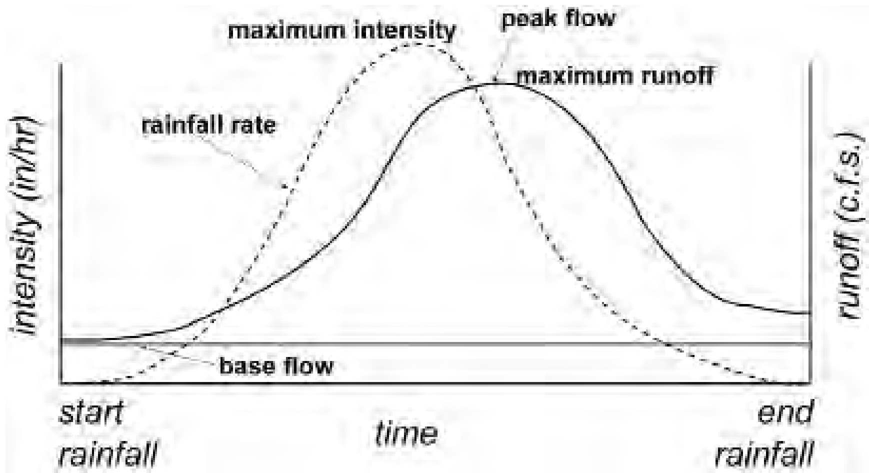


Figure 11. Delay between peak in rainfall intensity and maximum runoff

Another factor to consider is what is referred to as a watershed. In watersheds, size does matter. Larger watersheds will catch more precipitation and have a larger amount of runoff for the same design storm as a smaller watershed, assuming the ground surfaces are similar. Figure 12 is an example of a small watershed contributing to a culvert crossing.

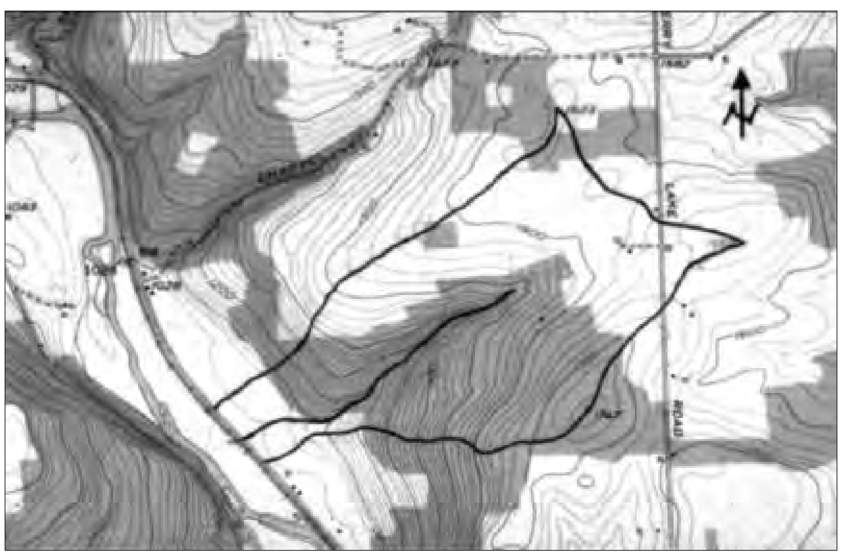


Figure 12. Example of a watershed

RUNOFF FACTORS

Pervious surfaces, like grassed, landscaped and woodland areas, typically allow a majority of the precipitation to soak into the soil, while a small percentage runs off as stormwater. Impervious surfaces, such as parking lots, highways and rooftops, typically do not allow the precipitation to soak in; most of the precipitation runs off as stormwater. There are many factors to determine the perviousness of a particular section of land.

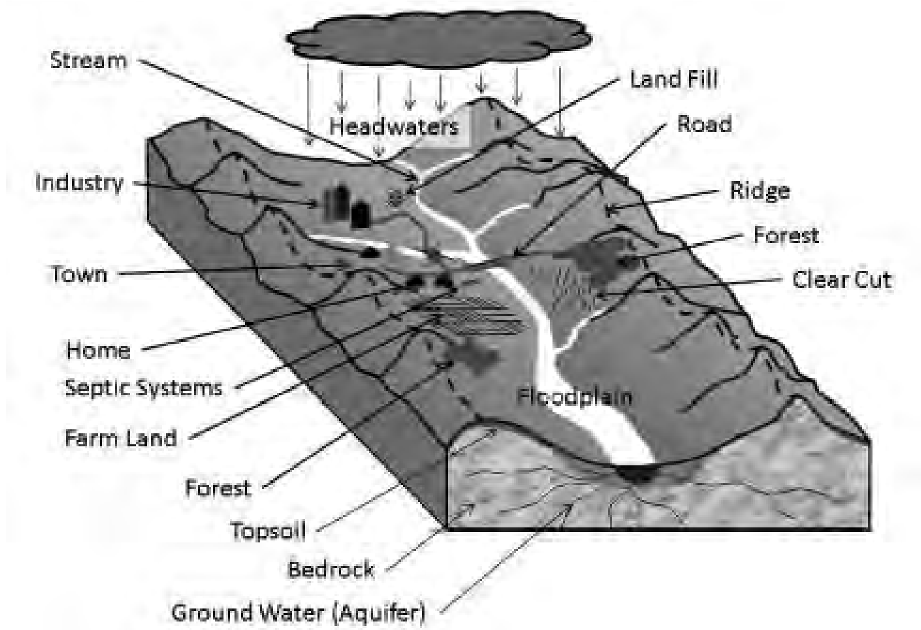


Figure 13. Diagram of a watershed

Soils

Soils are a very important and often overlooked factor when it comes to assessing the potential for higher runoff. The soil in a region can often absorb a lot of the precipitation. In this case, the soil can:

- contribute to the replenishment of an aquifer or the water table
- reduce the amount of precipitation that results in runoff

Soils can be classified in various ways depending on how it is relative to the task at hand. The most common classification used in the United States is the Unified Soil Classification System (USCS) that divides soils into three groups, coarse-grained soils (gravel and sand); fine-grained soils (silts and clays); and highly organic soils (peat). Important characteristics of soil, as related to stormwater, include porosity, water content, hydraulic conductivity or permeability, penetrability and other less significant characteristics.

Porosity is the measurement of the pore spaces within the soil. This will vary depending on the amount, size, shape, diffusion of the particles, and the quality of the diffusion of particles. Porosity is an important soil property and defines its ability to retain and transport moisture and pollutants through the soil.

Water content is the amount of water in the soil and can affect plant growth and the infiltration ability of the soil. A soil with high water content will have a limited ability to store additional moisture. The constant presence of high water content will also reduce the amount of air within the soil. A prolonged presence of high water content can cause a reduction in the chemicals in the soil resulting in a hydric soil where chemicals form “mottles” or small areas of differing colored soils of red, gray, yellow, brown or black. Hydric soil is a characteristic soil of wetlands.

Permeability, or hydraulic conductivity, is a measure of a soils ability to transmit water, and is critical for the infiltration of runoff into the soil.

Penetrability, or **bulk density**, is a measurement of soil compaction. Compacted soils typically have a reduced porosity that directly affects the soils ability to hold and transfer water. Compacted soils can restrict root growth, infiltration rates and increase the amount of runoff from a site. The compaction of the soils within a retention basin can severely restrict the ability of the stormwater from infiltrating into the underlying soil, limiting the effectiveness as a basin.

When determining a management practice that will function best in any specific area it is helpful to know the Hydrologic Soil group. Hydrologic soil groups are determined by the soil layer with the lowest water permeability and depth to an impermeable layer or to the water table. This soil layer will dictate the rate at which the soil below will receive the transmitted water.

There are four hydrologic soil groups identified. Assumptions are made for comparison purposes when identifying hydrological soil groups, these include the soil is well aggregated, has a low bulk density (not highly compacted), and that the material is thoroughly wet so that moisture uptake by the soil does not influence the soil runoff potential.

Table 4. Hydrologic soils group

			Major Components		**Restrictive Layers**		**Permeability Rates**	
Group	Runoff Potential	Infiltration	Clay	Sand/ Gravel	Impermeable Depth	Water Table	0 to 20 inches	40 inches to Restrictive Layer
A	Low	High	10%	90%	>20”	>24”	> 5.67 IPH	> 5.67 IPH
B	Mod. Low	Moderate	10% - 20%	50% - 90%	>20”	>24”	1.42 - 5.67 IPH	0.57 - 1.42 IPH
C	Mod. High	Low	20% - 40%	<50%	>20”	>24”	0.14 - 1.42 IPH	0.06 - 0.57 IPH
D*	High	Very Low	>40%	<50%	<20”	<24”	</= 0.14 IPH	</= 0.06 IPH

* *All soils within 24 inches of the Water Table are considered D soils*
For Soils A, B and C a Dual designation; AD, BD or CD is used
IPH = Inches per hour; flow rate of water in soil

If you are uncertain of the specific makeup of the soil that is present at a site, there are several options available; conduct a percolation test, consult your local Soil & Water District or go to the Web Soil Survey and look up your own soils at *http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.*

Land Use

How the land is used is just one of many factors that can influence a watershed. Various degrees of land use directly affect how a watershed responds to rainfall events by dictating the amount of rainfall that leaves a site. Forested lands retain the greatest amount of precipitation, while the impervious surfaces of parking lots and rooftops retain very little of the precipitation. As the land use changes from forested through agricultural, residential to commercial, the amount of precipitation retained on the land proportionately decreases; the greater the amount of the development, the greater the amount of stormwater runoff that can be expected from the site. As the amount of runoff increases, the volume capacity in streams, ditches and culverts become diminished. As a greater amount of runoff travels through the existing channels, there is an increase in rate in which the runoff flows. The increase in velocity results in the increase in erosion and sediment transfer, which also carry pollutants that are attached.

An increase in impervious surface area as development expands means an increase in the amount of runoff that can be expected from that site. If uncontained, the excess runoff contributes to the existing stormwater flow in ditches and culverts. The peak flow, Q, is measured in cubic feet per second or Area (in square feet) times a speed (feet per second).

Peak Flow (Q) = Cubic Feet per Second (cfs)
= Area (Square Feet) * Velocity (Feet per Second)

When the Peak Flow increases and the area of the culvert or ditch remain the same, the velocity must increase to allow the increase in cross sectional volume to pass. The increase in the velocity reduces the amount of time it takes for a drop of rain to reach the point of consideration. (In the TR-55 calculation method, the time of travel from the furthest point of impact from the point of concern is referred to as the Time of Concentration.)

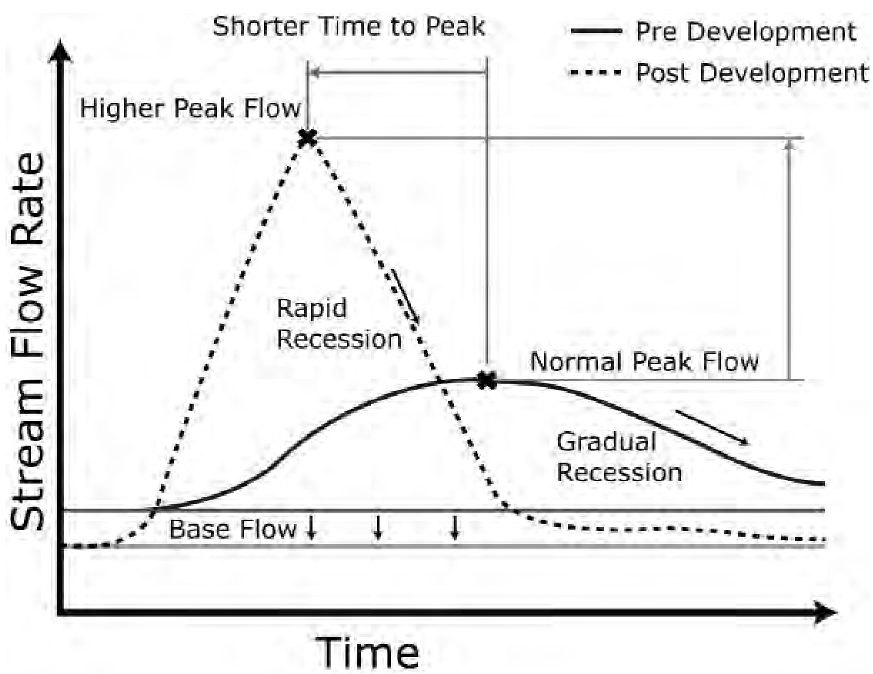


Figure 14. Difference in runoff characteristics between developed and undeveloped land

The effect this has on the hydrograph can be dramatic. As the velocity of the flow increase the bulk of the flow arrives at the point of consideration much sooner than under normal conditions.

This is represented by an earlier peak on the hydrograph. Since the bulk of the flow arrives at the specific point earlier, at the same time other areas are anticipated to arrive, the combined peak flows of the contributing areas result in an increased total peak flow. Not only is the flow moving faster, but it also arrives in a much greater volume. This change in the hydrograph is represented in Figure 14, Pre- and Post-Development hydrographs.

Runoff Calculations

The differences in land use are a major component when calculating the amount of runoff that can be expected from a given area. When doing an analysis of a watershed there are several methods that are used, each either easier or more in depth depending on the size and the precision required for the analysis.

- Rational Method: for smaller drainage areas <25 acres +/-, simple and easy
- SCS Graphical Method: Limited to homogeneous watershed, used for only peak discharge and focuses on only one main stream
- TR-55: Can be used for non-homogeneous watersheds, multiple factors can be obtained, based on SCS method.
- Bureau of Public Roads: An early version to determine runoff

One of the more basic runoff calculation methods, the Ration Method, illustrates the inclusion of land usage into the peak runoff calculations.

Ration Method Equation: $Q = C*I*A$

Q = Peak Runoff (Cubic Feet per Second: cfs)
C = Coefficient of Runoff
I = Rainfall Intensity (Inch per hour)
A = Contributing Watershed Area (acres)

Table 5. Coefficient of runoff (C) for each land type

C	Land type
0.1 – 0.4	Forested land
0.3 – 0.4	Suburban residential areas
0.3 – 0.5	Single–family residences
0.7 – 0.9	Downtown business districts
0.1 – 0.2	Parks and cemeteries
0.2 – 0.4	Pastures
0.2 – 0.5	Cultivated land
0.8 – 0.9	Paved development

To take into account the various land uses, a multiplying factor, known as the Coefficient of Runoff, is used. The Coefficient of Runoff represents the amount of runoff that could be expected from each land use type. The smaller the C value, i.e. 0.1 - 0.2 of parks and cemeteries, will yield less runoff than a high C; 0.8 - 0.9 of paved developments, where 80 to 90 percent of the precipitation could be expected as runoff. The Coefficient of Runoff is determined based on soil types; basin slopes and varies with land use.

GEOGRAPHY

When we discuss geography relative to stormwater we focus on the slope and stream density of the contributing watershed or drainage area.

Watersheds

A *watershed* as defined by the NYSDEC as an “area of land that drains into a body of water.” The body of water can be a stream, river, pond, lake, and the ocean. In the true sense, a watershed is separated from other watersheds by high points in the land such as ridges. A smaller scale is often considered with the design of a new or replacement culvert. When developing a watershed management plan, or enlarging an existing culvert size, it is important to not only consider the upstream contributing area, but also the effects that may result to downstream structures and property. The critical key is that we ALL live in a watershed.

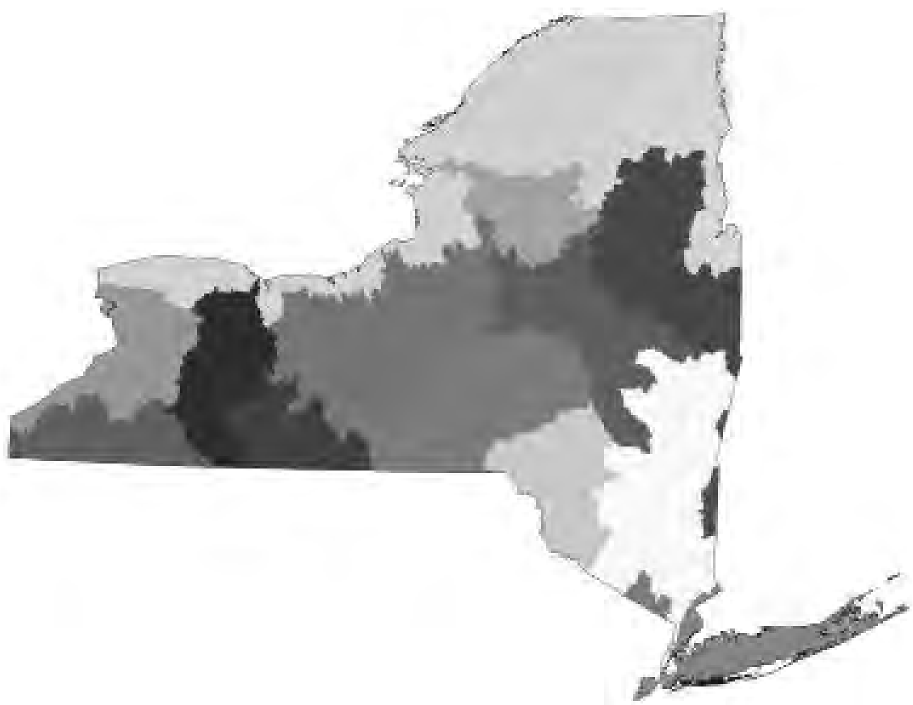


Figure 15. The 17 major watersheds in New York State

Slope

In areas where the slope is steep, runoff can accelerate very quickly. As the velocity of the runoff increases, the time it takes for the bulk of the runoff from a watershed to reach a point of interest is decreased, causing a larger volume of runoff to collect in very short period of time. This increase in the runoff velocity also increases the potential for erosion. In areas of steep slopes - vegetation and other structural methods may be required to stabilize the slope to minimize the potential for erosion.

Stream Density

Stream density is the relationship of the total length of stream channels in a drainage area to the total drainage area.

Stream Density = Length of Stream Channels/Drainage Area

An area with a high stream density will often be a quick draining area that is prone to flash flooding risks due to the short time the runoff has from the time it falls to the stream to a point of concern or discharge. High stream density areas are often characterized by soils of low permeability or high bedrock which allow the formation of many streams to discharge the precipitation runoff. In New York State, higher drainage densities are found in the Allegany watershed in the western portion of the southern tier and include areas in Cattaraugus, Chautauqua, and Allegany counties.

Vegetation

Vegetative cover is another factor that influences the potential for increased runoff and also erosion. Vegetation serves to provide a porous soil structure encouraging the infiltration of the precipitation into the soil. Roots of plants hold the soil together reducing the effects of erosion. Vegetation can also buffer the impact force of raindrops as they hit the earth's surface, thus reducing the impact erosive force. The presence of vegetation reduces the volume and velocity of stormwater runoff and contributes to the filtering of nutrients and sediment.

Storage

Storage areas are extremely effective when addressing runoff. They can slow down and mitigate the volume and velocity of the water at a particular location. Ponds and wetlands are often capable of retaining substantial amounts of stormwater runoff and allow the velocity of the runoff to diminish. As the flow velocity reduces, its ability to carry sediment and pollutants are reduced, allowing both to settle out of the flow.

Two types of ponds are used primarily for holding stormwater; retention ponds and detention ponds. Retention ponds are permanent ponds with the ability to hold large amounts of stormwater runoff, preventing the runoff flow from causing damage downstream. A detention pond is a pond that is designed specifically to collect and hold stormwater runoff, releasing it over a longer period of time to reduce its impact downstream. They are intended to be dry most of the time, and often include subsurface drainage pipes to drain the entire basin. These are the types that are often seen at large big box stores and are enclosed by a fence or buried underground.

Wetlands, particularly natural ones, are also effective on retaining the addition of stormwater runoff. Wetlands however, have the extra benefit, through natural processes, of being able to "treat" several types of pollutants through adhesion, absorption and biological consumption.

4 - Pollutants

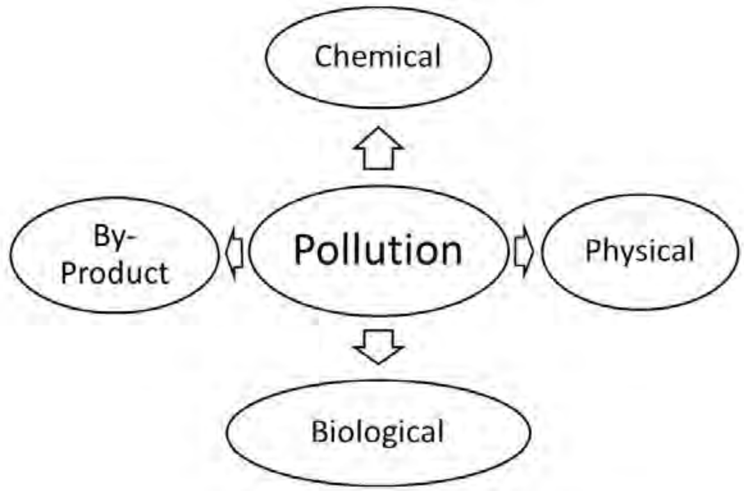


Figure 16. Pollution factors

Historically, the focus on stormwater runoff was to make sure it stayed away from roads, houses and out of the fields. Recently, more attention is being paid to the quality of the stormwater runoff. Stormwater can be both a major carrier of and, in some cases, a generator of pollutants. A successful stormwater plan will address the pollutants in stormwater.

POLLUTANT SOURCES

A "Stormwater Outfall" is the "point where a storm sewer or drainage system discharges to a waterway, often the end of the pipe, but can also be an open ditch or channel." These stormwater outfalls are viable points for monitoring stormwater quality. Generally, there are two different types of sources for pollutants: point and non-point.

Point Source pollution refers to situations where a specific function can be attributed to polluting a water source. Examples include the PCB disposal that occurred in the 1960's and 70's in the Hudson River, or a factory that discharges contaminated and untreated water into a river or lake. A wastewater treatment plant is considered a point source for pollution.

Non-Point Source pollution is the result of the collective accumulation of many various types of pollutants from over a wide area, the contributing drainage area, and not from a specific location or discharge point. Non-point source pollution is one that would result from the rainfall washing oil and fuel from a pavement surface or the erosion of an unstabilized soil surface. These are sources that are not specifically from a single location, but still a significant contributor of pollution to rivers and lakes.

Stormwater is considered a non-point source of water pollution, and can come from farm lands, construction sites, and paved or impervious surfaces. In an urban area the main contributor of non-point source water pollution is the runoff from parking lots, roadways and lawns, and is referred to as ‘Urban Runoff’.

According to a study conducted by the EPA, half of the impaired waterways are affected by urban/suburban and construction sources of stormwater runoff.

POLLUTANT TYPES

Each type of pollutant can influence the habitat and health of local surface and drinking water sources, resulting in the depletion of aquatic life, degradation of the environment and pose harmful human health related issues. Pollutants can be natural or man-made. During dry periods, pollutants from fertilizers, automobiles, dust, and animal wastes, collect on land surfaces only to be washed to and collected in the storm drainage system and then discharged into a local water body.

Pollutants are separated into four main categories: Chemical; Physical; Biological; and By-Product Pollutants.

Chemical Pollutants

Nutrients

Phosphorous, nitrogen, potassium and ammonia are nutrients found in fertilizers, pesticides, detergents, animal wastes, sewer overflow, and decaying vegetation. Elevated concentrations of nutrients in runoff can “enrich” streams, lakes, reservoirs and estuaries and can result in algal blooms. Algae blooms form at the surface of the water shielding light from other aquatic plants reducing their ability to produce oxygen. When the algae decompose, it consumes the oxygen in the water. Combining the depletion in oxygen production and the increase in oxygen consumption the oxygen available for other aquatic creatures is substantially diminished. The decrease in the amount of Dissolved Oxygen (DO) in the water body can reduce or eliminate the natural habitat. In some cases, the algae blooms can be harmful to people and animals.

Nitrogen is also generated in fossil fuel combustion in automobiles, power plants and industry. Lawns are also considered a major contributor of nitrogen. Nitrogen contributes to hypoxia in salt water sources (i.e. Long Island Sound, NY Harbor, Peconic Estuary).

Phosphorous, on the other hand, impacts the quality of fresh water sources (i.e., lakes and ponds). Phosphorous is a key issue in the quality of the New York City reservoir system.

Trace Heavy Metals

Cadmium, copper, lead, iron, mercury, chromium, nickel, manganese, cyanide and zinc are commonly found in stormwater. Sources include brake pads, paints, road salts, galvanized metal (pipes & building), fungicides, pesticides, tire wear, motor oil, engine parts, rust, machinery, erosion, and industrial activities. These metals are toxic to aquatic life at certain concentrations through bio-accumulation that collect in bottom sediments and impact bottom-dwellers. Most are considered carcinogenic or teratogenic, and can cause fetal malformations or birth defects.

Hydrocarbons (Petroleum Products)

Hydrocarbons found in petroleum products such as vehicle oils and grease, fuels, and hydraulic fluids contribute to the large variety of hydrocarbon compounds found in stormwater. Hydrocarbons in a water source can be harmful to aquatic life at low concentrations. Most sources come directly from the spills or dripping of fluids from automobiles. Hydrocarbons are considered to be carcinogenic and teratogenic.

Chlorides (Salt) (Sodium, Magnesium & Calcium)

The primary source of chlorides in New York State is salt applied to road surfaces as a deicer. Salts mix with the runoff and snow melt and create a highly concentrated salt solution, much higher than most freshwater organisms can tolerate. Toxic effects of the addition of the highly concentrated salt solution can impact macro-invertebrate organisms and alter the mixing cycle of impacted lakes. Using the proper amount of salt for a specific application can greatly reduce this problem.

Organic Compounds

Phthalate esters, phenolic compounds, and volatile organics from pesticides, plastics and some cleaners.

Physical Pollutants

Sediment and Particulates (Suspended Solids)

Consist of particles washed from impervious surfaces and erosion from stream banks and construction sites. Particles include clay, silt sand and other types of materials that settle to the bottom of standing water. Stream bank erosion accounts for approximately 70 percent of sediment load in urban watersheds.

Excessive sediment results in *turbidity*, which reduces the penetration of light through a body of water, reducing the ability of aquatic vegetation to produce oxygen, a necessity for ecosystem health. Also, the sediment can alter habitats by destroying the riffle-pool structure in stream systems, and smothering organisms such as clams & mussels. These particles can help transport other pollutants such as phosphorous and petrochemicals. The critical issue is to reduce erosion before it starts.

Thermal (Temperature) Impacts

The changing of the ambient temperature of a water body as a result of runoff warming reduces the amount of oxygen that the water can hold as dissolved oxygen. As the impervious surface areas in a watershed increase, the ability of the surface to absorb and hold warmth from the sun is substantially increased. When the rains fall on these warmed surfaces, the temperature of the heated impervious surface is imparted to the stormwater runoff. This warmed runoff can increase the temperature of the receiving stream or other water body as much as 5 to 12 degrees F. Thermal impacts are a serious concern in trout waters where the cold temperatures are critical for its survival. Other sources of warm discharge can be from power plants that use the water source as a means of cooling the facility, where the heat of the plant is transferred to the water and released to cool, often into a water body that is cooler. The removal of trees and vegetation along streams and rivers can reduce the amount of shade, allowing the sun to warm up the water.

Trash & Debris

Referred to as *gross solids*; trash, leaves, litter and organic debris are collected in storm drains, streams and lakes, and can be either floating or part of the bed load. In addition to the human contribution, gross solids also refer to inorganic breakdown products from soil, pavement, or building materials, i.e., chunks of asphalt and concrete. Trash and debris can result in unsightly conditions, impair recreational facilities and cause illness in humans and animals. This debris can leach harmful pollutants and cause unpleasant odors. Food contaminated litter/wrappers can contribute to an increase in organic matter and/or toxic contaminants in receiving water bodies.

Biological Pollutants

Organic Carbon

Organic carbon comes from organic matter washed from impervious surfaces and attaches to sediment. Organic carbon can also be formed directly from algal growth within systems with a high nutrient load. The decomposition of organic matter causes a depletion in the amount of dissolved oxygen in lakes and tidal waters. A lack of oxygen in the water can have adverse effects on the ability of life to survive. Trihalomethane (THM) is a carcinogenic disinfection by-product caused by mixing chlorine with water high in organic carbon. This is very important to unfiltered water supplies such as the NYC reservoir water system.

Bacteria/Viruses

Sources include pet waste and urban wildlife, sanitary and combined sewer overflows, wastewater, and illicit connections to the storm drain system. These are the leading contaminants in many New York State waters, causing the closing of shellfish beds and periodic bathing beach advisories; particularly after a significant rainfall event. Water tests for coliform are conducted to determine the presence of bacteria in drinking water, testing for coliform is used as an indicator test for the presence of pathogens.

By-Product Pollution

Snow Melt Concentrations

As snows fall and roads and parking lots are cleared, large volumes of snow are collected in specific locations. As the snow is collected, contaminants that had settled onto the large impervious surface are gathered with the snow. When the collected snow begins to melt, the stored contaminants; hydrocarbons, oil and grease, chlorides, sediment, and nutrients, “attach” or dissolve into the snow melt, resulting in a runoff of high contaminant concentration. Studies suggest that 90 percent of the hydrocarbon load from snowmelt occurs during the last 10 percent of the melting event, the final melting of the last snow banks are major contributors. (SWM practices should be designed to capture as much of the snowmelt event as possible).

Illicit Discharges

The EPA defines illicit discharges as “any discharge to a municipal separate storm sewer system that is not entirely composed of stormwater, except for discharges allowed under a NPDES (SPDES) permit or waters used for fire fighting operations”. Illicit discharges are often the result of illegal connections to storm sewers. Illegal connections such as the direct connection of the sanitary sewer discharge from a residence, commercial space, or building floor drains to the storm sewer system are considered illicit and can result in excessive amounts of nutrients, viruses and bacteria in the local surface and ground water. Indirect connections include the infiltration of sanitary sewerage through cracks in sanitary sewer structures. In areas where private sewer systems are utilized, overuse, damage, or failure can result in the leaching of the septic liquids to the ground surface, allowing it to enter into the drainage system, carrying with it pathogens and nutrients. The same result occurs when sanitary sewer systems, pipes and structures, crack and allow leachate to enter into the soil and the ground water.

Illicit discharges encompass most types of flow entering an MS4 that are NOT comprised solely of stormwater runoff. These include:

- Sanitary septic system discharges: private and public
- Sanitary sewer cross-connections, typically to public storm sewer
- Floor drains
- Industrial waste
- Dumping into catch basins
- Carwash wastewater
- Improper oil disposal
- Radiator flushing
- Laundry wastewater
- Transportation spills
- Improper disposal of auto and household cleaners and toxins

As a Minimum Control Measure for Municipal Separate Storm Sewer Systems (MS4's) the 'intent of MS4 permit is to ELIMINATE these discharges.'

Illicit Discharge Exceptions: A few exceptions exist for flows that are generally clean: [these types of discharges are legal if not contaminated]. These activities are not regulated under the MS4 permit unless the MS4 operator specifically identifies them as significant contributors of pollutants. These include:

- Fire hydrant flushing
- Foundation drains
- Irrigation/lawn watering
- Springs
- Air conditioner condensate
- Potable water discharges
- Diverted streams
- Rising ground waters
- Crawl space pumps
- Footing drains
- Individual residential car washing (not vehicle washing at municipal facilities)
- Dechlorinated swimming pool water
- Street wash water

Winter Maintenance

Every winter large amounts of de-icing and treatment products are used on highways for snow and ice control. Most chemical alternatives for snow and ice removal have focused on the performance and cost under various weather conditions and on new proprietary chemicals that are routinely introduced. Unfortunately, selection and use of these products do not reflect the potential harmful aspects that may result to the environment from them.

Several identifiable materials used in winter road maintenance include Sodium Chloride (NaCl), Calcium Chloride (CaCl), Magnesium Chloride (MgCl), Calcium Magnesium Acetate (CMA) and Potassium Acetate (KA). Abrasives are also utilized and present their own issues related to stormwater.

Roadway application is the primary source of snow and ice treatment materials based on the volume of material applied. Spills and discharge during transport and storage also contribute to the discharge of these materials into the environment, although typically very localized and in significantly greater concentrations.

Once the materials are applied to the road surface, there are several means by which the contaminants can travel and enter the environment. In wet form chlorides are dissolved into a salt solution and leave the road surface by splashing, spraying or draining. After the event has passed and the road surfaces dry, salt becomes powdery or flaky and is moved by wind and traffic off of the road and into the environment or a drainage system.

5 - Stormwater Tool Box

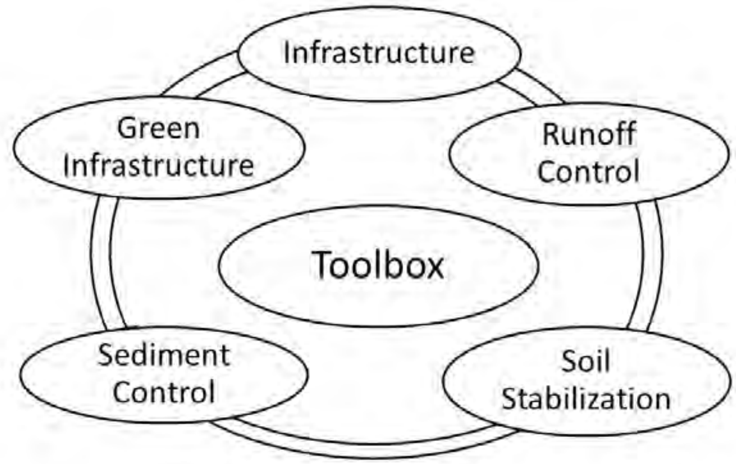


Figure 17. Stormwater toolbox

This section covers many of the practices applicable in minimizing the effects of stormwater runoff as they are directly related to the activities of a local highway department. Additional options for alternative practices and further details on all practices can be found in the Blue Book put out by the NYSDEC. If you are trying something new or different for the first time, be sure to ask for assistance.

INFRASTRUCTURE

The best means of understanding how to address problem areas within a drainage system is to be familiar with your drainage infrastructure. Knowing the specifics on your drainage infrastructure can have many benefits. Aside from identifying problem areas, knowing and documenting the details of each structure will facilitate obtaining support and reimbursement for the replacement of these structures after damage or disasters from emergency management programs. Collecting and maintaining documentation on your drainage inventory is a critical factor when justifying upgrades or improvements to them.

Inventory

Inventory items should be collected for all culverts, bridges, ditches and other pertinent structures such as catch basins, manholes, linear piping, drainage inlets, and outfalls. Physical information for each structure should be recorded, such as:

- Length
- Width/diameter
- Shape
- Material
- Orientation to road and flow channel
- Slope

- Depth (if subsurface)
- Construction type (bridges)
- Manufacturer
- Surface type (bridges)
- Depth of structure (manholes, catch basins)
- Depth of sump (manholes, catch basins)
- Frame and Grate style, size, condition
- Inverts in and out
- Lining material (ditches)
- Check dams, channel drops (ditches)

Inspections

Regular scheduled inspections are critical in identifying erosion and sediment buildup and can facilitate proactive maintenance. Proactive maintenance can reduce the potential for erosion and sediment buildup from compounding issues within the drainage network and can reduce the costs of major repairs when caught early. Information collected during inspections should include at a minimum:

- Conditions
- Maintenance work and dates conducted
- Inspection records
- Replacement information (date, size/material changes, reason)
- Photographs
- Historical data

Erosion and Sediment Control

Throughout this section we refer to the New York State *Standards and Specifications for Erosion and Sediment Control*, a.k.a. the *Blue Book*, and suggest it as a permanent resource for anyone addressing stormwater issues. Hardcopies of this manual are available for purchase from the NYSDEC or can be downloaded from the DEC website at no cost.

According to this manual "controlling erosion is the first line of defense", and it has been determined that the most efficient and effective way to control erosion is by limiting the amount of disturbance.

Erosion control is achieved through runoff control and soil stabilization. In highway and maintenance practices sediment is often the result of an upstream activity that is improperly designed, maintained and/or constructed. Sediment is then conveyed into the ditches and culverts maintained by the municipality. For this reason sediment control practices are a necessity in roadside ditches. The most cost effective way of addressing erosion and sediment is to develop an erosion and sediment control plan that is specific for the region and/or area, utilizing vegetative and structural practices.

The Blue Book provides three flow charts developed by the NYSDEC and the Soil and Water Conservation Committee focusing on runoff control, soil stabilization and sediment control. These charts walk through the options that can be taken depending on the particular region's characteristics. In this section we will cover several of the available practices, for additional information on any of these and others consult the NYSDEC, your local Soil and Water Conservation District, and/or the NYSDEC Blue Book.

Best Management Practices (BMPs)

Once a good inventory and history has been collected and evaluated, problem areas can often be identified. Depending on the issues present a management practice can be selected to remediate any problems. In this chapter we will discuss several practices; Runoff Control, Soil Stabilization, Sediment Control and Green Infrastructure, which can be utilized to minimize or eliminate the erosion and sediment problems. It is important to take into consideration the runoff factors discussed earlier when selecting a proper management practice. There are a variety of differing practices that work in some locations but not others.

RUNOFF CONTROL

Runoff controls focus on minimizing the potential of erosion by diverting and dispersing runoff, creating obstructions to reduce the flow rate in channels, protect the channel from erosion and collect and hold the excess runoff for a controlled discharge over a longer period of time.

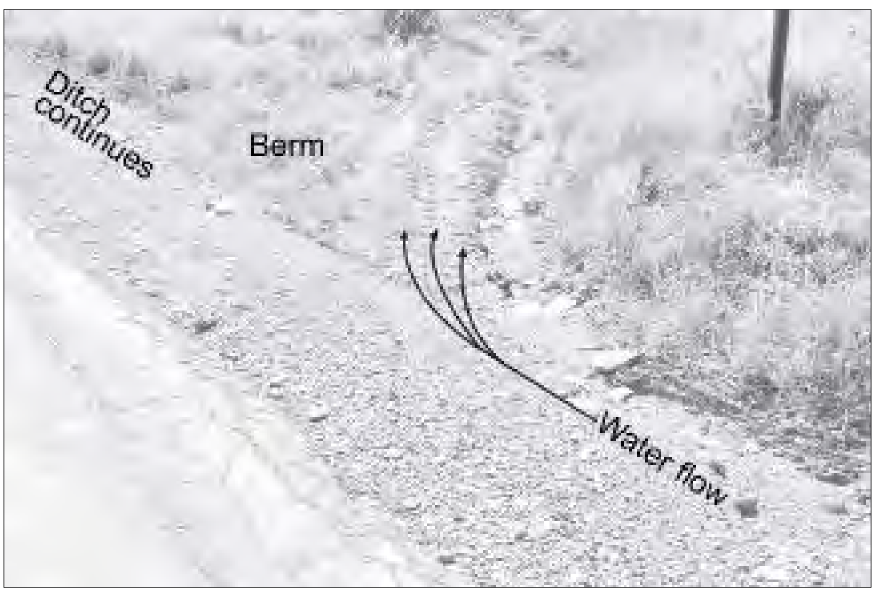
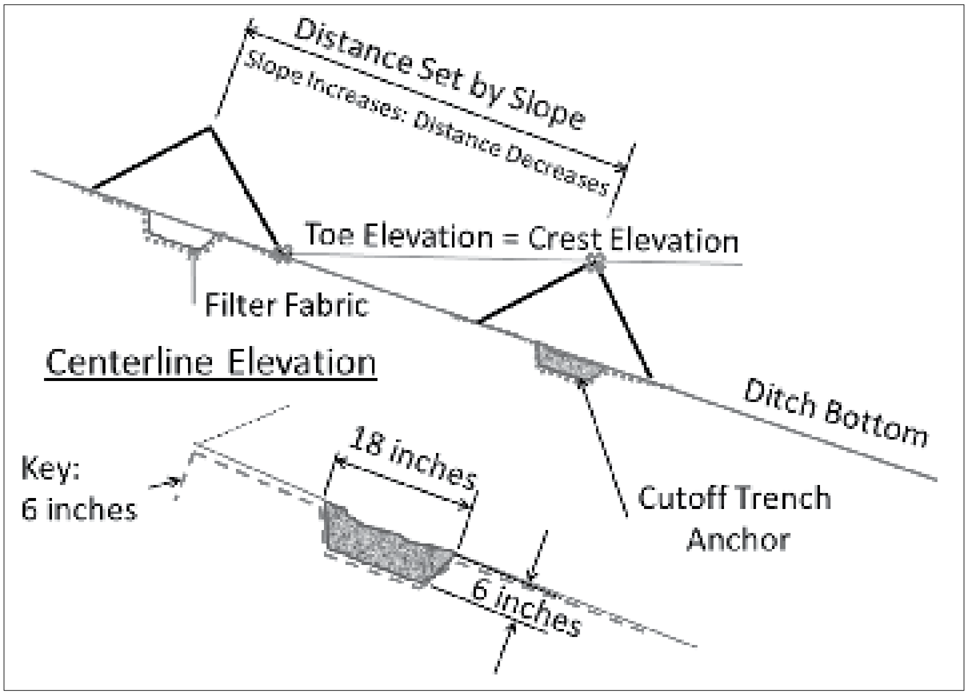


Figure 18. Diversion ditch

Diversion

Diversion structures can be permanent or temporary. The idea is to collect and redirect the flow from or around an area, reducing its flow rate and discharging to a stabilized area. Along the roadside, diversion ditches are used to reduce the flow volume in an existing ditch by directing and dispersing the flow into a stabile vegetated area. This will allow the diverted runoff to slow down, release any sediment load, and promote infiltration.

When using a diversion structure, it is important to know the native soils, outlet conditions, vegetation, and slope. Maximum flow velocity is also important. If the flow rate is less than 3.5 feet per second, the use of vegetation as a lining can be effective; at greater flow rates provisions such as stabilization matting or blankets will need to be considered to prevent erosion. Diversions should not discharge onto steep slopes since this can create additional erosion problems in difficult to reach locations. In residential areas the down slope discharge areas should be investigated, do not discharge flow where impact to the private property may be an issue. Dispersion of the flow may require the use of a level spreader, which is discussed later in this section.



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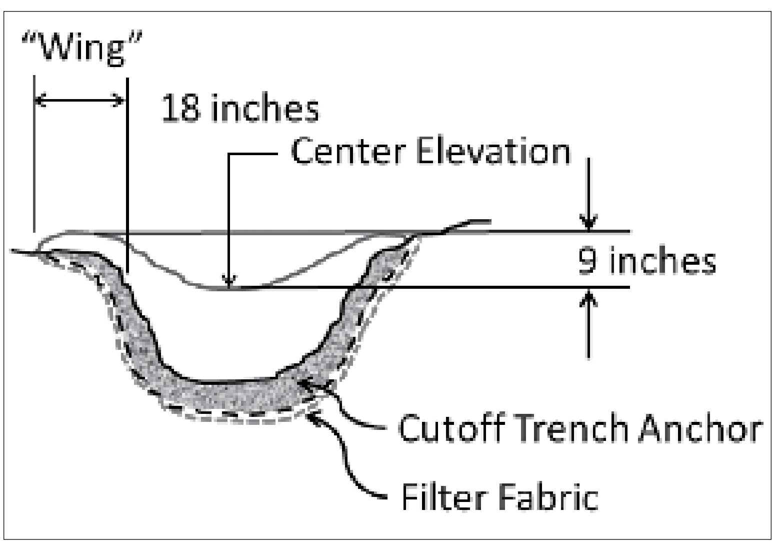


Section

Figure 19. Check dam

Check Dams

A check dam is a small barrier placed in a drainage way to reduce the velocity of the flowing water. They can be constructed of stone, sand bags, wood, concrete, gabions, etc. and can be temporary or permanent. Slowing of the flow in a water way reduces the potential for erosion to occur and allows sediment to "fall" from the flowing water.

Recommendations:
Maximum Drainage area = 2 acres

- Use Filter Fabric to prevent soil/stone mixing
- Last check dam in series requires a liner or stone pad to prevent scour
- Use a Cut off Trench to anchor the structure
- Permanent Check Dams:
    - Provide deep bedding
    - Create a constant slope (<5% slope)
    - Provide Scour Pad at toe
- Stone Size: Well Graded Stone Matrix 2 – 9 inches (NYSDOT Light Stone Fill)

Maintenance:

- Regular inspection and after heavy rain events
- Replace eroded materials
- Remove sediment build up
- Temporary structures to be removed when contributing area stabilized

Pipe Slope Drain

A pipe slope drain is a temporary pipe placed from the top of a slope to the bottom of a slope to carry runoff down the slope without causing erosion. An earthen dike is constructed at the top of the slope to direct runoff into the pipe. The pipe slope drain, typically a flexible pipe, is to have a minimum of a 3 percent slope and discharge to a rip rap apron prior to release to a stabilized area. Pipe diameters are determined by the contributing drainage area.

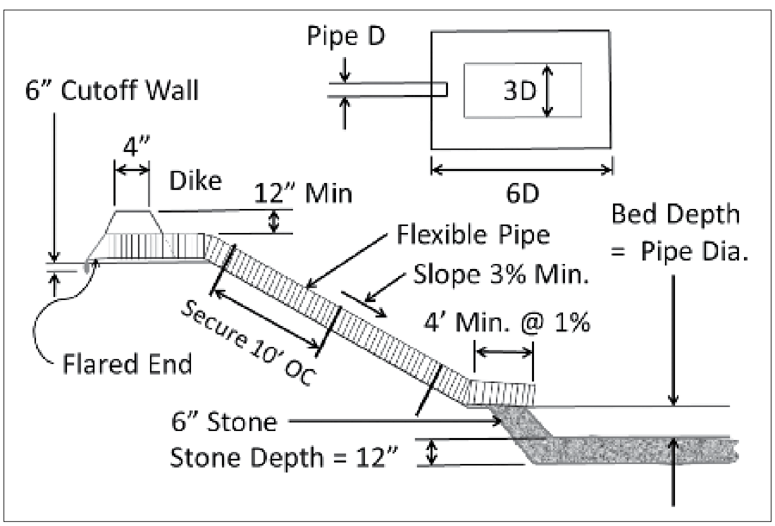


Figure 20. Pipe slope drain

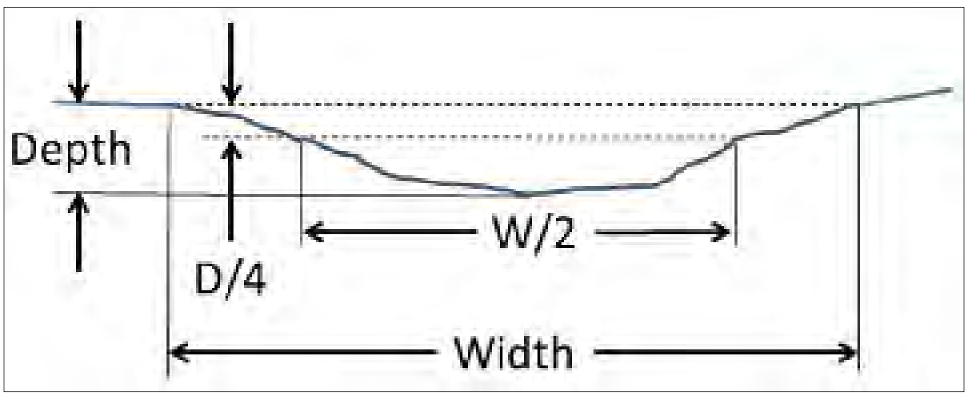
Table 6. Pipe slope drain size

Pipe/Tube Size Diameter (inches)	Maximum Drainage Area (acres)
12	0.5
18	1.5
21	2.5
24	3.5

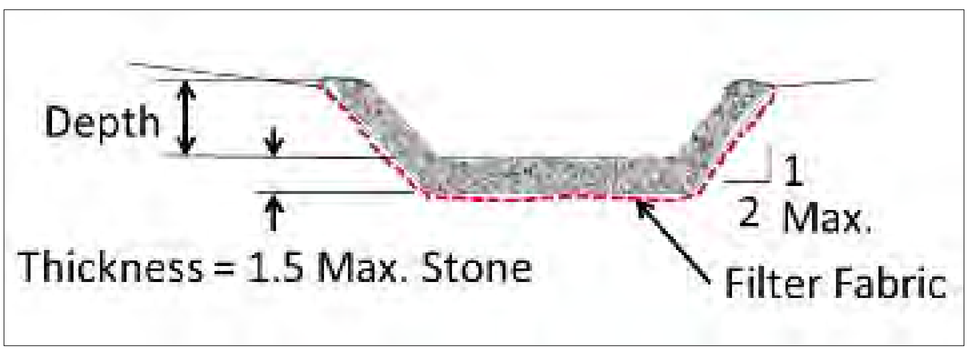
Waterways

Grassed: Grassed waterways are utilized to direct water flow when the flow rate is less than 3.5 feet per second (fps).

Lined: Lined waterways are utilized when the flow rate of the channel is to exceed 3.5 fps. High flow rates can remove the vegetation and cause the flow path to erode.



Typical Grassed Section



Typical Lined Section

Figure 21. Waterway sections

Construction Recommendations:

- Remove tree stumps, roots, sod and loose rock
- Channel section shaped according to existing grade and/or design needs
- Compact fill areas = to existing base material
- Fill material at optimal moisture
- Avoid sharp alignment changes
- Minimize land disturbance
- Reestablish vegetation; stabilize disturbed areas within 24 hours of final grading
- Protect inlets and outlets during construction

Maintenance:

- Regular inspection and after heavy rain events
- Remove sediment and debris as required
- Repair damage areas
- Replace lining material as required
- Inspect & repair inlets and outlets
- Prevent tree growth
- Inspect for undermining, and deterioration
- Maintain adjacent vegetation in good condition

Table 7. Riprap maximum size

Velocity (fps)	dmax (inches)
5	6
8.5	12
10	18
12	24
15	36

Rock Outlet Protection

Rock outlet protection is the practice of placing rock at the outlet end of culverts, conduits and channels. The purpose is to reduce the depth, velocity and energy of the discharge flow to reduce the potential for downstream erosion. Outlets at toe cuts or on slopes greater than 10 percent cannot be protected by rock aprons.

Rock outlet designs vary depending on the discharge flow depth immediately below the pipe outlet; this is known as the tailwater condition. Two tailwater conditions are discussed; maximum and minimum tailwater conditions.

Maximum Condition: Discharge > 0.5 Pipe diameter
Minimum Condition: Discharge < 0.5 Pipe Diameter

The most common discharge encountered in roadway drainage is the Minimum Tailwater Condition; pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition.

Installation:

- Bedding thickness = 1.5 x maximum stone size (dmax)
- Compact fill areas smooth = to existing base material
- Filter Fabric Overlap = 1 foot minimum
- Filter Fabric Strength = Punching: 40 lbs minimum; Grab = 90 – 120 lbs;
- Filter Fabric Thickness = 20 – 60 mils
- Aprons installed level with receiving flow
- Machine/Hand Placement
- Stabilized with vegetation immediately
- Stone Specific Gravity =/> 2.5
- Stone Size: See Appendix 7

Maintenance:

- Inspect after heavy rains
- Use appropriate size replacement stone
- Do not change finish grade

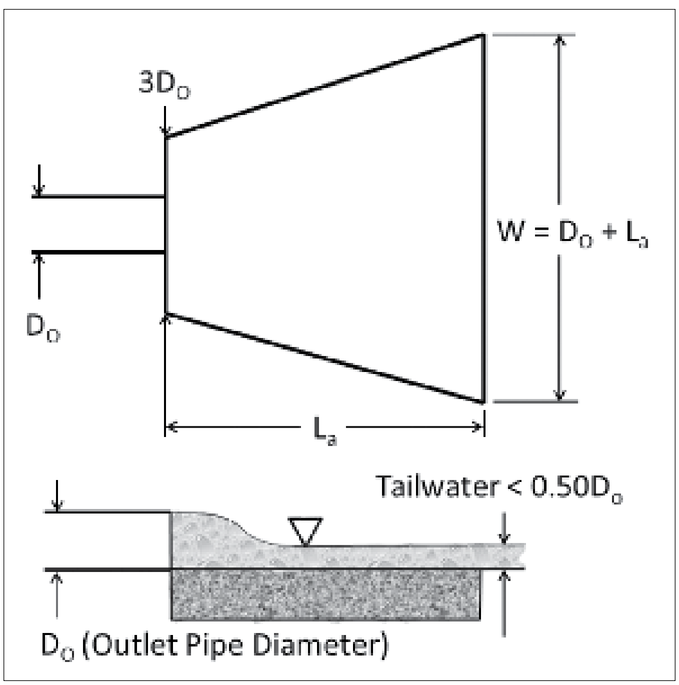


Figure 22. Rock outlet protection

Minimum Tailwater Condition Apron

Infiltration

When soil conditions allow, infiltration is one of the more effective means of reducing runoff from impervious surfaces. Infiltration practices include: basins, trenches, dry wells, cisterns, permeable pavements and pavers, and to a lesser degree, vegetative filter strips where sheet flow facilitates the infiltration into appropriate soils.

Basin/Trenches: Shallow excavated structures designed to capture and temporarily store runoff to allow for evaporation, transpiration and infiltration. Design is very similar to bio-retention/ infiltration which utilizes engineered soils to help remove pollutants. They may or may not have an underdrain, depending on the native hydrologic soil type.

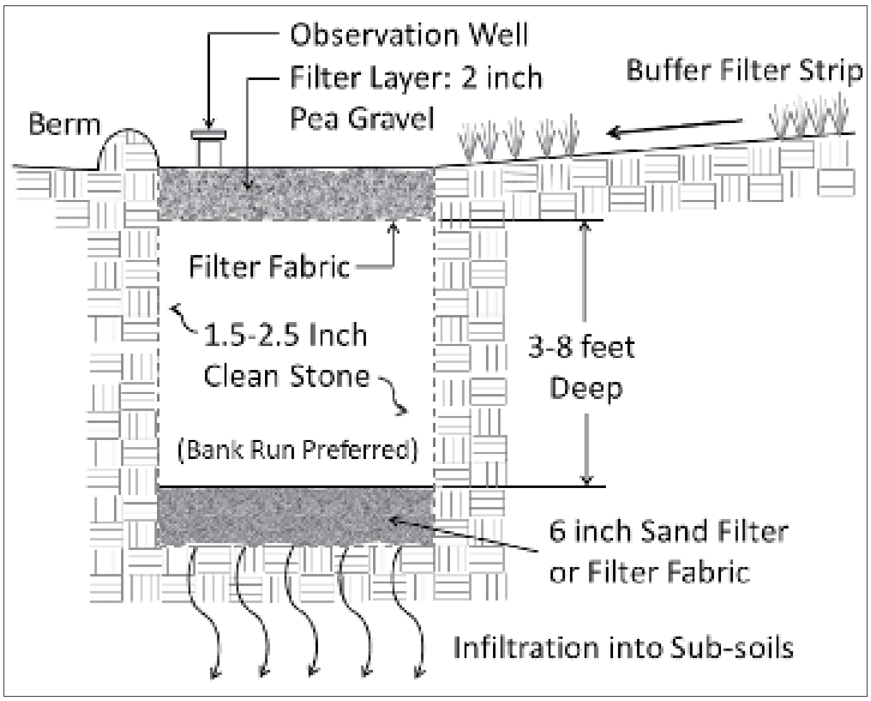


Figure 23. Infiltration trench

Filtration is similar in design with the difference being that its focus is on runoff treatment and not specifically intended to infiltrate into the soil. Filtration requires an under drain or discharge point to release the collected runoff and does not contribute significantly to the reduction of runoff rates and volumes.

Design Specifications:

- Pretreatment (sediment basin, vegetated filter strip)
- Drain within 48 hours
- 0.5 inch/hour infiltration rate minimum
- Native Hydrologic Soil Groups A & B only
- 2 feet separation to water table/impervious layer
- Maximum drainage area: Basins = 5 acres; Trenches = 2 acres

- Avoid high sediment runoff
- 6 percent slopes maximum
- Planting bed = 36 inches
- Pond depth = 9–12 inches

Benefits:

- Reduce runoff rate and volume
- Reduce runoff pollutant load (60 – 80%)
- Applicable in post-construction in urban and rural areas

SOIL STABILIZATION

The basic approach to soil stabilization is to control the rain drop impact, and sheet and rill erosion on surfaces which have been disturbed or stripped of its vegetative cover. Two approaches for stabilization depend on whether the disturbance is on a slope or an area of relatively level slopes.

Level and moderate slope areas:

- Plant vegetative cover to protect and stabilize the soil: seeding (temporary or permanent), sodding
- Place a non-vegetative cover over the soil: mulch, rip rap, soil stabilizers (erosion control blankets)
- Utilize a structural method such as a retaining wall, land terracing, rip rap, and/or surface roughening

Steeper slopes and stream banks require different approaches due to higher runoff flow velocities:

- Bio-technical methods (Brush matting & layering, fiber roll, live plantings, vegetative rock gabions, vegetative stream bank protection)
- Structural methods: (Land grading, retaining wall, structural stream bank protection, surface roughening)

Dust Control

Dust is the fine particle of soil that becomes airborne as a result of land disturbance during dry periods. Dust is erosion by wind. When these fine particle drift onto vegetation it can impact the plants ability to process, when the dust is washed away by rain or drifts into a water body it can contribute to the existing sediment load and turbidity of the water. Dust control is the practice of preventing the movement of the soil particles through the air.

Maintenance:

- Continual maintenance required during dry periods
- Maintenance continued until area is stabilized

Table 8. Dust control treatments

Treatment	Non-Driving Areas	Non-Roadway Driving Area	Gravel Roads
Plant Vegetation	X		
Mulch[1]	X		
Spray Adhesives	X		
Sprinkling Water		X	
Polymer Additives[2]		X	
Barriers[3]		X	
Wind Breaks[4]		X	
Stabilizers[5]			X
Grade Crown			X
Shoulder Drainage			X
Remove Potholes			X

Notes:
[1]Including erosion control blankets
[2]Polymers:
Mix & apply as per manufacturer
Post application: 48 hours of clear weather
Maintain MSDS
Emulsion application depth based on traffic
95% compaction after emulsion application
[3]Woven geotextiles or stone
[4]Silt fence or vegetation
[5]Stabilizers: Chlorides (calcium, magnesium, sodium) resins, asphalts etc.
Loosen top 2 inches
Apply consistently
Use proper material and application rate for gravel treated
Do not apply if rain expected
Compact with pneumatic roller
Keep traffic off for 2 hours
Add moisture if very dry

Seeding

Planting grasses and legumes are the most cost effective means of preventing the soil from eroding away. Temporary seeding is typically used when the soil is to be disturbed again in the near future, i.e. within a year. Permanent seeding is conducted when the final grading and water control measures are complete and will not be disturbed for a period of greater than one year.

Temporary Seeding:

- Done within 24 hours of disturbance (or soil will require scarification prior to planting)
- Lime and fertilizer typically not applied
- Summer/Spring: Use rye grass at 30 lbs per acre (0.7 – 1 lb./1000 SF)

- Late Fall/Early Winter: Use Certified ‘Aroostock’ (winter/cereal rye) at 100 lbs./acre (2.5 lbs./1000 SF)
- Mulch: Hay or Straw at 2 tons/acre (90 lbs. or 2 bales/1000 SF)
- Mulch may require anchoring

Permanent Seeding:

- Chisel or disc compacted areas up to 12 inches (a.k.a. Soil Restoration)
- Ensure adequate moisture in soil
- Done within 24 hours of disturbance (or soil will require scarification prior to planting)
- Remove stones > 4 inches
- Test soil to determine lime or fertilizer requirements
    - Upper 2 inches of soil: pH = 6.0
    - Commercial Fertilizer (5-10-10): 600 lbs. per acre (MS4 must record amounts as per MS4 permit)
- Seed mixtures vary depending on season and location (See Table 3.1 “Permanent Critical Area Planting Mixture Recommendations in the NYSDEC Bluebook or contact your local Soil and Water Conservation District)

Hydroseeding

Hydroseeding is the application of a slurry mixture consisting of grasses, other vegetation seed, mulch, fertilizer and water. This is an effective means of providing protection to large disturbed areas.

Seed types vary depending on location and season and include:

- Annual seeds: provide a quick vegetation cover
- Perennial seeds: provide slower, deep rooted vegetation
- Mulch: allows the retention of moisture and:
    - Includes recycled paper, wood fiber, cotton products, etc.
    - Steep Slopes mixtures include: Bonded Fiber Matrices (FBMs) or Flexible Growth Media (FGM) which include tackifiers and engineered wood fibers to hold hydroseed to slope
    - Crown Vetch & Clover: deep root growth & nitrogen fixation

Maintenance:

- Inspect to ensure growth
- Reseed eroded areas
- Water as required to ensure growth

Sodding

The use of sod is the placement of +/- ¾ inch root base machine cut grass material. It is effective in providing immediate esthetic soil stabilization and is typically utilized on soils that have a high potential for erosion such as silt. Sod should:

- Be a Bluegrass or Bluegrass/Red Fescue mixture (a perennial ryegrass may be used but caution should be taken due to its limited cold tolerance)
- Be harvested or planted only when moisture content is not excessively dry or wet
- Be harvested and installed within a 36 hour period
- Include a soil test to determine the need for lime or fertilizer on the native soil (See seeding soil requirements)

Mulch

Mulch is the covering of the soil surface with a coarse plant residue or chips, and is intended to protect seeds and plant establishment from initial erosion. Mulch helps maintain moisture in the soil, limit soil temperature fluctuations, and help control weeds. Mulch can be used to provide temporary stabilization during the non-growing season.

Recommendations:

- Use on soils with low infiltration rates
- Place after final grading and site preparation
- Apply after seeding and the addition of any soil amendments
- Most effective mulch usage for grass/legume placement:
  - Use straw (cereal grain) mulch
  - 2 ton/acre (90 lbs./1000 SF)
  - Anchor with wood fiber mulch (hydromulch) at 500 – 700 lbs/acre (11 – 17 lbs./1000 SF)
  - Wood fiber mulch applied immediately after mulching (through hydroseeder)
  - Mulch Materials, Rates and Uses: See Table 3.7 ‘Guide to Mulch, Rates and Uses’ of the DEC Bluebook

Erosion Control Blankets

Erosion control blankets, or rolled erosion controlled products, are used to provide an immediate level of protection from erosion on slopes and in flow channels. It is typically placed over seed, but can be used by itself to reduce erosion. They are manufactured from a variety of materials including coconut fiber, agricultural straw, and polypropylene, and consist of single, double or triple net blanket layers depending on their intended goal. Below are some examples, refer to manufacturer’s recommendations for specific applications.

Blanket Types

Single Net Layer Blankets:

- Biodegradable: for use up to 12 months
- Slopes: 3:1 to 4:1
- Uses: mild grades, swales, roadside slopes

Double Net Layer Blankets:

- Biodegradable: 12 – 24 months
- Slopes: up to 2:1
- Uses: moderate flow channels, moderate slopes
- Improve soil stabilization

Triple Net Layer Blankets:

- Permanent stabilization
- High flow channels, lakes, ponds
- Helps stabilize roots
- Greater shear strength
- Material includes polypropylene and/or coconut fiber

Materials:

- Matrix:
  - Agriculture Straw: provide EC up to 12 months
  - Coconut Fiber/Agriculture Straw Combination: EC up to 24 months; Coconut extends blanket service life and improves moisture absorption
  - Coconut Fiber: EC up 24 month; improved absorption
  - Polypropylene: permanent, high velocity stabilization
- Netting:
  - Organic Jute netting: biodegradable
  - Lightweight photodegradable polypropylene netting: short term netting
  - Medium weight UV-stabilized polypropylene netting: permanent netting

Surface Roughening

Surface roughening is the roughening of the bare soil with horizontal grooves, stepping or tracking with construction equipment. It is intended to reduce runoff velocity, increase infiltration and trap sediment to facilitate the growth of vegetation on slopes greater than 3:1. The use of construction equipment tracking should be limited to sandy soils to avoid excessive compaction.

Rip Rap Slope Protection

Rip rap slope protection is used on slope soils subject to seepage, soil with poor structure, and to protect slopes from erosive forces where vegetation growth is difficult to establish.

Material:
Rip rap:

- Well graded
- Size: Minimum = 1 inch; largest = 1.5*d50
- Hard durable, and angular; Specific Gravity = 2.5 minimum

Filter Blanket:
Material layer between rip rap & native soil, reduces migration of native material into riprap layer

- Gravel: 6" minimum thickness; stabile design dependent on existing soil particle size (refer to NYSDEC Bluebook Standard Specifications for Riprap Slope Protection)
- Synthetic Fabric: Woven or Non-woven Acceptable
  - 4% minimum open area
  - Equivalent opening size (EOS) > 100 sieve (0.15 mm)
  - Thickness: 20 – 60 mils
  - Grab Strength: 90 – 120 lbs.
  - Conform to ASTM D-1682 or D-177

Installation:

- Place stone immediately after filter blanket installation
- Place in full depth
- Key slope toe a minimum of 2 feet
- Key filter fabric at top of slope a minimum of 6 inches
- Rip rap material to extend 3 feet from slope toe
- Refer to NYSDEC Bluebook Standard Specifications for Riprap Slope Protection for details and stone size selection

Maintenance:

- Inspect regularly for scour
- Control weed and brush growth

Bio-technical Slope Protection

Biotechnical slope protection is the use of natural and available woody plant materials to stabilize slopes. It is generally less expensive and simple to install and does not require heavy equipment. They can encourage wildlife habitats, look good and often be self-repairing. As with everything they have their limitations. They require time to establish and therefore can require more attention during this establishment period. They can also be vulnerable to season changes. These practices are typically applicable to streambanks and roadside slope sloughs, but are not strictly limited to these uses. The most common woody plant is usually dormant shrub willow branches.

Live Facines

Live facines are bundles of twigs or branches placed in shallow trenches along the contour and are used on road cuts, slumps, fill areas, gullies and stream banks.

Materials:
Live native or cultivated plants capable of serving purpose; Maximum Diameter = 1 inch

Overlap Bundles: 12 – 18 inches at tapered ends

Vertical Spacing:

- Slopes: 1:1, 1:1.5 = 3 Feet
- Slopes: 2:1, 2.5:1 = 4 feet
- Slopes: 3:1, 3.5:1 = 5 Feet
- Slopes: 4:1 = 6 feet
- Slopes: 6:1 = 8 Feet

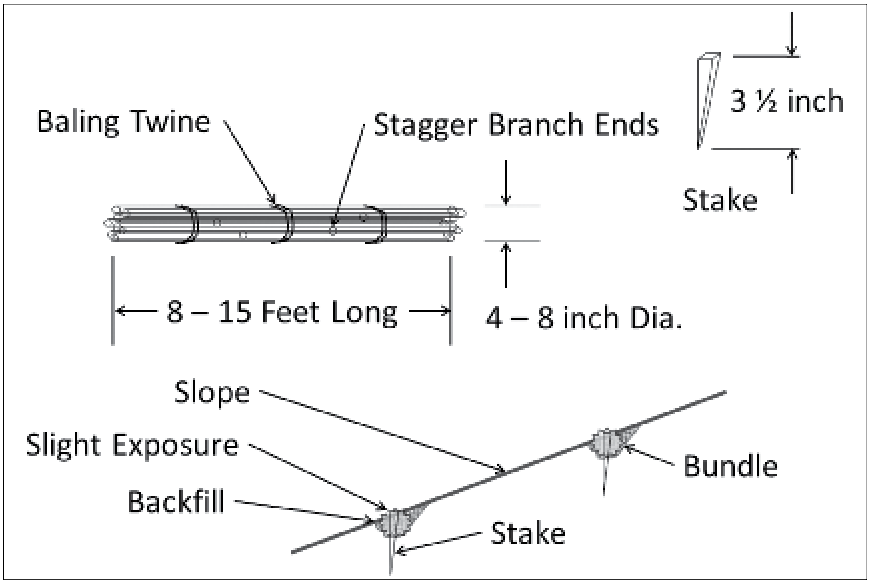


Figure 24. Live facine

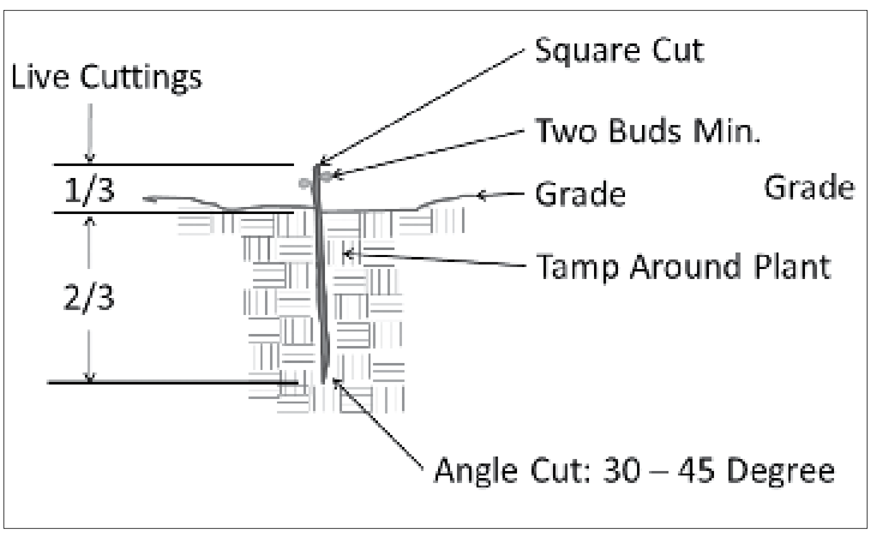


Figure 25. Live stakes/cutting detail

Live Stakes

Live stakes are used to repair small earth slips and slumps in frequently wet soil and in small scale stabilizing of exposed stream banks. Not applicable for large scale lateral earth pressure failures.

- Size: 1- 2 inches in diameter, 2-6 feet long
- Leaf buds: Maximum of ¼ inch long; green and moist outer layer
- Can be harvested from on site, but must be planted the same day

Brush Layer

Brush layer is a horizontal row of brush cuttings used to stabilize cut and fill slopes, and areas above the flow line of stream banks. This practice is useful for reinforcing soil, trapping debris on slopes, drying out excessively wet slopes and redirecting slope seepage.

- Slopes up to 2:1
- Slopes up to 20 feet height
- Material:
  - Cuttings ½ - 2 inches in diameter
  - Cuttings from dormant plants
  - Leaf budding ¼ inch maximum
  - Green and moist outer layer
  - Length: contact back of bench and protrude out of slope face
  - Bench: 2 -3 feet wide; outer edge higher than back of bench
- Installation:
  - Crisscross overlapping layout
  - 3 – 4 inches thick
  - Backfill & tamped in 6 inch lifts
  - Slope distance between layers: (Slope, dist. between layers, max slope length)
    - Slopes: 2 to 2.5:1 = 3 feet, 15 feet max.
    - Slopes: 2.5 to 3.5:1 = 3 feet (wet slope); 4 feet (dry slope); 15 feet max.
    - Slopes: 3.5 to 4.0:1 = 4 feet (wet slope); 5 feet (dry slope); 25 feet max.

Branch Packing

Branch packing is used to repair existing slopes which have slipped or slumped by filling the void area with plant material and soil. This practice consists of alternating layers of live branch cuttings and compacted backfill and is limited to areas less than 4 feet deep or 6 feet wide and is not to be used as a structural means of bank stabilization

Material:

- Cuttings ½ - 2 inches in diameter
- Length: Extend from back of area to 4 to 6 inches beyond the finished grade
- Secure with wooden post 6 – 8 feet long, 3 – 4 inches in diameter (or standard 2x4)
- Post driven 3 feet deep, in a grid pattern 1 – 2 feet apart
- Bottom layer: Crisscross pattern, with growing tip out, 4 – 6 inch thick
- Branch layers placed 1.5 to 3 feet apart with compact soil in between
- Refer to NYSDEC Standard Specifications for Branch Packing for additional details

Fiber Roll

A Fiber Roll is used to reduce sheet flow on slopes and reduce flow energy along stream banks and channels. They typically consist of coconut fiber, straw, or a proprietary roll encased by jute, nylon or burlap netting and are useful in areas where the area remains continuously wet.

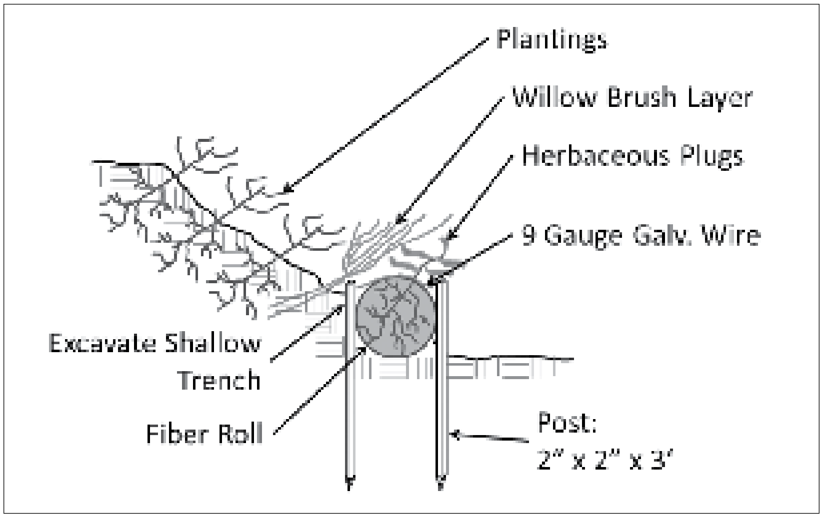


Figure 26. Fiber roll

Refer to NYSDEC Standards and Specifications for Fiber Roll for more information.

Streambank Protection

Streambank protection includes the stabilization of eroded stream banks and consists of several structural and biotechnical methods that are commonly used. Any and all work in and around streams require a stream disturbance permit and, if necessary, a stormwater permit to address the disturbance adjacent to the stream. There are exceptions to this rule; however, bank stabilization is not one of them. This work typically requires excavation or placement of material which would include the disturbance of the bed and/or bank material for it to be successful. As such it will be covered only briefly here.

Of the methods often used to stabilize stream banks the use of rip rap is one of the more permanent and common. Other methods include gabions, pre-cast concrete pavers, and grid pavers. These methods are heavier and typically designed to withstand a 10-year storm event or a bank full event, whichever is greater.

Bio-technical methods can found in the NYSDEC Blue Book and include brush mattress, Live Stakes, Live Crib Wall, Tree Revetment and Fiber Rolls. Many of these bio-technical methods are limited by flow velocity (less than 6 feet per second) and require regular inspection and maintenance until adequately established.

For more information on stream bank stabilization refer to the NYSDEC Blue Book and seek help from the local Soil and Water Conservation District for permit submittals.

SEDIMENT CONTROL AND REDUCTION

Sediment control and reduction is focused on protecting off site areas from the impacts of mud, dust and sediment by retaining and conveying turbid runoff through structural and maintenance practices.

Sediment Traps

Sediment traps are small detention basins or ponds that collect and hold sediment laden runoff. Holding the runoff allows the sediment to "fall" from the water and collect within the structure. The runoff is then discharged at a slower rate, often to another treatment practice, free from most of the sediment it had previously carried.

Key Points:

- Install at points of discharge
- They are used as a secondary measure for erosion and sediment control
- Must be sized to handle the expected flow
- Larger basins are more effective
- Construct with future access in mind for maintenance
- Construct to avoid the need for special equipment or easements for maintenance
- Lining with stone make sediment removal difficult

Maintenance:

- Inspect regularly
- Remove sediment for basin to be effective

Inlet Protection

Inlet protection is used to prevent sediment laden runoff from entering into the storm drainage system through catch basins or inlets. The intent is to provide a permeable barrier around the inlet, trapping the water and allowing the sediment to "fall" from the runoff through settling. Each practice is limited to a maximum of 1 acre contributing drainage area and is not a substitute for a preferred sediment basin.

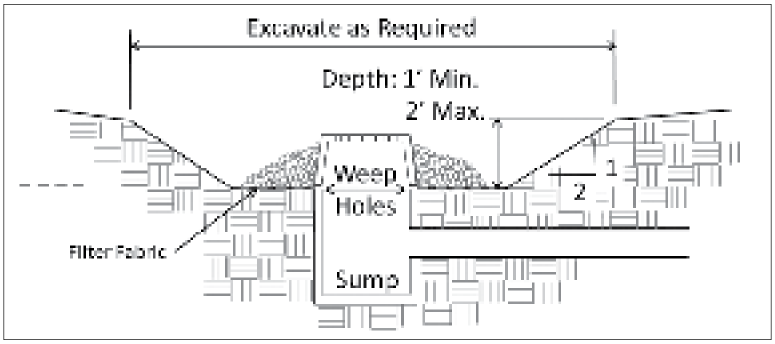
There are several methods of inlet protection available and include:

Type I: Excavated Drop Inlet Protection: A 900 CF excavated basin: excavated 1 to 2 feet deep below the structure rim.

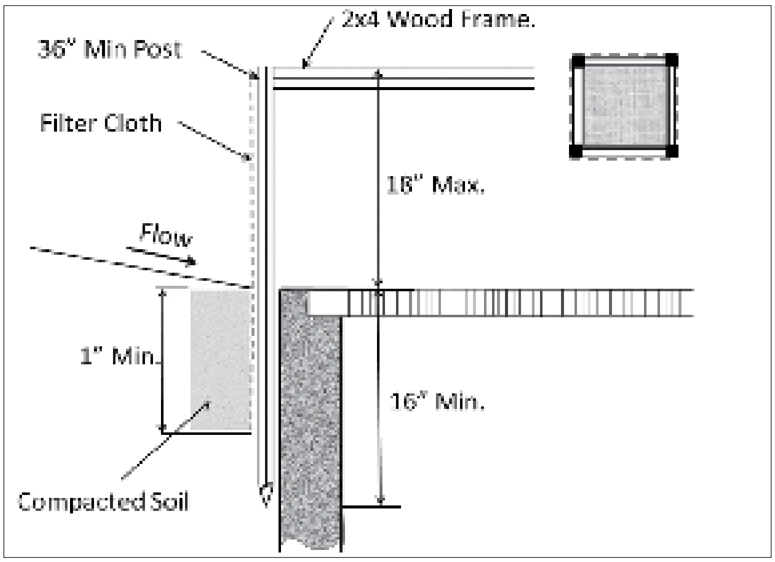
Type II: Fabric Drop Inlet Protection: A silt fence/straw bale/burlap enclosed structure; Straw bales and burlap should be replaced every four months.

Type III: Stone and Block Drop Inlet Protection: A Block and stone configuration around the inlet 1 – 2 feet high; a stone circle placed around the inlet in the shape of a donut 1-2 feet high and 1 foot away from the inlet.

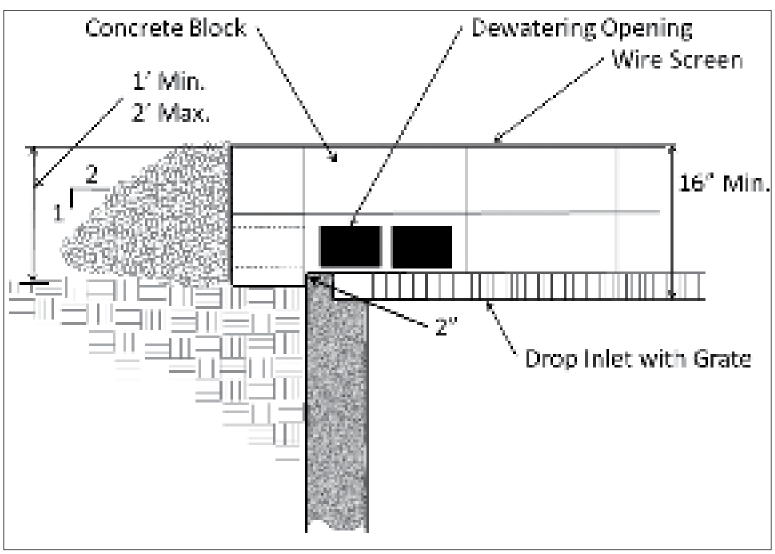
Type IV: Curb Inlet Protection: Wire mesh, filter fabric and stone placed over the entrance to a curb inlet, supported by a 2x4 wooden frame.



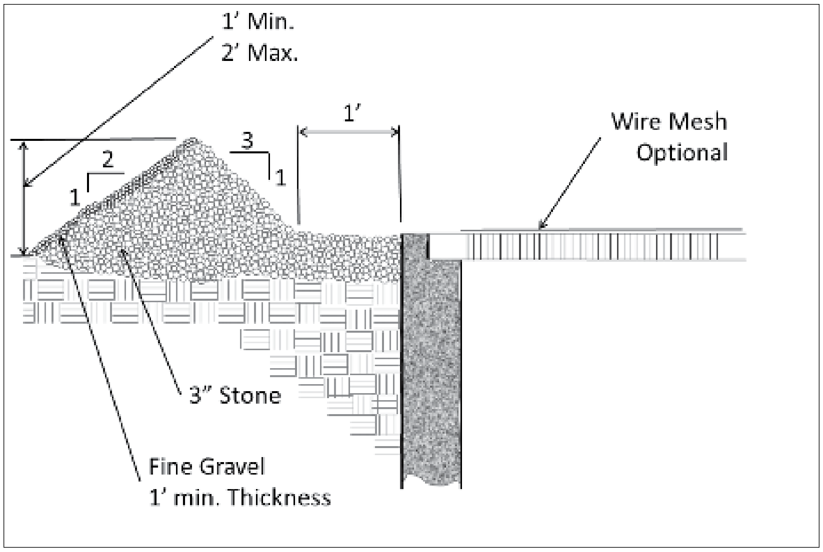
Type I: Excavated Drop Inlet Protection



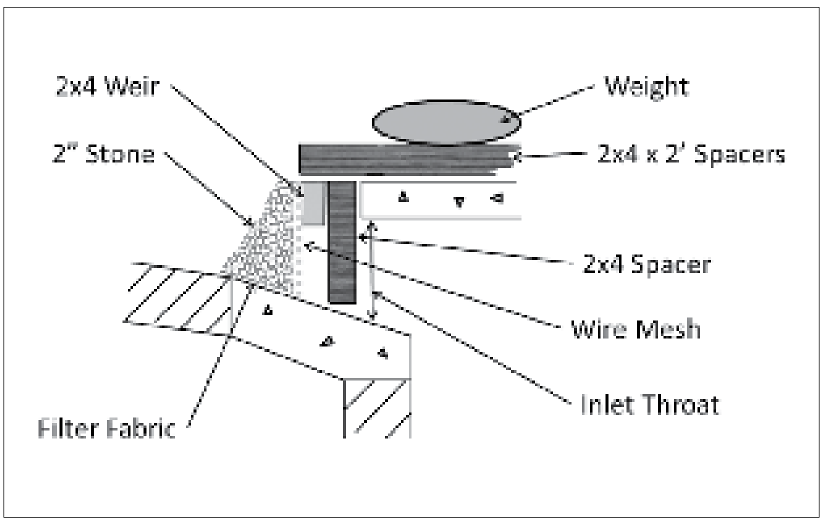
Type II: Fabric Drop Inlet Protection



Type III: Stone and Block Drop Inlet Protection



Type III: "Doughnut" Detail Inlet Protection



Type IV: Curb Inlet Protection

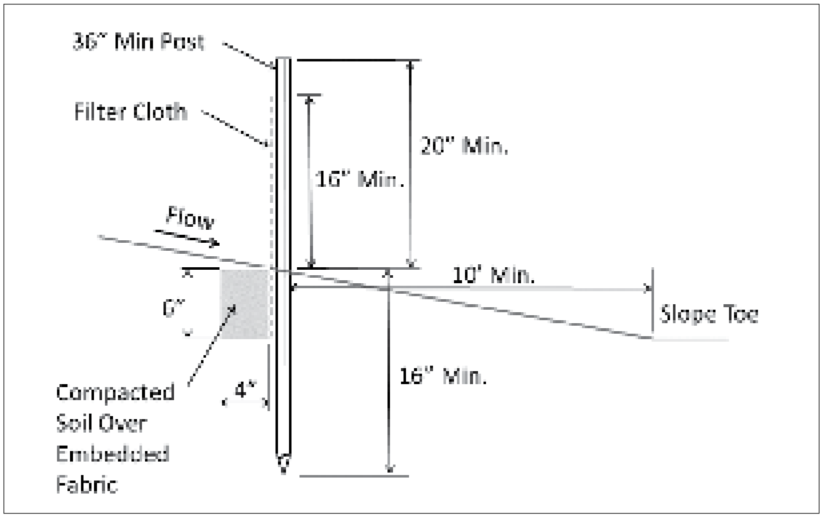
Figure 27. Inlet protection

Maintenance:

- Inspect and clean after every storm
- Maximum sediment capacity = 50 percent storage volume
- Clean regularly for most efficiency
- Repair as necessary
- Remove when contributing drainage area is stabilized

Silt Fence

Silt fence is a temporary fabric filter barrier installed to prevent the migration of sediment from sheet flow runoff. Silt fence is placed parallel to the contours and should not be placed in ditches, swales, streams or channels.



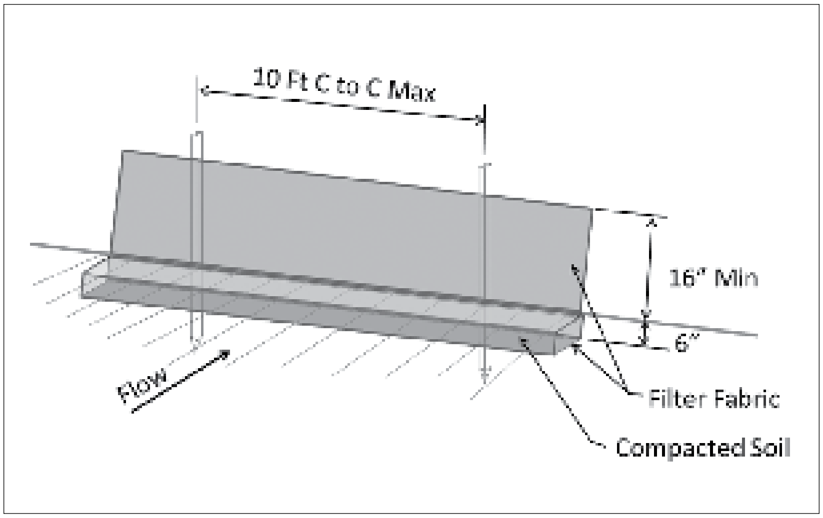


Figure 28. Silt fence

Maintenance:

- Inspect after every rainfall
- Replace damaged sections
- Remove sediment build up
- NOT to be used as a retaining structure
- Remove when contributing area is stabilized

Table 9. Silt fence/hay bale spacing table

Slope	Fence Spacing
2:1	25
3:1	50
4:1	75
5:1 or Flatter	100

Straw Bale Dike

Straw bale dikes are temporary barriers, similar to silt fencing, designed to prevent sediment from leaving disturbed areas. Straw bales are to be placed at the toe of a slope and/or parallel to the contours and should not be placed in ditches, swales, streams, or channels. Straw bales are to be anchored with two stakes, which are to be hammered flush with top of the bale. Spacing is similar to silt fence placement on slopes.

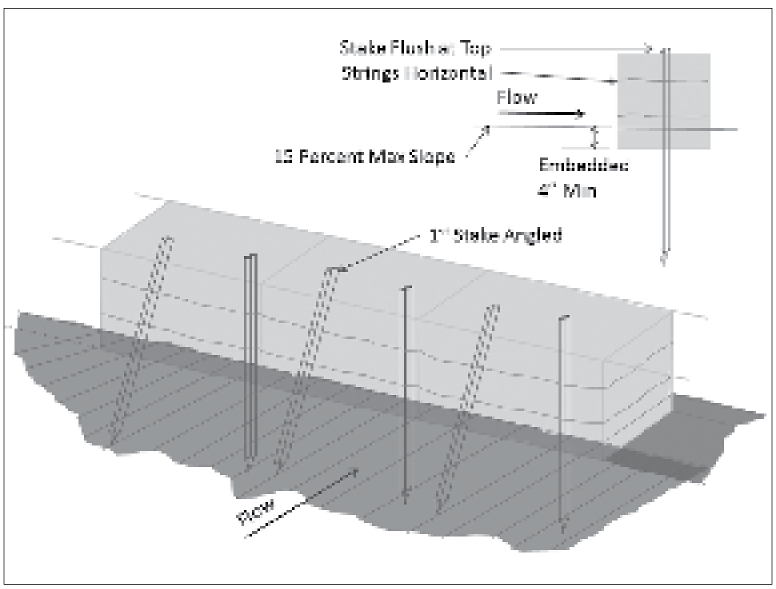


Figure 29. Straw bale dike

Maintenance:

- Inspect after every rainfall
- Remove sediment build up
- Estimated useful life = 3 months
- Remove when useful life has expired or contributing drainage area is stabilized

Stabilized Construction Entrance

Stabilized construction entrances are a stone pad designed to reduce the amount of sediment tracked from disturbed areas and onto the roadway. Tracked sediment eventually ends up in the drainage system resulting in additional time and labor to remove it. Stone aggregate is placed on filter fabric to reduce the infiltration of the native soils into the aggregate.

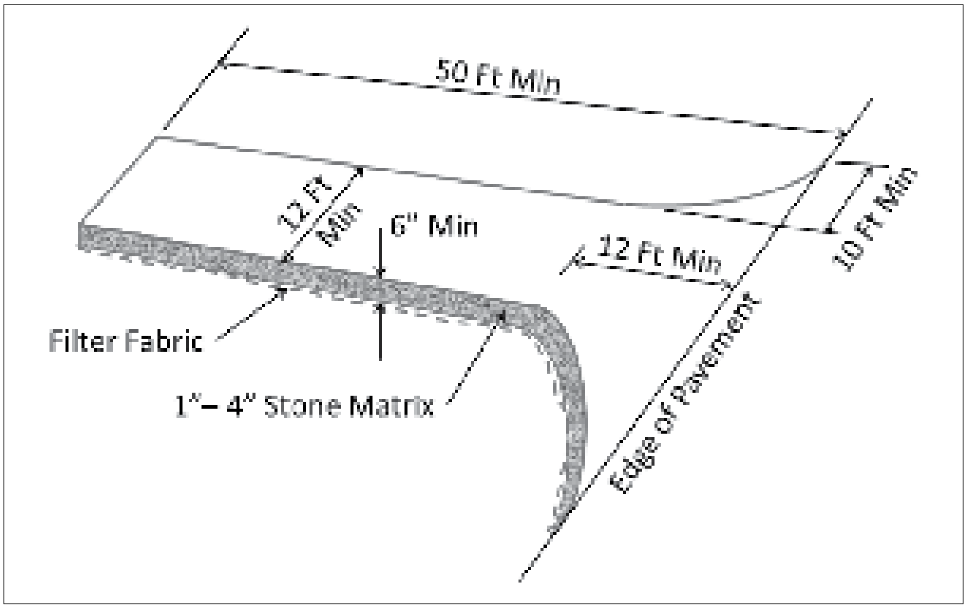


Figure 30. Stabilized construction entrance

Key Points:

- Remove all sod and topsoil
- Place fabric on solid subgrade
- Runoff should drain away from the structure
- Reroute or avoid flowing surface water

Maintenance:

- Inspect after every rainfall
- Keep aggregate clean
- Add aggregate as required
- Remove sediment and aggregate that gets to the roadway
- Prevent sediment from entering the storm drainage system

Level Spreader

Level spreaders are used to convert concentrated flow to sheet flow. By converting to sheet flow the velocity and sediment carrying ability of the runoff is diminished. The sheet flow is then discharged over a stabilized vegetated surface.

Level spreaders consist of a level lip a minimum of 10 feet wide that detains the inflowing water, spreads it out and then discharges to a convex slope of less than 10 percent. They are designed for the peak flow of the 10-year storm; maximum inflows are limited to 30 cubic feet per second (cfs).

Maintenance:

- Inspect annually (permanent) minimum and after every rainfall (temporary)
- Inspect for erosion above and below structure
- Remove sediment and debris as required
- Mow permanent structures a minimum once per year
- Do not place in areas of snow storage
- If downslope areas indicate a re-concentration of flow, reconstruct

Table 10: Level spreader/apron specification

Design Flow (cfs)	Entrance Width	Depth (ft)	Outlet End Width (ft)	Outlet Length (ft)
0 - 10	10	0.5	3	10
10 - 20	16	0.6	3	20
20 - 30	24	0.7	3	30

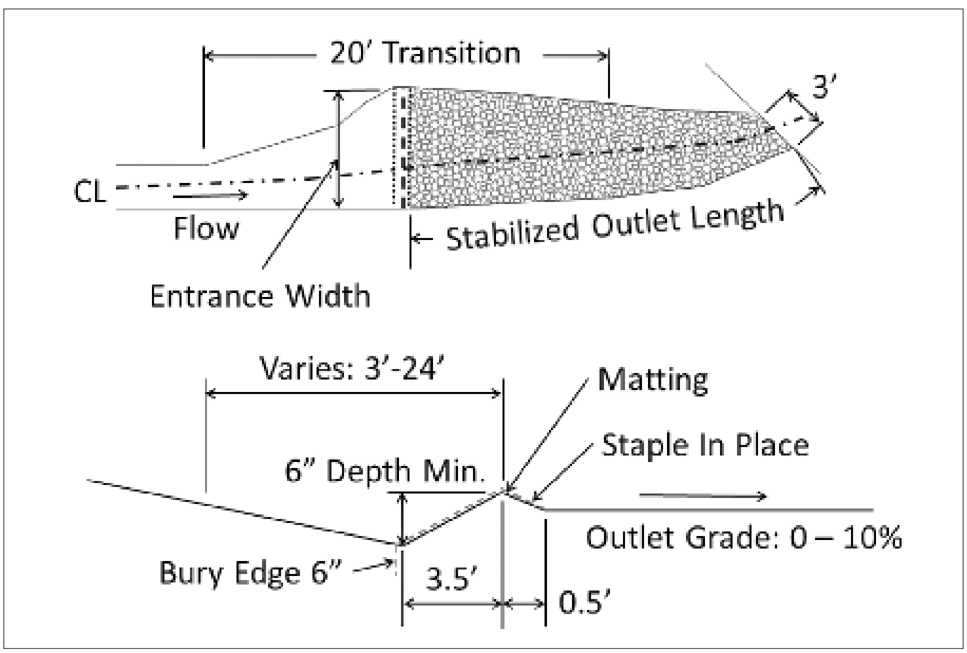


Figure 31. Level spreader

Sump Pits

Sump pits are used to lower the water table during construction and to trap and filter sediment laden water. Pumps withdraw the collected water from within the excavation and discharge to a sediment basin/trap or a vegetated area for further filtration and infiltration. If the discharge is to be pumped directly to storm sewer, the perforated pipe should be wrapped with filter fabric; Marafi 100X, Poly Filter GB (40-80 sieve size equivalent). ¼ inch to ½ inch hardware cloth may also be installed prior to filter fabric for additional support.

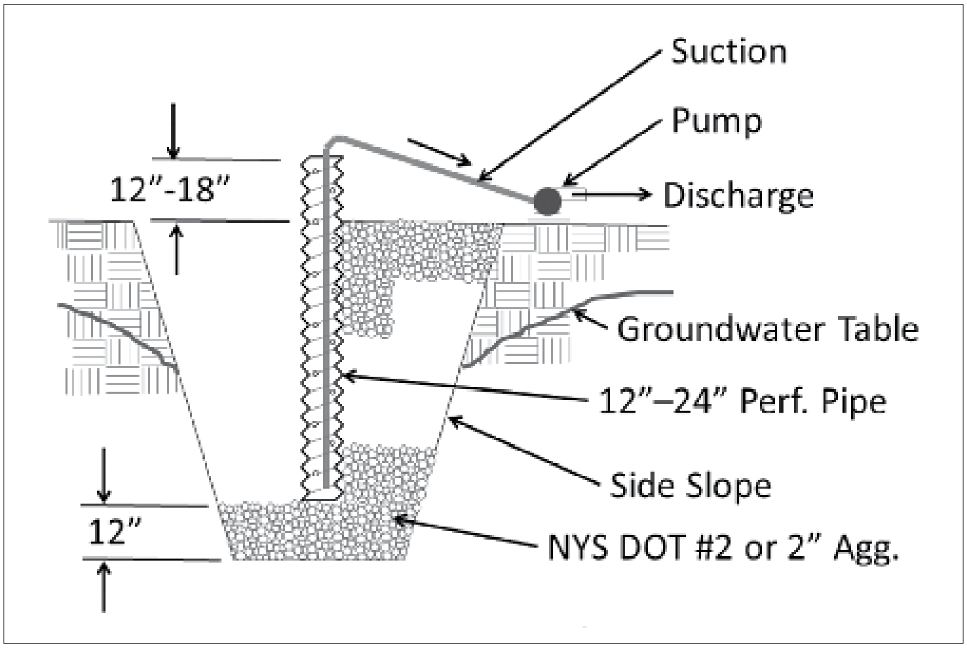


Figure 32. Sump pit

Culvert Replacement By-Pass Options

NOTE: All work within or near a stream requires the submission and approval of a Stream Disturbance Joint Application Permit. Depending on the work additional permits may be required.

When replacing a culvert or stream crossing it is often necessary to allow the existing flow to by-pass the work area. Typical designs allow the base stream flow to pass through the area in temporary culvert pipes. Occasionally, it is necessary to pump the flow around the work area to minimize additional disturbance required for the installation of a temporary culvert by-pass. In these cases it is necessary to evaluate both the intake and outlet ends of a pumping system.

Intake ends should be placed so sediment, vegetation and debris are not sucked up by the pump, while the discharge end should be selected or placed to minimize the erosion potential developed by the pump. "Clean water in, clean water out" does not specifically require any particular practice. Discharge points should be maintained in a manner that ensures that the final discharge back to the stream is clean.

When removing turbid or muddy water from a project site it is important to address the sediment to prevent it from entering any water body. Turbid water must not be discharged into a stream, pond, or lake. Typically, water pumped from a work area is muddy; this water should be treated to allow for the removal of the sediment. Depending on the flow velocity of the pump and site limitations several options are available that can help minimize the potential for turbid water entering a water way. All of the options below should be placed in well vegetated areas to further facilitate the filtering of the discharge.

Pump to Vegetated Area

Pumping muddy water into well-established grasses that do not slope directly into the stream will help filter some of the sediments from the water and allow the discharge to infiltrate into the soil away from the stream.

Pump to Sediment Basin

Pumping turbid water from a project disturbance can be discharged into a sediment basin, which allows the discharge to be stored, releasing sediment slowly into the basin. The stored water is then discharged slowly into a vegetated area or infiltrates into the ground.

Splash Pad

A splash pad is a simple device that holds and filters the pumped water. A splash pad consists of a piece of plywood enclosed with staked hay/straw bales. The bales serve to filter the flow and contain the contaminants. A splash pad should be placed well away from the stream in an area with substantial vegetation to help disperse the flow and reduce its velocity. Straw/hay bales have a limited useful life and should be replaced after 3-months or when its useful life has expired.

Coiled-perforated HDPE Pipe

The uses of 6-inch to 8-inch coiled, perforated drainage pipe placed in a well vegetated area away from the stream is another option for slowing the pump discharge flow, and allowing the sediment to fall from the water. This practice allows the pump discharge to be directed into the upper end of the coiled pipe, as the water flows through the pipe and its perforations it slows, depositing the sediment within the pipe. Cleaner water is then discharged from the pipe, leaving much of the sediment within the pipe. Sediment build up is expected, the pipe can be removed from service, and the site if necessary, and where the sediment can then be removed from the pipe, the pipe can then be made available for reuse.

GREEN INFRASTRUCTURE

Green infrastructure (GI) refers to stormwater management practices that focus on maintaining and restoring natural hydrological and ecological functions through infiltration, transpiration, and the capturing and reusing stormwater. Restoring and maintaining natural vegetation and site hydrology are successful approaches when considering green infrastructure.

Green infrastructure seeks to reduce runoff and/or establish habitat areas with significant usage of infiltration, vegetation and engineered media rather than the traditional hardscape collection, conveyance and storage structures. GI is utilized to replicate the pre-development hydrology by maintaining pre-construction infiltration, peak runoff flow, discharge volume, and to minimize concentrated flow by using runoff control techniques to provide treatment in a distributed manner before runoff reaches the collection system. Runoff control is most effective on smaller more frequent storms and is not often applied to large storms. Runoff Control techniques look to:

- Reduce runoff volume and peak flow (infiltration, transpiration)
- Reduce runoff flow rate (increase Time of Concentration)
- Improve Groundwater Recharge (infiltration)
- Reduce flooding and property damage
- Protect downstream water resources (i.e. wetlands)
- Reduce combined sewer over flows
- Reduce thermal pollution
- Improve wildlife habitat
- Improve water quality & treatment costs

Three main components of GI that mitigate the effects of development include:

- Avoid impact: minimize disturbance, preserve natural features
- Reduce impact: minimize impervious cover
- Manage impact: Use natural land features to slow flow; promote infiltration & transpiration; minimize need for “end of pipe” practices

Examples of Green Infrastructure include:

- Green roofs
- Trees
- Tree boxes
- Pervious pavement
- Rain gardens
- Vegetative swales
- Planters
- Reforestation
- Protection and re-establishment of riparian buffers and flood plains

Buffers

Buffers are strips of vegetation, typically grasses or trees and shrubs, intended to serve as a natural way for runoff to filter prior to entering into a water way. The buffers help capture sediment and nutrients, preventing them from entering the water.

> **Contour Buffer Strips** are strips of vegetation, usually grasses, alternating with cultivated field sections and placed along the contours. They are typically 15 feet wide and serve to trap pesticides and reduce rill erosion. Proper planning allows the grasses to be harvested for other purposes.

Vegetative Barriers are narrow contour barriers found in open fields, they typically consist of hardy native grasses and shrubs

Field Borders are sections of grasses and other permanent vegetation that enclose disturbed crop land. They provide a means of filtering field runoff and provide storage for equipment.

Filter Strips are sections of grasses and other permanent vegetation that reduce the transport of sediment and nutrients from entering waterways. Filter strips are typically smaller scale vegetative strips that serve as pre-treatment for bio-swales and rain gardens.

Riparian Buffers, similar to stream buffers, are areas of land adjacent to rivers and streams that consist of native vegetation and include trees, shrubs and grasses. Preservation of existing river/stream vegetation provides an effective means of protecting the aquatic environment from pollutants and the harmful effects of heating from the sun.

Bio-swales

Bio-swales are drainage courses that consist of multiple landscape elements designed to remove silt and pollution from stormwater runoff. They are designed to be flat and wide with the intent of slowing the velocity of the flowing runoff to allow the sediment to drop out of the flow and to promote infiltration. They are commonly found along parking lots and other paved surfaces to serve as a first flush of the runoff during a rainfall event.

Permeable Paving

Permeable paving is a broad group of pervious pavements and pavers that provide an alternative to normal impervious pavements. They allow the runoff from the surface to pass through the surface material and into a constructed reservoir where it can infiltrate into the ground and recharge the water table. Outlet pipes are provided to prevent the storage area from over filling. They typically contain three main components: surface, storage and outflow.

Porous Pavements: porous asphalt and concrete

Permeable Pavers: brick pavers, interlocking concrete blocks, reinforced turf

Permeable paving is subject to clogging when winter maintenance includes sand and other materials. The application of salt on these materials should be limited since the porous material allows the chlorides to enter into the groundwater. Maintenance such as vacuuming and pressure washing has been found to be effective in restoring permeability.

Green Infrastructure in Management Planning:

On a regional scale, management and planning can also be considered Green Infrastructure. This approach looks to preserve and protect natural features and open spaces such as forests, wetlands and flood plains, all in the effort to improve water quality on a large scale.

Land Conservation

Land Conservation is the practice of preserving the existing landscape and vegetation to maintain the ability of the environment to minimize the effects of stormwater runoff. This practice is often coordinated and implemented with consent and cooperation of private landowners for the benefit of the environment.

Erosion and Sediment Control Plan

Erosion and sediment control plans have become a common requirement for any type of land disturbance and is required for any construction activity that disturbs greater than one acre of land, or 5,000 square feet in areas under the jurisdiction of the NYCDEP. The EPA considers the initial construction phase of clearing and grubbing the land of its vegetation, and the initial grading on a site the most critical stages of any development. The initial exposure period of these areas is a particularly sensitive time for soils, which are very susceptible to erosion. Erosion and sediment control is considered a necessary practice in preventing and controlling erosion and in the discharge of sediment laden runoff into adjacent waterways.

6 - Regulations

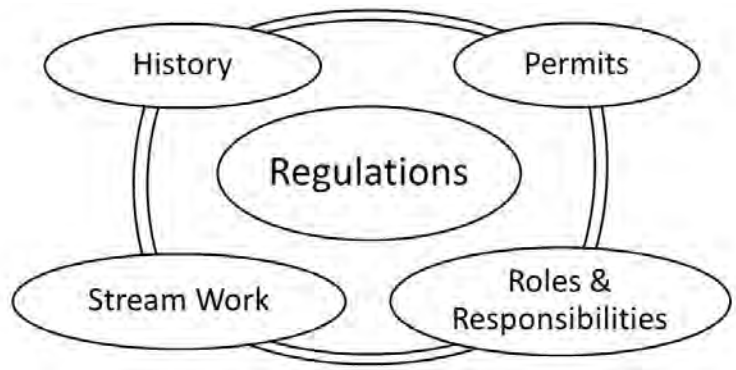


Figure 33. Components of regulation

HISTORY

The history of stormwater regulations have evolved over the years in the United States, beginning in 1948 with the *Water Quality Law* which focused on reducing or eliminating pollution and improving the surface and underground water conditions. For years this program was modified and upgraded with minimal success in achieving their goal.

In 1972, the Federal Water Pollution Control Act, also known as the Clean Water Act (CWA), was introduced to strengthen the earlier regulations by setting deadlines for the elimination of toxins and other pollution from discharges and to set standards and timelines for the improvement of surface waters. The National Pollution Discharge Elimination System (NPDES) was authorized to issue permits in order to restore water quality and address point source discharges. With this, point discharges became illegal without a permit. The NPDES in New York is enforced by the New York State Department of Environmental Conservation (NYSDEC) under the State Pollution Discharge Elimination System (SPDES).

In 1977, amendments to the 1972 Clean Water Act were added. These amendments expanded regulation to include stormwater discharges from municipal stormwater systems and industrial sites to reduce pollution discharges into the waters of the US. The development of Best Management Practices (BMP) was also introduced.

From 1978 to 1983 the Federal Government, through the EPA, funded the National Urban Runoff Program (NURP) to conduct an analysis on stormwater runoff in urban areas to determine which activities were detrimental to the contribution of pollution to stormwater runoff.

1987 Water Quality Act

The 1987 Clean Water Act was a complete revision of the previous water pollution Acts. This program was intended to provide a more comprehensive method and means of addressing stormwater runoff. This Act included the development of a (2) phased approach. Phase I for larger cities was implemented in 1990, and Phase II implemented in 1999. Phase II covers municipalities with 50,000 in population or areas where population density exceeds 1000/mile. Below are more specifics of the Water Quality Act (WQA):

- Water Quality Act (WQA) of 1987 revised the CWA through amendments:
  - Added section 402(p) which establishes framework for regulating stormwater discharges under the NPDES Program
  - By 1990, the EPA had promulgated regulations and an NPDES permitting system for stormwater runoff for Municipal Separate Storm Sewers (MS4s) and industrial and construction site runoff
  - Mandated that stormwater discharges from towns and cities be classified as point sources of pollution
  - Required a two phase national program to address water pollution created from stormwater

NYSDEC is an executive agency that delegates responsibility for the Phase II program under the State Pollution Discharge Elimination System (SPDES). It requires operators of small municipal separate storm sewer systems (MS4s) located in urbanized areas and serving populations of 50,000 or more to obtain a permit for their stormwater discharges. It also requires construction sites disturbing more than 1 acre of land to obtain a permit.

Local Regulations

For the implementation and enforcement of stormwater regulations to be possible it is necessary for local and regional authorities to declare this ability through local resolution. The ability to enforce and regulate stormwater by resolution is provided by the EPA. The NYSDEC has prepared a DEC sample law for the purpose of assisting municipalities in implementing local regulations.

DEC Sample Local Law: Purpose for establishing minimum stormwater management requirements and controls to protect and safeguard the general health, safety, and welfare of the public residing within a jurisdiction. The sample Law includes:

- Zoning Law Amendment:
  - Stormwater Pollution Prevention Plans
  - Performance and design criteria
  - Maintenance, inspection, repair
  - Severability, effective date
  - Subdivision regulation: identifying preliminary and final subdivision plat requirements
  - Site Plan Review: Requirements for a Stormwater Pollution Prevention Plan
  - Erosion and Sediment Control Law: provides verbiage to amend or repeal and replace an existing law

  - Administration & Enforcement
  - Inspection
  - Performance guarantee
  - Enforcement and penalties
  - Fees for services
- Erosion Control Regulations
- Best Management Practices (BMP) regulations
- Stormwater detention regulations

Stormwater Pollution Prevention Plans (SWPPP)

A Stormwater Pollution Prevention Permit is required when a construction activity is to disturb greater than one acre. The SWPPP is a document that addresses controls for erosion and sediment, and pollution that can be anticipated during disturbance and construction. Control is typically achieved using applicable Best Management Practices (BMPs).

SWPPPs include multiple phases that include site evaluation, design impact assessment, BMP selection and design, Site plan development, certification and notification, construction and BMP implementation, and final stabilization and close out.

> **Site evaluations** include the collection of soil data, existing runoff data, identification of local surface waters and runoff destination surface waters.
>
> **Design impact** assessment utilizes the previously collected information to determine the amount of disturbance required and the impact the project will have on runoff.
>
> **Site plans** identify the development and phasing of disturbance and BMP implementation and include surface water locations, slopes generated through grading, disturbance areas and locations, post construction drainage patterns and runoff discharge points.
>
> **Certification** of the plan by an authorized representative of the site operator is required to ensure the information is true and to assume responsibility for the plan. In addition, the contractor and sub-contractors are required to sign the document certifying that they understand the permit requirements, and making them responsible for the plan implementation.
>
> **Notification** documentation is required to be sent to the NYSDEC prior to the implementation of the plan, Notice of Intent (NOI) and once the site has final stabilization, Notice of Termination (NOT).
>
> **Construction and BMP implementation** are to follow the design plans, and include the inspection and maintenance of BMPs, and the documentation of construction activities, plan updates, and reported spills. On-site plans and documents are to be made available during the entirety of the project.
>
> **Final stabilization** represents the point at which the permit requirements have been met and the site is stabilized. At that point a Notice of Termination can be filed to terminate permit coverage on the site.

The SWPPP also addresses the proper disposal of construction site wastes, and the treatment and disposal of sanitary waste developed during the construction. In addition, the plan addresses the prevention of sediment and dust from leaving the site. Contaminated non-stormwater discharges are also to be identified and prevented from leaving the site.

Regulatory Authorities

There are multiple regulatory entities that must be considered when doing a project. Each authority is responsible for specific items of concern based on how it affects the environmental asset they are imparted to regulate. These regulatory entities include:

- EPA: Clean Water Act
- NYSDEC
- Army Corps of Engineers
- NYC DEP Regulations
- Local /Regional/Watershed Authorities

Additional authorities may also be required to be consulted when planning a project. It should not be assumed that contacting one agency will address the concerns of another agency. Each agency is concerned about specific parameters which do not always overlap, and are not always addressed in the same manner.

Goals

The goals of all of the regulations implemented are to reduce pollutants from entering into the environment. By reducing the potential for pollutant discharge the improvement of water sources and recreational waters will make the consumption and enjoyment of these waters better for both humans and aquatic life.

Included in the reduction of pollutants is the reduction or the elimination of increased flows resulting from future development. The erosive forces that result from the increased flows will therefore also be reduced, decreasing the potential for erosion and pollutant transport. Aside from, improving the waters for consumption and recreation an added benefit is found in the reduction of the costs associated with correlating the above issues.

PERMITS

Federal Regulations allow two permitting options for stormwater discharges: Stormwater Construction Permits, and MS4 General Permits.

Stormwater Construction Permit (General Permit for Stormwater Discharges from Construction Activities GP-0-10-001)

Individual permit are issued for specific activities:

- Projects disturbing greater than one acre of land must obtain permit coverage from NYS under this permit
- NYC DEP Requirements: 5,000 sf + area of disturbance

- Routine Maintenance on Linear Projects:
    - Routine maintenance performed on linear projects that involve soil disturbance greater than one acre requires permitting under GP-0-10-001. Disturbances include the removal of paved surfaces (travel lanes, sidewalks, driveways, parking lots) that disturb the bottom 6 inches of sub-base material; unless the work is considered routine maintenance
    - Routine maintenance activities include ditch cleaning, placing shoulder backup material and milling and filling are not to be considered in disturbance calculations
- Routine maintenance activity is defined as an "activity that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the facility." This includes the activities identified above
- The following is a list of routine maintenance activities that do not have a limit on the amount of disturbance that can occur
    - Cleaning and shaping existing ditches to maintain the original flow line and hydraulic capacity
    - Cleaning and shaping of ditches that are modified to accommodate water quality controls to improve water quality
    - The placement of shoulder back up fill material to transition from shoulder to ditch.
    - Full depth mill and fill of existing pavements that do not disturb the bottom 6 inches of the sub-base material
    - Replacement of concrete slabs that do not disturb the bottom 6 inches of the sub-base material
    - Removal of sediment from the edge of the roadway to correct surface drainage from the road
    - Replacement of curbs, gutters, sidewalks and guiderail posts
    - Reshaping and grading of gravel roads
    - Stream bank restoration projects, not including the placement of spoil material (NOTE: a stream disturbance permit is required for work in or around streams)

MS4 General Permit (Municipal Separate Storm Sewer Systems - GP-0-10-002)

GP-0-10-002 is a general permit required of municipalities, military bases, hospitals, etc. Under this General Permit the municipality, or MS4 operator, is given regulatory responsibility for several portions of this permit, such as:

- Reviewing SWPPPs at design stage and issuing an SWPPP Acceptance Form
- Perform inspections and take enforcement action during construction
- Developer must still obtain permit coverage from NYSDEC

Regulated MS4

Regulated MS4 describes a government entity that owns and operates an MS4 and is subject to the Phase II Stormwater Regulation due to the following criteria:

- Part of an urbanized area of more than 50,000 total population
- Has a population density greater than 1,000 people per square mile
- Must obtain coverage under SPDES MS4 General Permit *GP-0-10-002*

MS4 General Permit (GP-0-10-002)

MS4 General Permit (*GP-0-10-002*) Requires MS4s to implement a Stormwater Management Program consisting of 6 Minimum Control Measures (MCMs)

Minimum Control Measures:

- **MCM #1: Public Education and Outreach**

  This Minimum Control Measure promotes the purpose of the MS4 and informs the public about water quality and the effects of polluted stormwater; this includes the distribution of educational materials and outreach activities.

- **MCM #2: Public Participation/Involvement**

  Minimum Control Measure #2 allows for the input and participation of the public in the development, implementation, review and revision of the Stormwater Management Plan. Participation includes publicized public hearings to encourage the public to be involved in the stormwater management process

- **MCM #3: Illicit Discharge Detection and Elimination**

  As part of the MS4 program, the detection and elimination of polluted discharges into the drainage system are an important measure to improve water quality. This step requires the development and maintenance of a mapping system of the storm sewer shed, to identify outfall locations and their receiving water bodies. This is often done through laws or ordinances. This measure also promotes the public awareness of the hazards associated with illegal discharges and improper waste disposal.

- **MCM #4: Construction Site Runoff**

  Land disturbance from construction activities within an MS4 is also regulated, focusing on the development, implantation and enforcement of erosion and sediment control on actions that disturb greater than or equal to one acre of land. This disturbance limit varies within specific regions such as in the watershed of the NY City Reservoir system, these limits should be verified prior to any land disturbance.

- **MCM #5: Post-Construction Runoff Control**

  MCM #5 addresses stormwater runoff from new development and redevelopment projects, through the development, implementation and enforcement program. Controls can include preventive actions to protect and preserve sensitive areas and structural devices such as porous pavement and grassed swales.

- **MCM #6: Pollution Prevention/Good Housekeeping**

  This control measure is focused on the activities of municipal responsibilities. The development and implementation of this program looks to prevent or reduce polluted runoff from municipal operations. This measure includes the training of municipal staff on pollution prevention practices and activities such as street sweeping, catch basin cleaning and techniques and practices to reduce the use of pesticides, fertilizers, and street salts.

Additional requirements can be expected in pathogen and nitrogen impaired watersheds, phosphorous watersheds, and the NYC East of the Hudson watershed MS4s.

ROLES AND RESPONSIBILITIES: MUNICIPAL OFFICIALS & DEPARTMENTS

Roles and responsibilities identified are required of municipal officials within an MS4; however, this does not mean that the implementation of practices and responsibilities listed in this section are only for those in an MS4. Developing and following the practices that directly apply to a municipality, although not required by designation, should be considered to better address the issues related to that municipality.

- **Planning Boards:**

  Planning boards play an important role in conducting an "Administrative Review" of Stormwater Pollution Prevention Plans (SWPPPs) submitted for construction projects, to verify the plans contain all the required components, prior to sending the plan to the NYSDEC for final review and approval. Once reviewed and approved by the Board, a SWPPP Acceptance form is issued to the developer or engineer and is to be submitted along with the final plans for review by the NYSDEC. Public involvement in the review is encouraged.

- **Code Enforcement Officers:**

  Code Enforcement officers serve several purposes including inspection of construction sites, illicit connection detection and elimination and responding to public complaints regarding runoff, flooding and drainage issues. Code Enforcement officers are given the authority, under law, to issue violation notices and enforcement actions.

- **Highway Departments:**

  Highway Department activities include the detection of illicit discharges, implementation and training of staff on pollution prevention and good housekeeping practices, maintenance of post-construction stormwater management practices and respond to residential drainage complaints. Documentation of each activity is required to quantify activities and confirm staff training.

Stormwater Regulatory Laws required as part of the MS4 General Permit *GP-0-10-002*

- **Site Plan and/or Subdivision Review Regulations**: To designate the Planning Board SWPPP review powers
- **Stormwater Management Officer** (or Code Enforcement Officer): To be designated with inspection and enforcement powers (construction sites and illicit discharges)
- **Illicit Discharge Detection and Elimination Local Law**
- **Stormwater Management and Erosion and Sediment Control Local Law**

STREAM WORK

Stream Disturbance Permit: Joint Application Permit

- Required for all activities that disturb the stream bed, remove or add fill to a stream bed and its banks and when working in or near wetlands or water bodies.
- Disturbing the streambed includes:
  - Placing structures in or across a stream (culvert, pipe, arches, bridges, etc.)
  - Fill placement for bank stabilization (rip rap, coffer dams)
  - Excavation to remove gravel or as part of construction activity
  - Lowering stream banks
  - Working in a stream with equipment
- Any work within streams should be conducted between May 15th and September 30th. The NYSDEC stocks streams with trout from March 15th – May 15th.
- Joint Application Permit for Stream Disturbance requires review and approval from multiple jurisdictions depending on where a project is located and the type of water body to be disturbed. They include:
  - New York Department of Conservation (NYSDEC)
  - Army Corps of Engineers (ACOE)
  - New York Offices of General Services (NY OGS)
  - New York Department of State (NY DOS)
- Complete joint applications must be sent separately to each agency, all requirements must be fulfilled for review of submissions
- Joint application permits for stream disturbances <u>does not</u> eliminate the need to obtain other permits related to the project (i.e., General Permit for Stormwater Discharges from Construction Activities)

Stream Related Projects That Require A DEC Permit

All streams classified as C(T) or higher:

- AA or A: Waters designated as drinking water source
- B: Good for recreation: i.e., swimming and other water contact activities, not good enough for drinking water
- C: Waters supporting fisheries and suitable for non-contact recreational activities
- Any of the above with a standard of (T) indicates it may support trout populations; (TS) indicates waters may support trout spawning. Special requirements may apply to project waters that involve these designations that support sensitive fishery resources.
- Small ponds or lakes with a surface area of less than 10 acres are considered part of the stream and are therefore subject to regulation under the stream protection category of **Protection of Waters** regulations.
- All navigable waters
- **NYSDEC** regulated freshwater wetlands outside of the Adirondack park; (Wetlands

within the Adirondack Park are regulated by the Adirondack Park Agency: 518-891-4050)

- **U.S. Army Corps of Engineers**: Regulate dredging, excavation, placement of fill, or construction of certain structures in waterways and wetlands of the US. (US ACOE: NY District: 528-266-6350; Buffalo District: 716-879-4330)
- **Joint Application Permit**: Individual *Joint Application Permits* should sent to each department separately, required for stream disturbances
- **Protection of Waters Permit**: Required for disturbing the bed or banks of a stream with a classification of "C(T)" or higher, whether permanent or temporary.
  - Banks: Land area immediately adjacent to and which slopes toward the bed of a watercourse and which is necessary to maintain the integrity of the watercourse.
    - Bank does not extend beyond 50 feet horizontally of the mean high water line; except when:
      - A uniform slope of 45 degrees (100%) or greater adjoins the bed of a watercourse
      - The bank is extended to the crest of the slope or first definable break in slope
      - Either a natural or constructed (road, railroad grade) feature lying generally parallel to the watercourse

Exempt Activities to Joint Application Requirements

- Work performed under agreement with the NYSDEC
- Agricultural activities involving the crossing of stream with livestock or farm equipment, using the same location(s) consistently
- Withdraw of water for irrigation, provided the withdraw does not affect the water source and cause downstream implications
- Removal of limbs and tree trunks if equipment is not used in the stream bed or within its banks.
- Consult with the local Soil & Water District regarding specific details for each activity prior to beginning any work.
- Disturbance of a protected stream by a town or county which has entered into a written agreement with the DEC for specific categories of work undertaken in compliance with performance criteria that are protective of stream resources

7 – Management

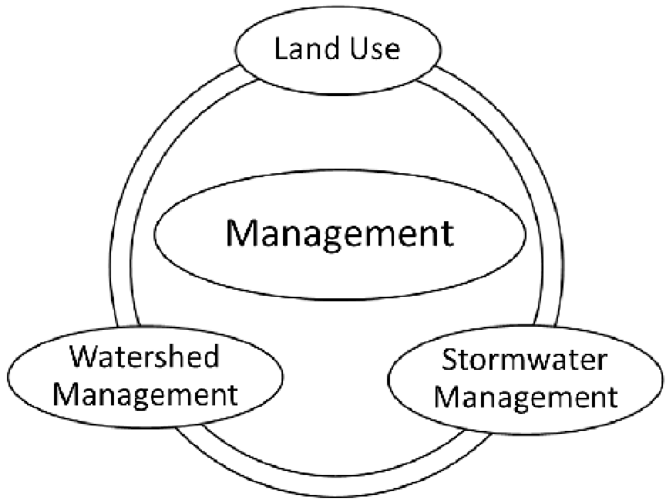


Figure 34. Management of stormwater

When minimizing the impacts of stormwater there are several common techniques and recommended management practices. We defined stormwater as the excess precipitation not utilized and retained by the soil and vegetation; the moisture that remains on the surface of the earth and discharges to streams, lakes and oceans. There a several ways that this excess moisture can be addressed to reduce the impacts that can result from it.

The NYSDEC modified its approach several years ago in dealing with runoff. Although detention and retention ponds remain an option for addressing the runoff, it is not the focus of the approach. Recently, the focus has been on developing methods of reducing runoff at its source. This can be done several ways; from reducing impervious surfaces, preserving existing vegetation and natural features and utilizing natural features.

For highway maintenance and utility construction the first two options play a minimal part on a daily basis. The reduction of impervious surfaces, from the highway department perspective, may be most effective on new developments where streets can be minimized in width, installing sidewalks on only one side of a roadway, using smaller footprints for dead ends and cul-de-sacs and reducing parking requirements or increasing the use of impervious materials to achieve the necessary parking. Many of these items are delegated through the planning review process and although they must often be maintained and repaired by the highway department, they are often not subject to the requests or review of the highway department. Many of these items are dictated within the town roadway design standards, which are often not focused on decreasing impervious surfaces or addressing stormwater. Even further removed from the authority of the highway department is the preservation of natural features unless it is in direct conflict with a drainage structure or other utility within a permanent easement. Stream crossings and land disturbance adjacent to roadways and stream corridors are the instances when existing vegetation can be preserved and utilized to facilitate the stabilization of the soil and serve as a means of filtration of any sediment that may try to leave the disturbed area.

The utilization of natural features in reducing the impact of runoff include the use of vegetative filter strips, open vegetative channels and ditches, the use of bio-retention and rain gardens, the use of the soils ability to infiltrate the runoff into the ground, tree planting and the disconnection of roof runoff from the drainage system. Often these methods are more likely to be usable for highway crews when attempting to reduce the impact of stormwater runoff.

Stormwater is initially reduced naturally by multiple factors including evaporation, transpiration, interception, and infiltration.

Evaporation
Evaporation is continuously happening when the air is unsaturated and the temperatures are warm enough.

Transpiration
Transpiration is referred to as the respiratory process of vegetation, the moisture released into the air from a plant's leaves. Plants retain moisture and help stabilize the soil. Planting vegetation is an important means of reducing the impacts of runoff.

Interception
Interception is the process of the precipitation wetting buildings, parking lots, trees and other vegetation at which time it evaporates back into the atmosphere.

Infiltration
Infiltration is the absorption of the precipitation by the earth through percolation. This is a very important aspect to consider when determining the surface runoff volume from an area. Infiltration is dependent on multiple factors including soil type, vegetation cover, existing moisture conditions, rainfall intensity and temperature. Variations of the factors can greatly influence the amount of runoff that may occur.

LAND USE

Land use planning involves the control of development types and locations through public policy. In doing this the local municipality can manage the development of land within their jurisdiction and protect the existing natural resources. By systematically evaluating land and water and their potential to contribute positively or negatively to an area, a land use plan can be developed that will look to benefit the community economically and socially. Planning of this type protects flood plains from easy development that could result in disaster for those who eventually reside there.

STORMWATER MANAGEMENT

Stormwater Management Plans (SWMP) are a required element of an MS4 permit. It is a management plan that is focused on mitigating potential impacts from stormwater. No two Stormwater Management Plans should be identical. Each agency must evaluate critical elements of their community that contribute to or are harmed by contaminated stormwater runoff, and consider the Best Management Practices that are of the biggest benefit to the community. Not all

Best Management Practices (BMPs) are best for every situation. Many of these BMPs require that the runoff be infiltrated into the existing soil. In many cases this is not possible due to the soil type or proximity to a water source or water table.

In large projects, a Phased development approach is encouraged to minimize the amount of exposed soil at any one time. A phased plan requires each step, or phase, to contain detailed BMPs and level specific implementation information for each step. The plan must show how each previous disturbed section is to be stabilized prior to the disturbance of the next phase.

A Stormwater Management Plan must be reviewed and approved by the permitting agency before obtaining coverage under the stormwater permit. The permitting agency may include the NYSDEC, ACOE, NYC DEP, etc. This will depend on where in the State your project will occur.

The MS4 General Permit requires that the goals of the Stormwater Management Plan are identified and objectives for each of the 6 Minimum Control Measure are stated.

Planning Process

When planning for a stormwater management program, understanding and evaluating all of the characteristics present on a site are important. Environmental features such as slopes, soil types and drainage patterns are important factors to understand. Evaluation of these features should be included for both new and redevelopment projects. There are several approaches that are identified by the Center for Watershed Protection (CWP) and include:

Low-Impact Development (LID)

The approach that looks to minimize runoff by using small scale methods that infiltrate, filter, evaporate, and detain runoff to maintain the site runoff to the pre-development hydrology. Preserving nature drainage features and developing small-scale landscape practices work to achieve this goal.

Green Infrastructure

Refers to the utilization of the natural processes of plants, soils, and microscopic organisms to clean, and collect pollutants in stormwater runoff. Regionally, green infrastructure refers to the natural features and open spaces, such as forests, wetlands and flood plains, which are interconnected to improve the water quality of runoff from the region. Overall improvements are sought in wildlife habitats, recreation waters, and water supply quality. The reduction of asphalt surfaces on a regional scale can also reduce the effect of temperature in local water bodies. On a site specific scale, green infrastructure look to maintain the precipitation on site through infiltration and absorption.

Better Site Design

An approach that looks to copy natural systems and drainage patterns in a watershed. Imitating the natural hydrology through the use of preservation, minimization of land disturbance, redirecting runoff from pavements and roof tops, cluster housing and implementing vegetative swales and natural features are just a few of the available practices.

WATERSHED MANAGEMENT

Approaching stormwater management on a larger scale, taking into account the entire watershed to reduce and eliminate water polluting sources, requires multiple entities participate on an equal level for the good of everyone within that watershed. Addressing developmental changes from the perspective of the entire watershed allows the benefits of conscious development to be shared by all. This approach facilitates the improvement of both land and water resources physically and ecologically. Working together on addressing upstream activities can directly affect the potential for flooding, pollution discharge and transport, and damage to infrastructure. Reducing these post-development affects can directly reduce the maintenance and costs associated with additional sediment and water volume, and improve the waters ecologically to facilitate recreation activities such as swimming and fishing.

This approach requires the preparation and approval of a formal agreement between jurisdictions to allow the entities to work together on the management and monitoring of the shared watershed. It should include an acknowledgement of the importance of recognizing geographic boundaries as a more appropriate approach to managing the resources of the watershed. Agreements typically include joint responsibility and decision-making clauses, an understanding of shared expenses, costs and liabilities that may result from decisions, and the development of a committee to make recommendations on the management of the watershed, develop laws and by-laws surrounding the watershed, any changes that may be required to the watershed agreement. Terms of an agreement may include the right and authority to approve or disapprove any activity and disallow any activity within the watershed. Funding to address watershed issues is easier to obtain when a watershed approach to stormwater is made.

Watershed Management has proven to be a successful means of addressing water quality problems and minimizing or preventing future problems because it involves both upstream and downstream communities. With the intent of protecting and restoring the water quality of New York's water sources, Watershed Management plans allow for the development of plans that address pollution reduction from multiple sources without placing the responsibility and expense on one source. A Watershed Management approach is one way that municipalities can look to minimize the issues related to the changes in the land use. Many areas have already organized Watershed Committees to evaluate what and where issues are happening within their relative watersheds. The goal of watershed planning is to develop a program that will preserve and protect the watershed as a whole, providing the benefits of development with the restoration and protection of the environment and the infrastructure within that region.

The New York State DEC has been promoting the Watershed Management approach to planning and management to protect water resources and restoration efforts that have already been made. This approach is defined hydraulically as opposed to politically; it acknowledges that everyone's actions affect others within the watershed, and allows for more effective solutions for the entire watershed and the people who live and work in them.

Planning Process

Watershed planning allows for the integration of water resource protection and watershed restoration with growth management to accommodate the need for economic growth and development. Typically, development means economic growth and is encouraged by municipalities to increase their tax base to increase the available funding that can be used in their budget. Development in this respect is a good thing. However, if it is done without considering the amount of runoff and pollution that can be generated, it can be disastrous, not only environmentally but also economically.

To overcome the effects that can result from unregulated development at any point in a watershed addressing the watershed as a whole unit should be considered. This approach allows for the evaluation of the potential impacts, good and bad, that can be anticipated as the result of the development. As the flow of the runoff increases, the efficiency of the existing culvert system decreases resulting in flooding, embankment erosion, culvert failure, and roadway washouts; each coming with its own associated costs and expenses.

Recent studies have indicated that the Northeast is experiencing an increase in frequency in “extreme” precipitation events. For whatever the reason, and many have been cited, the events that were experienced recently in New York certainly support these studies. Rainfalls of 1-inch or more have become a fairly common occurrence in recent years. Studies indicate that this has been a trend that has been occurring over a 60-year period. Regardless of the cause, the affect is that as the rainfall frequency of larger rain events increase and regional development continues, the amount of runoff that every community will have to deal with will also increase.

Controlling the amount of rainfall is not an option and, therefore, has to be an accepted variable that has to be accounted for. Controlling runoff is a factor that is within the ability of mankind to address. By taking the watershed approach to addressing how runoff is dealt with, as opposed to the local approach where storm management ends at the municipal boundary, the effects of development and construction can occur with a reduced effect on each of the municipalities’ infrastructure, which is where the many costs addressing stormwater are occurring for nearly every municipality.

Watershed planning looks at the interaction between land use and land cover, the movement and storage of water, and water quality. This allows for responsible land use by recognizing the relationship between the economic, social, and natural systems and maintaining and improving the drainage water quality. As part of the process, watershed planning encourages public participation in recognizing the economic benefits and need for growth.

A watershed plan should address specific questions that will guide the process and achieve the intended goals. Questions should address:

- Why a plan is needed
- Where problem areas are located and what problems are present or can be anticipated.
- What should be done to address these problems
- When actions should be implemented
- Who will lead in the implementation of the actions
- How much will implementation cost

Appendix 1 - Emergencies

EMERGENCY PLANNING

Before a disaster strikes there is always the question of what can be done to be better prepared. If there is the potential that reimbursement from Federal Emergency Management Agency (FEMA) or New York State Emergency Management Association (NYS EMA) is an option when a disaster hits, several steps can be taken to facilitate the process. A good documentation of your infrastructure is a must.

For bridges, culverts and roads, documentation of recent inspections and the inspection evaluation are extremely valuable. Measurements, photographs and a construction/repair history are also valuable when looking for reimbursement of an item that no longer exists.

Having **Construction Standards** for your roads, bridges and culverts will provide guidance and an understanding of the infrastructure to outside parties when the time comes for requesting financial assistance for replacement. These standards will clearly identify a municipality's practice in constructing and replacing infrastructure.

Having **Permanent Easements** and **Right-of-Ways** along streams, at stream crossings and at drainage inlets and outlets will facilitate and expedite debris removal and stream repairs during and after an event occurs.

Developing and becoming familiar with an **Emergency Declaration Procedure** will outline a process and identify key personnel and their duties when a disaster hits. A step by step process will simplify what is necessary in a time when many things are occurring. Key personnel and contact information should be available immediately to facilitate the organization and implementation of an efficient response. Having a prepared declaration procedure will help facilitate the response to the disaster.

A **Procurement Policy** for equipment, supplies and labor will reduce the paperwork and increase response time for obtaining needed supplies.

Developing and implementing **Mutual Aid Agreements** with the state, local municipalities and businesses will minimize the red tape when seeking assistance from neighboring communities. This will allow those who can assist the ability to act sooner to help restore and recover.

Having a **Hazard Mitigation Plan** will help identify and assess risk areas in a community. This type of plan will allow the community to assess the risks and develop a plan to mitigate the risks associated with them. This is a plan that helps identify problem areas, attempt to reduce their potential of risk and allow the monitoring of these risks to identify if the mitigation steps are working or if they need to be changed.

Knowing the process and maintaining the appropriate documentation for obtaining FEMA and NYS OEM reimbursement will substantially improve the working relationship with these authorities. Planning in advance for a disaster and training of key personnel will greatly improve the proper initial response to any disaster and facilitate the success of obtaining reimbursement for damage that may occur.

EMERGENCY RESPONSE

Protocol

Immediate Priority
Items include those facilities and infrastructure which need immediate repair and/or kept open in order for further recovery to proceed or to prevent immediate loss to human life.

High Priority
Typically the first items considered during clean up. Focus on getting the stream channels back to a functioning condition.

Assess Stream Reach
Allows contractor or municipality to focus work on where it is needed to avoid unnecessary work, time and money.

Permitting
All federal and state permitting must be complied with prior to any work being done. Documentation of compliance with environmental laws will be required prior to receiving any disaster relief funds from FEMA or the State Emergency Management Association (SEMA). Work conducted without the required permits are subject to significant fines and may result in the redoing of the work and void the potential to receive reimbursement from funding agencies.

Perform Work
After the stream is assessed and the priorities have been determined work to restore the stream can begin.

POST FLOOD RESPONSE

Emergency Stream Repairs

- Must have a NYSDEC Permit and an US Army Corps of Engineers (USACE) permit
- Must be done in a timely manner

Immediate Priority
Repairs when public health and safety are immediately threatened such as:

- Opening clogged bridges and culverts
- Opening closed roads
- Open stream channels
- Keep important installations functioning, such as:
    - Power plants
    - Fire stations
    - Rescue centers
    - Water wells and systems
    - Sewage treatment plants and systems
    - Hospitals

High Priority

- Removing flood debris from plugged culvert pipes
- Opening clogged stream channels to allow normal flow
- Put channels back to prevent continued flooding
- Open up clogged bridges to prevent further flooding from follow up rain events
- Stabilize stream banks to prevent erosion, helps to prevent additional localized flooding
- Attempt to stabilize landslides, at least on a temporary basis, to prevent them from sliding into the channel and trigger an avulsion and/or localized flooding
- Return stream channel into a condition that will facilitate the natural processes of streams to return the stream to pre-flood condition
- Repairing or replacing critical infrastructure
- Focused on rescuing people and keeping them safe. May often not be a permanent solution and should be evaluated when time allows and as soon as possible to minimize potential additional damage by incorrect repairs

Permitting

The NYSDEC has (2) permitting processes available to respond to emergency and disaster situations.

- **Emergency Authorizations (EA):**
    - Issued for emergency actions to protect life, health, property and natural resources
    - Written pre-notification & plan required (for municipalities, notification within 24 hours if pre-notification is not possible)
    - DEC must certify or deny the EA within (2) business days
    - Expire in 30 days; can be renewed for an additional 30 days
    - EA and permit conditions: Intended to contain enforceable conditions that are intended to ensure that the project will not impact adjacent landowners, protect natural resources and maintain state water quality standards, including:
        - Isolating and dewatering the work area
        - Work in trout waters are limited to June 15 – September 30, whenever practicable
        - Proper bedding of culverts
        - No discharge of turbid waters
        - Proper stabilization and revegetation of work site
- **General Permits for Disaster Recovery:**
    - Expedited evaluation process
    - Valid for all restoration not just emergencies
    - Available for a set period after a natural disaster (i.e., 6 months)
    - Expiration date is variable
    - Permits can be issued during a site visit or in response to an application received at the DEC office
    - Follow Stream Disturbance Permit regulations in natural disasters

Post-Emergency Repairs

For more information and training on Post-Flood Emergency Stream Intervention please refer to the *Post-Flood Emergency Stream Intervention Training Manual* prepared by the Delaware County Soil and Water Conservation District and NYSDEC. Hands-on training is available in various locations throughout NYS. Contact your local Soil and Water District or the NYSDEC for dates and availability.

Reconstruct stream channels to pre-flood dimensions:

Use an undamaged stream reach as a reference, from immediately upstream or downstream. The comparable reach should be similar in bank-full depth, bank-full width and flood plain stream-channel dimensions. Alternative sizing of stream-channel dimensions can be done by using the Bank-full Hydraulic Geometry Tables for Selected Hydrologic Regions found on the DEC web site: *www.dec.ny.gov/lands/86450.html*

Avoid creating abrupt vertical drops (head cut):

Abrupt vertical drops erode, or cut, the foot of the drop point in an upstream direction against the flow. This eroded material is carried downstream causing sedimentation problems downstream. In stream structures, such as rock-cross vanes, can be used to prevent head cutting.

Avoid increasing channel depth (scouring/down-cutting)

The best means of avoiding scouring of the channel is by reconstructing the channel to bank-full dimensions, taking into consideration the grade and available flood plain to minimize the erosion of the channel and the banks.

Gravel deposits downstream are often associated with scour and should be considered a source to reconstruct stream channels and to fill scour holes.

Repair eroded banks

Repair banks to prevent future eroding. If room allows construct banks to a 3:1 slope or flatter; slopes of 2:1 may be considered if rocks or other stable materials are used. Rock vanes can be used to deflect the current away from the bank.

Appendix 2 - Stream Work

Stream work maintenance: *pre* and *post flood* (woody debris, gravel removal)

General: Water Quality In and Near Streams: Any work in or near streams requires a permit, contact your **Soil & Water Conservation District for more information**.

- Any work in or around streams require at a minimum the completion of the *Joint Application Permit*
- All efforts must be taken to "minimize to the greatest extent practicable" causing erosion or muddying the water (turbidity)
- Machinery should keep out of flowing water; operation from stream banks is preferred.
- Do not work within streams between November 1 – June 15 to avoid trout spawning
- Typically clearing debris from stream is acceptable if no fuel powered machinery is used within the stream's banks, and debris is manually removed or dragged from the stream without the use of mechanical equipment within the stream banks. Handsaws and the pulling of debris with ropes within the stream banks are typically acceptable any time of the year, provided the stream bed and banks are not disturbed during the activities.

Assessing Stream Reach

- Assessing stream reach involves the measurement of specific dimensions across the width of a stream. These dimensions are the:
    - Bottom width
    - Bank full depth
    - Bank full width
    - Flood plain width
- In damaged areas these dimensions can come from areas immediately up or down steam from the damaged area and be replicated in the damaged area. By reconstructing the damaged stream to its "original" dimensions there is a reduction in the impact from erosion and an improved ecological recovery time for the stream.

Other Permits

- **Stormwater Construction Permit**: (GP 0-10-001) (See Chapter 6)
- **Joint Application Permit** (See Chapter 6)
- **Local Municipal Floodplain Development Permits**: Nearly all municipalities in NYS participate in the Nation Flood Insurance Program
    - Addresses any development within a mapped Special Flood Hazard Area (also referred to as the 100-year floodplain having a 1 percent chance or greater of flooding every year.)

- Requires a permit to allow "development", defined as: "*any manmade change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations or storage of equipment or materials*." (FEMA regulations, 44 CFR 59.1)
- Prior to any work within the flood plain, a plan demonstrating the "development" will not result in physical damage to other property, such as stream erosion and increased velocities, must be approved by the local floodplain administrator, typically a building code or zoning official.
- NYSDEC serves as the state National Flood Insurance Program coordinating agency and provides technical assistance to local communities on how to comply with floodplain development requirements.

- **US Army Corps of Engineers** (USACE) Permit Requirements:
  - USACE has emergency procedures (33 CFR Part 325.2), which may be used to authorize work when their exiting permit process procedures are not timely enough to respond to emergency work.
  - USACE under Section 10 of the Clean Rivers and Harbors Act requires a permit for any work in or affecting navigable waters of the US (including structures)
  - USACE under Section 404 of the Clean Water Act requires a permit for any activities that involve or result in the discharge of fill material into waters of the United States. Waters of the US include 1) navigable waters and adjacent wetlands, (2) tributaries to navigable waters and wetlands, regardless of their DEC classification.
  - Typical Flood Response Permit actions:
    - Channel shaping
    - Sediment removal
    - Bank stabilization
    - Culvert and bridge repair or replacement
    - Road repair or replacement that takes place in water
    - Cofferdams or temporary fills required to complete the work
    - Minor projects with minimal individual and cumulative impacts may be authorized under general national permits including nationwide permits, which require pre-notification prior to the beginning of any work. It is particularly important when projects are:
      - Located near in or near wetlands
      - Located in or near riffle pool complexes
      - May affect historical property
      - May affect endangered species
      - NOTE: these terms must be complied with regardless of whether USACE permits or approvals are required.

- Nationwide Permits typically involved with flood responses are:
  - Nationwide Permit (NWP) 3: Maintenance
  - NWP 13: Bank Stabilization
  - NWP 27: Aquatic Habitat Restoration, Establishment, and Enhancement Activities
  - NWP 33: Temporary Construction, Access and Dewatering
  - NWP 37: Emergency Watershed Protection and Rehabilitation
  - NWP 45: Repair of Uplands Damaged by Discrete Events
  - All NWP must comply with the:
    - Wild and Scenic River Act (Delaware River)
    - Section 7 of the Endangered Species Act
    - Section 106 of the National Historic Preservation Act

Appendix 3 - Right-Sizing Culverts

STREAM CROSSINGS

- An effort by the DEC and others has begun to "right-size" stream crossing culverts. There are several reasons for this mostly focused on restoring stream continuity and protecting the wildlife associated with the streams by restoring natural conditions and eliminating the manmade restrictions placed in the stream when the crossing was created.
- When roadways were constructed and watercourses obstructed the path of travel for humans, culverts and bridges were installed to safely allow the passage of the people. Minimal regard for drainage patterns and watersheds were considered causing a breakup of the long linear ecosystem known as a stream. Many of the crossings act as barriers for the movement of aquatic organisms, fish and wildlife. For a stream, or an ecosystem, to be successful it must be allowed to interact with other parts of its system, to allow for an interdependence of the isolated sections to develop and bring "continuity" to the stream ecosystem.
- Designs intended to facilitate the improvement of the stream's continuity need to consider and evaluate the needs of the fish and wildlife present. This evaluation includes the unimpeded movement of the animals to obtain shelter, escape danger, find food and improve the health of the stream as well as the environment around it.
- Items that are of importance are:
    - Access to cold water habitats
    - Access to feeding areas
    - Access to breeding, spawning, and nursery areas
    - Natural dispersal
    - Nearby habitats
- Common Stream problems:
    - **Undersized Crossings:**
      Restrict natural flow, increase high flow velocities, scour and erosion, and clogging and ponding
    - **Shallow Crossings:**
      Low flows result in limited mobility of organisms to move to either side of the crossing; lack of streambed material discourages wildlife passage.
    - **Perched Crossings :**
      Perched Crossings are elevated discharge outlets that restrict the movement of aquatic and wildlife from freely moving upstream. Issues include the restriction of natural flow, do not typically have natural bedding material, cause scouring and erosion on both ends of the culvert and can result in ponding.

- **Double Culverts:**
  Double Culverts have not been the preferred solution when it comes to replacements, and are discouraged for several reasons. Double culverts split the flow through the crossing, often one main tube addresses the natural low flow, while a second culvert is elevated higher and is used to allow high flows to pass on larger storms. Issues with double culverts include the restriction of wildlife movement, and the tendency for clogging from upstream flow due to debris catching at the opening of the dual pipes, all of which can result in ponding and flooding.

RIGHT-SIZING CULVERTS: PROTECTING & RESTORING STREAM CONTINUITY

Goal

To create no noticeable change in the stream at crossings including bridges, open-bottom arches and culverts that sufficiently span the stream channel; and box and pipe culverts that sufficiently span and are adequately sunk into the stream channel bed, and to make the crossings invisible to fish and wildlife.

Standards

Type:

- Bridges and bottomless arches: preferred and should be used whenever possible.
- Box and pipe culverts: secondary choice, if used follow:
  - Install culvert level
  - Use only on stream beds of 3 percent slope or less (“flat” streambeds)
  - Embed culvert to at least 20 percent of the culvert height at the downstream invert
  - Match stream slope within culvert
  - Embed upstream invert up to 40 percent culvert height

Width:

- Crossing opening size should be 1.25 the width of the stream channel bed. This is measured from bank to bank at the ordinary high water level (ohwl), which are the terrestrial, rooted vegetation edges.
- (3) average measurements should be used to determine the stream channel bed width: Minimum width locations:
  - Project location
  - Straight section upstream
  - Straight section downstream
- Measurement locations should be sufficient distances from the project location so that prior culvert issues are not reflected in the stream measurements. Additional measurements are recommended if great variances are observed.

Depth & Velocity:

- Depths and velocity should match that of the low flow condition and match the upstream and downstream natural areas.
- Substrate:
  - Stream bottoms should consist of natural substrate that matches the upstream and downstream conditions.
  - Stream bottom material must be able to resist displacement during floods.
  - Bottom material must be able to maintain normal flows

Other considerations:

When looking to replace a culvert and "right-size" the design, it is important to consider other portions of the stream.

- **Downstream:**
  When reviewing the replacement of a culvert, it is important to consider the receiving, immediate downstream culverts to determine if "right-sizing" of the culvert will achieve its goals of correcting the stream's ecosystem, or move drainage and flooding issues further down the stream and/or the watershed. It is necessary to determine if the crossing has been acting as a means of retaining the stream flow and excess runoff, and if so, locate the if and where any effects of the passing flow will be impacted.
- It is also important to determine if the right-sizing of a crossing will impact any existing wetlands that may have been created by the improper crossing structure. Designs would have to consider maintaining the wetland level while allowing free wildlife passage.
- **Upstream:**
  Evaluating the entire watershed contributing to the point of interest will help determine the estimated size of the crossing necessary to pass the required stream flow and fulfill the needs of the stream's ecosystem.
- **Location:**
  Evaluating the location and the crossing angle are important factors to consider; relocating a culvert or aligning the culvert to the flow of the stream can effectively improve the flow of the stream and reduce the potential for erosion on the stream banks and at the headwalls of the crossing.

Appendix 4 - Glossary

AASHTO
American Association of State Highway Transportation Officials

Acre–Foot
The quantity of water required to cover 1 acre to a depth of 1 foot and is equal to 43,560 cubic feet or about 326,000 gallons.

Algae
Microscopic, aquatic and (mostly) photosynthetic organisms that can live individually or form large groups, and can be unicellular or multicellular (like kelp).

Algal Blooms
Result of rapid growth of algae in a water body. Adding phosphorous and nitrogen into a body of water, increases the ability for the algae to reproduce substantially, a process referred to as eutrophication. This rapid growth allows the algae to cover the water's surface, shielding light from existing aquatic plants thereby causing these plants to either decrease growth and oxygen production, or die off. This decreases the available oxygen supply in the water. As algae grow they consume more oxygen, known as BOD, further decreasing the amount of oxygen in the water; causing animal life to reduce reproduction and/or die off. Algal blooms are often toxic or turn toxic when they die off, becoming even more harmful to both animals and humans.

Allowable Headwater Depth
The maximum depth of water impoundment for a drainage facility above which damage, some other unfavorable result, or a significant flood hazard could occur.

Apron
Protective layer placed on a streambed to prevent scour by a culvert or other drainage structure. More specifically, a floor lining of such things as concrete or rip-rap to protect a surface from erosion, such as the pavement below chutes, spillways, at the toes of dams, or at the outlet of culverts

Backfill
The material used to refill a ditch or other excavation, material placed adjacent to, or around a drainage structure, or the process of doing so.

Bacteria
In a storm water context, these are microorganisms that attach themselves to sediment and debris and are carried by stormwater runoff. Bacteria sources include illicit sanitary sewers connecting to storm sewers, sanitary waste overflow, animal wastes, and leaky septic systems. Bacteria, such as *Escherichia coli* (*E. coli*) and fecal coliform, are often a concern when addressing Total Maximum Daily Loads (TMLDs), of a body of water.

Bank
The side slopes of a channel between which the stream or river is normally confined.

Basin, Detention
A basin or reservoir incorporated into the watershed whereby runoff is temporarily stored, thus lowering the maximum flow of a watershed.

Berm
A narrow shelf or ledge; also a form of dike

Best Management Practices (BMP)
BMPs, when discussing stormwater management, are identified as practices, both structural and non-structural, that are used to treat or mitigate polluted runoff. BMPs are not a "one size fits all" approach; each practice must be specific for the physical attributes of a region within a municipality. For example, infiltration may not be a BMP in an area where the soils have a high content of silt or clay, or the water table is within 2-feet of the surface.

Better Site Design
Better Site Design incorporates non-structural and natural approaches to new and redevelopment projects. The goal is to reduce the impact of the site on the watershed through conservation of natural areas, reducing impervious surfaces and utilizing appropriate BMPs.

Bio-Accumulation
Accumulation of a toxin, such as heavy metals, over time through gradual buildup of the toxin. This bio-accumulated pollutant is then transferable to the next consumer; (i.e. fish to human).

Biochemical Oxygen Demand, or **BOD**
The amount of oxygen that is being consumed by micro-organisms during the decomposition of organic matter or the chemical oxidation of inorganic matter. The rate of oxygen consumption in water is dependent on multiple factors including the temperature, the pH, the number and kinds of consuming micro-organisms and the type and amount of organic material. The greater the BOD rate, the greater the rate of oxygen depletion within a water body. An excessive amount of organic and inorganic matter will result in increased micro-organism activity causing a greater demand for oxygen. This happens when sanitary waste water, septic overflows, animal wastes and other organics related to farming and urban settings enter into stormwater systems, streams, rivers, lakes and ponds.

Bio-Retention
Bio-retention areas trap and treat stormwater by allowing the water to flow through vegetation and soil. Bio-retention areas typically consist of (4) main layers: (1) Grass Buffer strip, (2) Organic/Mulch Layer, (3) Soil, (4) Plants; sand may also be added to provide aeration and drainage of planting soils. Engineered soils are used to improve the pollutant removal ability, for example the addition of clay to improve the adhesion of pollutants. Characteristics of bio-retention areas:

- 5 acre maximum contributing area
- Designed to capture and store Water Quality Volume (WQv): 1-yr 24-hour storm
- Rain gardens are small bio-retention areas (0.5 acre maximum contributing area)
- 1"/hr min. Infiltration Rate
- Minimum Surface Area 10 x 20 = 200 ft^2

- Maximum Slope for Construction = 6 percent
- Minimum depth to water table or impervious surface = 2 ft
- Runoff to completely pass through within 48 hours

Capacity
A measure of the ability of a channel or conduit to convey water.

Catch Basin
A structure, sometimes with a sump, for inletting drainage from such places as a gutter or median and discharging the water through a culvert. Also referred to as a "drop inlet"

Channel
The bed and banks that confine the flow of surface water in a natural stream or ditch.

Channel Lining
The material applied to the bottom and/or sides of a natural or man-made channel. Material may be concrete, sod, grass, rock, or any of the several other types of commercial linings.

Check Dam
A small barrier placed in a drainage way to reduce flow velocity. Reducing the flow velocity will reduce the potential for erosion, and allow sediment and pollutants to settle. It can be temporary or permanent. (See page 30).

Chlorides
The combination of chlorine and other elements such as sodium (NaCl), potassium (KCl), and magnesium (MgCl) to create a salt compound. Many of these salts are used for road stabilization and deicing.

Clay
Material passing through the No. 200 (0.074 mm) U.S. Standard Sieve that exhibits plasticity (putty-like properties) within a range of water contents and has considerable strength when air-dry (Unified Soil Classification System)

Clean Water Act
The Clean Water Act (CWA) is the name for legislation also known as the 1972 Federal Water Pollution Control Act and is the basis for the National Pollution Discharge Elimination System (NPDES) and the basic structure for regulating stormwater discharge from point sources. The NPDES, SPDES where states regulate, requires a permit for discharging pollutants in an effort to restore water quality. The Best Management Concept was also introduced. The Water Quality Act was further amended in 1987 and introduced the phased approach to addressing pollution.

Coefficient of Runoff
Coefficient of Runoff, or Runoff Coefficient, represents an approximate percentage of runoff that can be anticipated from a drainage area. The Runoff Coefficient is calculated using infiltration, evaporation, retention and interception values of an area. As such, the Runoff Coefficient varies due to soil types, vegetation types and densities, impervious surface coverage, etc.

Culvert
A structure used to convey surface runoff under such things as a highway or driveway. By definition, a structure of less than 20-foot span as measured along the road centerline is classified as a culvert. Typically prefabricated and available in standard sizes.

Cutoff Wall
A wall, collar, or other structure intended to reduce percolation of water along culvert sides.

D50 Stone Size
D50 stone size represents the median stone diameter in a well graded mixture of stones used for armoring and riprap where 50 percent of the stones are larger and 50 percent of the stones are smaller. When ordering RIPRAP the D50 size must be determined to identify the appropriate size required.

Debris
Any material transported by the stream, either floating or submerged, such as logs, brush, suspended sediment, bed load, or trash that may lodge against a structure.

Design Discharge
The maximum rate of flow (or discharge) for which a drainage facility is designed and thus expected to accommodate.

Design Storm
A rainfall event of a specific size and return frequency that is used to calculate runoff volume and peak discharge flow to size a culvert or determine the discharge rate to a BMP; they are based on historic rainfall data. It is NOT a measure of when a storm will appear; it is the potential for a rainfall event of a specific size and return frequency. For example, a 10-yr storm is a storm that has a 1/10 chance, or a 10 percent chance of occurring, a 25-year storm has a 1/25, or 4 percent chance of occurring; and a 100-year storm has a 1/100, or 1 percent, chance of occurring.

Detention
The retarding or holding back of stormwater runoff for a limited period of time to manage water quantity, while providing limited protection of water quality.

Dissolved Oxygen (DO)
The amount of oxygen present in the water. It is measured in milligrams per liter (mg/L).

End section
A structure, commonly made of concrete or metal, that is attached to the end of a culvert spilling into the waterway, improving the appearance, providing anchorage, improving the discharge coefficient, and limiting some scour.

Erosion
The process of slowly wearing away by water wind or other natural forces.

Erosion and Sediment Control Plan
A plan identifying the minimum erosion and sediment control practices and management techniques for a project site. Its goal is to prevent the discharge of pollutants from a project site. It can be stand alone for very small projects or part of the Stormwater Pollution Prevention Plan (SWPPP) necessary for compliance with the General Permit for Stormwater Activities from Construction Activities.

Erosion Control
The practice of preventing erosion by controlling the factors that contribute to it. Effective erosion control can prevent water, pollution and soil loss.

Eutrophication
An enrichment process due to elevated concentrations of nitrogen and phosphorous. As these nutrients enter into a water body, they “fertilize” the algae and phytoplankton into accelerated growth resulting in an Algal Bloom.

Evaporation
The process that converts water from its liquid form to its vapor form. As it relates to the water cycle, evaporation is the transfer of moisture from the land and water to the atmosphere.

FEMA
Federal Emergency Management Agency

Fertilizer
Plant food that combines the nutrients plants require to grow. Fertilizers consist of three primary nutrients: Nitrogen (N), Phosphorous (P) and Potassium (K); and several secondary nutrients: Sulfur (S), Calcium (Ca), Magnesium (Mg).

Filtration
The process of separating solids from a liquid.

Fines
Silts and clays. Material which pass through a #200 sieve.

Flood
An event that overflows the normal flow banks or runoff that has escaped from a channel or other surface waters. An overflow or inundation that comes from a river or other body of water and causes or threatens damage.

Flow Line
Line connecting the invert of the inlets and outlets of pipes.

General Permit for Stormwater Discharges from Construction Activity (GP 0-10-001)
This SPDES permit authorizes stormwater discharges to surface waters of a State from construction activities involving soil disturbances of one (1) or more acres; soil disturbances of less than one (1) acre where stormwater discharges have the potential for contributing to a violation of a water quality standard or where pollutants are discharged to a surface waters of the State; and where Construction Activities located in a critical or sensitive watershed involve a disturbance of between 5,000 square feet and 1 acre of land. Its goal is to maintain Water Quality.

MS4 General Permit (GP 0-10-002)
This SPDES General Permit authorizes discharges from small municipal storm sewer systems (MS4’s) provided all requirements are met.

Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activity (GP 0-12-001) (MSGP)
This SPDES General Permit covers discharges of stormwater to surface waters of a State from defined Industrial Activities.

Green Infrastructure
Refers to stormwater management practices that are intended to manage and treat stormwater runoff through a range of soil/water/plant systems that intercept, infiltrate and evaporate the runoff back into the ground or air.

Groundwater
Water found within pore spaces of the soil and fractures of rock. Subsurface water from which wells and springs are fed.

Headwall
The structure usually applied to the end of a culvert inlet and outlet or storm drain outlet to retain an adjacent highway embankment and protect the culvert ends and highway embankment from erosion and scour.

Headwater Depth
Depth of water above the inlet flow line at the entrance of a culvert or similar structure. Natural flow depth plus backwater caused by a drainage structure

Highwater Mark
A mark left as evidence of the height to which a flood reached; usually in the form of such things as deposited sediment, debris, and detritus.

Hydraulics
In highway drainage, the science addressing the characteristics of the flow of water in or through drainage facilities.

Hydrograph
A graph showing, the discharge, velocity or other property of water with respect to time. Hydrograph is also a graph showing the rate of water flow verses time as the flow passes a specific point in a stream river or other channel. The flow is measured in cubic feet per second (cfs).

Hydrologic Cycle (Water Cycle)
Represents the continuous movement of water above, on and below the earth's surface, changing physical states (liquid, vapor and ice) as it moves.

Hydrologic Soil Groups (HSG's)
Soil classifications which indicate rates of infiltration and permeability for soils of various groups. There are four (4) HSG's:

- Group A - high infiltration and permeability (0.30 in/hr or greater), characterized by low runoff rates;
- Group B - moderate infiltration and permeability rates (0.15-0.30 in/hr);

- Group C - low infiltration rates with moderate permeability (0.05-0.15 in/hr);
- Group D - very low infiltration and permeability rates (0.00-0.05 in/hr), characterized by high runoff rates

Hydrology
The science and study concerned with the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere, including precipitation, runoff, and groundwater.

Hyetograph
A graph showing the distribution rate of the rainfall of an area over time.

Hypoxia
The reduced oxygen content in a water body caused by algal blooms. This typically decreases the number and diversity of animal and vegetation populations in a body of water.

Heavy Metals
Toxic, metallic elements; most have high density, specific gravity and atomic weight. (Some examples: lead; mercury; iron; copper; chromium).

Harmful Algal Blooms (HAB)
Algal blooms that create toxins, such as that caused by blue-green algae. HABs can cause sickness in people who consume contaminated shellfish or breathe aerosolized HAB toxins. HAB events can cause the closing of shellfish beds, massive fish kills, death of marine mammals and seabirds and alter marine habitats.

Illicit Discharge
Refers to any discharge into a municipally owned storm sewer system that do not completely consist of stormwater runoff.

Infiltration
The process where water on the ground's surface enters into the soil.

Inlet Control
A condition where the relation between headwater elevation and discharge is controlled by the upstream end of any structure through which water may flow.

Inlet, Flared
A specially fabricated culvert end appurtenance at the inlet and outlet, or a special end feature of box culverts where the walls flare outward from the culvert sides at the culvert inlet and outlet. It serves to retain the roadway embankment.

Invert
The flow line in a channel cross section, pipe, or culvert.

Joint Application Permit
An application for permission or a determination to undertake activities affecting streams, waterways, waterbodies, wetlands, coastal areas and sources of water withdrawal. This application must be forwarded separately to each agency listed on the form as related to the activity proposed.

Land Use
How land is used or zoned for use. A term which relates to both the physical characteristics of the land surface and the human activities associated with the land surface.

Low Impact Development (LID)
The land planning and engineering design approach to manage stormwater runoff as close to the source as possible. This approach focusses on preserving and recreating natural landscape features and minimizing the impact of impervious surfaces.

Minimum Control Measures
Elements of the MS4 program that are implemented to increase public awareness and reduce the amount of pollutants discharged into receiving waters.

MS4's (Municipal Separate Storm Sewer System)
A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains: (i) designed or used for collecting or conveying stormwater; (ii) which is not a combined sewer; (iii) which is not part of a Publicly Owned Treatment Works (POTW). [Title 40, Code of Federal Regulations (CFR 40) SS 122.26(b)(8).] (Any open or closed pipes or ditches that carry runoff from rainwater or snowmelt [not sanitary sewer discharge])".

National Urban Runoff Program (NURP)
A study conducted from 1977 to 1983 to determine the sources and types of pollutants sourced from urban areas.

Non-Point Source Pollution (NPS)
Non-point source pollution comes from many diffuse sources, which are picked up by stormwater runoff and snowmelt and carried to receiving lakes, ponds, rivers, streams, and wetlands. Non-point pollutants include:

- Fertilizers, pesticides, insecticides
- Oil & grease
- Sediment from farms, streambanks, etc.
- Salt
- Bacteria and nutrients from animal wastes and septic systems

Stormwater is considered a non-point source due to its ability to pick up and gather pollutants

Nutrients
Chemical elements that every living organism needs to grow. Excessive nutrients, particularly nitrogen and phosphorous, in the environment can lead to rapid overgrowth of algae resulting in toxic algal blooms which can harm the environment and damage water quality.

Oil/Water Separator (OWS)
Devices that are used to separate oil and water, typically through gravity. An OWS is considered a secondary containment structure and should be sized and maintained as necessary to preserve efficiency. OWS are used to maintain compliance with SPCC requirements.

Organics
Matter from previously living organisms. The decay of organics in an aquatic environment consumes the dissolved oxygen required for aquatic life.

Outlet Control
A condition where the relation between headwater elevation and discharge is controlled by the conduit, outlet, or downstream conditions of any structure through which water may flow.

Oxygen Demand
Streams and rivers both consume and produce oxygen. Oxygen in water is produced from plants through photosynthesis and obtained from the atmosphere. Moving water is capable of holding more oxygen than still, because as it moves and mixes, oxygen is dissolved more readily. Oxygen in water is referred to as Dissolved Oxygen, (DO). This oxygen is consumed by animals living in the water, by the decomposition of organic material and by chemical reactions.

Peak Discharge
The highest value of the stage or discharge attained by a flood; thus, peak stage or peak discharge. Maximum discharge of a particular flood at a given pint along a stream.

Peak Flow
The maximum amount of runoff coming from a watershed at any one time.

Percolation
Movement of a liquid through a medium, e.g. stormwater through soil.

Pesticides
Substances used to eliminate pests.

pH
A measurement of how acidic or alkali (basic) water is. pH is measured on a scale of 0 14, with 7 being neutral. Water with a pH of less than 7 is acidic, and water with a pH over 7 is basic. Each unit of increase or decrease in the pH is a 10-fold difference; a pH of 6 is 10 times more acidic than a pH of 7 and a pH of 8 is 10 times more basic, or alkaline, than 7. Changes in the pH of a water body can be an indicator of increasing pollution and can dramatically affect aquatic life. pH affects the biological makeup and availability of nutrients and heavy metals, i.e., metals tend to be more toxic at a lower pH because they are more soluble. Normal rainfall has a pH of approximately 5.6, which is slightly acidic as a result of carbon dioxide in the atmosphere. Acid rain on the other hand is in the pH range of 1 to 5, and can be very harmful. Low pH can affect the hatching success of fish and insects; pH below 4 or above 10 is deadly to most fish and animals. Low pH affects the skin of amphibians, which makes them vulnerable to disease.

Pollution
The introduction of contaminants into a water body or the land. Pollution comes in many forms and when excessive can become hazardous to health.

Pollutant of Concern (POC)
Any pollutant that fit into the following categories:

- Technology-based Effluent Limit (TBEL).
- Waste Load Allocated (WLA)
- Total Maximum Daily Load (TMDL).
- Water Quality Based Effluent Limits (WQBEL).
- Monitoring Identified Pollutants.
- Anticipated Pollutants from a source discharge.

Phase I SPDES
Implemented in 1990, created the MS4 permitting system for municipalities of populations of 100k or greater, and construction projects disturbing more than 5-acres of land. Mandated stormwater discharges from cities and towns are classified as pollution point sources.

Phase II SPDES
Implemented in 1999, expanded the coverage of the MS4s to municipalities of populations 50K, population densities of 1,000 persons per square mile, and construction site disturbances greater than 1-acre.

Point Source Pollution
Pollution that comes from a single source such as a wastewater treatment plant or a factory.

Pollutant transfer
Refers to the mode of transport for a specific pollutant. There are several means that pollutants can be transported. Many of the pollutants such as phosphorous, chlorides, organic compounds, and much of the snow melt concentrations are water soluble, meaning that they dissolve in water and move with the runoff. Still many more attach themselves to other elements and are moved with that particle. Phosphorous can attach to soil particles and be carried off as erosion or can be dissolved into the stormwater and be carried with the runoff flow. Viruses and bacteria attach to sediment and litter for transfer. Sediment can become suspended in stormwater runoff and move quickly in swift moving waters. Sediment is typically released from the water when the velocity and energy of the runoff decreases, which diminishes the ability of runoff to carry pollutants. Sediment and the attached pollutants can also be carried by wind.

Precipitation
The total measurable supply of water received directly from clouds, as rain, snow, and hail.

Pretreatment
Pretreatment refers to subjecting runoff to an initial treatment method. Pretreatment of an infiltration practice typically consists of a vegetated area that serves to filter (treat) sediment out of runoff prior to entering into the main treatment practice.

Protection of Waters Permit
A permit that is required for disturbing the bed or the banks of a stream with a classification of AA, A or B, or with a classification of C with a standard of (T) or (TS) (disturbance may be temporary or permanent in nature).

Rain Garden
A small bio-retention area with a maximum contributing area of 0.5 acres. The same application parameters of bio-retention apply to Rain Gardens.

Rational Formula
An empirical equation for estimating the flood discharge given as Q = C*I*A, where Q = peak discharge, C = a runoff coefficient, I = rainfall intensity in inches per hour for a duration equal to the concentration time of the basin, and A = area of basin in acres. This formula is based on approximation that one in/hr/acre equals one cubic feet per second (cfs).

Revetment
Rigid or flexible armor placed on a bank or embankment as protection against scour and lateral erosion.

Rational Method
A simple technique for estimating the peak discharge from a small watershed. The Rational Method equation is as follows:

> Q = C*I*A
> Q is the peak discharge flow in cubic feet per second, C is the coefficient of Runoff, I is the rainfall intensity, and A is the drainage area in acres.

Retention
The ability to hold, or as with stormwater, the ability to hold excess runoff.

Right-Sizing Culverts
Refers to the practice of installing culverts large enough to pass the required flow while allowing the stream bottom to extend through the culvert to prevent restrictions and improve habitat continuity.

Riparian
As in Riparian Buffer, refers to the area between the used land and the body of water either a stream or a river. This area serves to naturally filter runoff prior to entering the water and provide shading for the stream or river, helping to maintain a cool water temperature.

Riparian Rights
The right of the owners of lands along a watercourse, relating to such things as water, its use, nad ownership of soil under the stream or river. The legal right of a riparian owner to use the water on his riparian land originated in the common law, which permitted him to require that the waters of a stream or river reach his land undiminished in quantity and unaffected in quality except for minor domestic uses.

Rip–Rap
Stones, masonry, or similar man-made material such as broken concrete placed in a loose assemblage along the banks and bed of a channel to inhibit erosion and scour.

River
Natural stream of water of considerable volume.

Roadside
A general term denoting the area adjoining the outer edge of the roadway.

Rock Vane
A physical barrier placed in and along a stream at designated locations to direct stream flow to the center of the channel.

Roughness Coefficient
Numerical measure of the frictional resistance to flow in a channel.

Runoff
The portion of precipitation that appears as flow in streams; total volume of flow of a stream during a specified time.

Runoff Coefficient
A factor representing that percentage of rainfall which reaches a drainage location. Dependent on terrain and topography.

Sand
Soil material that can pass the No.4 (4.76mm) U.S. Standard Sieve and be retained on the No.200 (0.074 mm) sieve.

Scour
The displacement and removal of channel bed or other material due to flowing water, usually considered as being localized.

Section 402(p) (WQA)
Section 402 of the Water Quality Act, addresses the National Pollution Discharge Elimination System (NPDES), which requires a permit to discharge pollutants into the waters of the United States.

Sediment
Solid material that settles to the bottom of a liquid. Sediment in stormwater can include soils and rocks that have been eroded and have entered and been carried by a body of water.

Sediment Basin
A pond-like structure that is designed to capture eroded or disturbed soil that is washed off during a rain event. They are used to capture the runoff, slow it down and allow the suspended solids within the water to settle out. They can be temporary or permanent.

Shoulder
The portion of the roadway contiguous with the traveled way for accommodating stopped vehicles, for emergency use, and for lateral support of the road's base and surface courses.

Silt
Material passing the No. 200 (0.074 mm) U.S. Standard Sieve that is nonplastic or very slightly plastic and exhibits little or no strength when air–dried (unified Soil Classification System).

Slope
A measure of the steepness of a bank or terrain. Usually expressed as a ratio of one unit of rise to a given number of units of run or horizontal distance. As an example, a 1:2 slope rises 1 foot for every 2 feet of run.

Soil
Finely divided material composed of disintegrated rock mixed with organic matter; the loose surface material in which plants grow.

Spill Prevention
The practice of eliminating spills and the impacts associated with them.

Spill Prevention, Containment and Control (SPCC)
Regulations that are focused on preventing oil from entering navigable waters of the United States.

Spray Adhesives
Products that are mixed with water and sprayed on the soil surface to reduce dust, similar to hydroseeding without the seed.

Stabilization
As related to stormwater it refers to the steps of securing surface soils, embankments and stream banks.

State Pollution Discharge Elimination System (SPDES)
The State program approved by the EPA for the control of wastewater and stormwater discharges in accordance with the Clean Water Act.

Stream
A general term for a body of flowing water.

Stream Disturbance Permit
(See Joint Application Permit).

Stormwater
Defined as any amount of precipitation that is not absorbed by the soil and vegetation, trapped in ponds, lakes or rivers, or evaporates directly back into the atmosphere.

Stormwater Management Plan (SWMP)
A documented plan that focuses on managing stormwater for flood protection, water quantity and quality improvement. Each SWMP is specific to the region or area in which it represents. It identifies BMPs that may achieve these goals taking into consideration soils, slopes, pollutants, etc.

Stormwater Outfall
A discharge point where stormwater runoff or point sources discharge into a body of water. MS4's require identification, mapping and sampling of stormwater outfalls to determine and verify presence and level of contaminants in the discharged water.

Stormwater Pollution Prevention Plan (SWPPP)
A site specific document that identifies potential stormwater pollution sources, describes the mitigation steps to reduce the discharge of pollutants in stormwater discharges, and identifies the procedures that will be taken to comply with the construction permit.

SWPPP Acceptance Form
This is a form used by regulated, traditional land use control MS4's (ie: town, city, village, etc.) to indicate acceptance of a SWPPP that it has reviewed. This form must be submitted with final plans to the NYSDEC for final approval.

Stream Density
A measure of the amount of stream length to a given area. Mathematically it is:

Stream Density = Total Length of Streams/Total area of Consideration.

Swale
A wide, shallow ditch usually grassed or paved and without well-defined bed and banks. A slight depression in the ground surface where water collects, and which may be transported as a stream.

Time of Concentration (TOC)
The concept used in hydrology to measure the response of a watershed to a rain event. Specifically TOC is defined as the time it takes a drop of water to travel from the most distant point in a watershed to a point of concern where the peak flow information is needed.

Topography
Here refers to the geographic characteristics of height, shape and slope of the terrain of a watershed.

Total Maximum Daily Loads (TMLDs)
The calculated maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDLs are often implemented when the receiving waters' pollutant content exceed water quality standards.

Total Suspended Solids (TSS)
Refers to all particles suspended in water that will not pass through a filter.

Technical Release 55 (TR-55)
A simplified procedure to calculate storm runoff volume, peak discharge flows, hydrographs and storage volumes in small watersheds.

Transpiration
The process in which moisture moves from the ground through the plant and is released into the atmosphere as a vapor.

Turbidity
A measure of water clarity, the higher the turbidity the cloudier the water.

Velocity, Permissible
The highest velocity at which water may be carried safely in a channel or other conduit without channel bed scour or bank erosion.

Viruses
Small toxic agents that can only replicate inside of the cells of other organisms.

Water Quality Act
The Water Quality Act was signed into legislation in 1965 and focused on preventing water pollution by requiring states to establish and enforce water quality standards for interstate waterways.

Watershed
Defined by the NYSDEC as an “area of land that drains into a body of water”. We all live in a watershed.

Watershed Management
The study of the physical and chemical characteristics of a watershed to manage water supply, water quality, drainage, stormwater runoff, water rights and develop and maintain planning to sustain and improve the entire watershed.

Water Soluble
A substance that is able to dissolve in water.

Well Aggregated Soil
A well-mixed soil that includes all sizes of aggregate within the specified size limits of the material.

Well-graded Aggregate
An aggregate that includes a consistent mixture of a material that consists of all sizes from the minimum to the maximum as specified in the material description, to fill most of the voids in the material.

Appendix 5 - Bibliography

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Construction Stormwater Manual, NYSDEC, August 2007. *www.dec.ny.gov/docs/water_pdf/inspectman.pdf*

Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads, USDA Forest Service, 7700-Transprortation Management 1177 18-2-SDTDC, April 2012

Erosion Control Treatment Selection Guide, USDA Forest Service, December 2006

Erosion and Sediment Pollution Control Program Manual, Technical Guidance 363-2134-008, Pennsylvania Department of Environmental Protection Bureau of Waterways Engineering and Wetlands, March 2012.

Georgia Stormwater Management Manual: Volume 1 Stormwater Policy Guidebook, Atlanta Regional Commission, August 2001

Georgia Stormwater Management Manual: Volume 2 Technical Handbook, Atlanta Regional Commission, August 2001

Georgia Stormwater Management Manual: Volume 3 Pollution Prevention Guidebook, Atlanta Regional Commission, August 2001

Good Housekeeping and Pollution Prevention on Our Roadways Tech Tip, Cornell Local Roads Program, Technical Assistance On-line, *www.clrp.cornell.edu/tip_sheets/pdf/pollution.pdf*

Hydrologic Soil Groups: NRCS NY (USDA), *www.nrcs.usda.gov/wps/portal/nrcs/detail/ny/soils/?cid=nrcs144p2_027279*

Hydrology, FHWA-IP-84-15

Highway Superintendents Roads and Water Quality Handbook, Edition II, Cornell Cooperative Extension & Natural Resources Conservation Services of Steuben County, Steuben and Yates County Soil & Water Conservation Districts, March 1996

Municipal Stormwater Best Management Practices Handbook, California Stormwater Quality Association, 2003, *www.casqa.org/resources/bmp-handbooks/municipal-bmp-handbook*

MS4 Stormwater Compliance for Municipal Planning Boards, ppt by Kathleen Bertuch, CNY Regional Planning and Development Board

NACE Action Guide Volume III-5: Stormwater Management & Drainage, 2000

New Hampshire Stormwater Manual Volume 1: Stormwater and Antidegradation, December 2008

New Hampshire Stormwater Manual Volume 2: Post-Construction Best Management Practices Selection and Design, December 2008

New Hampshire Stormwater Manual Volume 3: Erosion and Sediment Controls During Construction, December 2008

New York Contractors Field Notebook for Erosion and Sediment Control, Empire State Chapter of the Soil and Water Conservation Society/NYSDEC Division of Water Quality Management

New York State Department of Environmental Conservation (NYSDEC): *www.dec.ny.gov*

NYSDOT Adaptation to Climate Change: Green Stormwater Management for Communities across NYS

New York State Standards and Specifications for Erosion and Sediment Control (Blue Book), NYSDEC Division of Water, August 2005, *www.dec.ny.gov/chemical/29066.html*

New York State Stormwater Management Design Manual, NYSDEC, August 2010, *www.dec.ny.gov/chemical/29072.html*

Pennsylvania Stormwater Best Management Practices Manual, Pennsylvania Department of Environmental Protection Bureau of Watershed Management, December 2006

Post Flood Emergency Stream Intervention Training Manual, Delaware County Soil and Water Conservation District, Delaware County Planning Department and the New York City Department of Environmental Protection Bureau of Water Supply Stream Management Program, 2011, *www.dec.ny.gov/docs/administration_pdf/streammnll.pdf*

Preparing and Planning for Storms and Floods, Training Session for Local Governments and Highway Officials Manual, March 1998

Roadside Ditches: Best Management Practices to Reduce Floods, Droughts, and Water Pollution, Department of Natural Resources, Cornell University, September 2010

Roadway and Right-of-Way Maintenance Management Practices for Non-Point Pollution Prevention and Water Quality in New York State, NYSDEC, May 1997

Roadway and Roadside Drainage, Cornell Local Roads Program, David Orr, PE, February 2003.

Stormwater Management Guidance Manual for Local Officials, Construction and Post-Construction Runoff Management, NYSDEC, September 2004.

Stream Process: A Guide to Living In Harmony with Streams, Chemung County Soil & Water Conservation District, August 2006.

USDA NRCS 24-Hour Rainfall Data, NYSDEC Blue Book (New York Standards and Specifications for Erosion and Sediment Control)

VIDEOS

Contact Cornell Local Roads Program to borrow the following videotapes:

- *Erosion Control*, Erosion Control Technology Council
- *Stormwater Pollution Prevention for Construction Sites, Ground Control* (DR 424)
- *Soil Erosion and Sediment Control* (DR 201)
- *Stormwater Management* (DR417)

Appendix 6 - Contacts

American Association of State Highway and Transportation Officials (AASHTO)
444 N. Capital Street, NW (Suite 249)
Washington, D. C. 20001
(202) 624-5800
www.transportation.org/Pages/default.aspx

American Public Works Association (APWA)
Kansas City, MO
(816) 472-6100
www.apwa.net

American Road and Transportation Builders Association (ARTBA)
The ARTBA Building
1219 28th Street
NW Washington, DC 20007-3389
(202) 289-4434
www.artba.org

Association of Towns
50 State Street
Albany, NY 12207
(518) 465-7933
http://nytowns.org

Better Roads Magazine
(Subscription free to public works officials)
3200 Rice Mine Road
Tuscaloosa, AL 35406
(800) 633-5953
www.betterroads.com

Cornell Local Roads Program
416 Riley-Robb Hall
Cornell University
Ithaca, NY 14853-5701
(607) 255-8033
www.clrp.cornell.edu

Center for Watershed Protection
8390 Main Street, Second Floor
Ellicott City, MD 21043-4605
(410) 461-8323
http://cwp.org

Department of Environmental Conservation
625 Broadway
Albany, NY 12233-4500
(518) 402-8013
www.dec.ny.gov

Dig Safely New York
5063 Brittonfield Parkway
East Syracuse, NY 13057
Stakeout request: (800) 962-7962 or 811
LI/NYC Stakeout Requests: (800) 272-4480
www.digsafelynewyork.com

International Erosion Control Association
www.ieca.org/regiononehomepage.asp

National Association of County Engineers (NACE)
25 Mass. Ave, NW Suite
580 Washington, D.C. 20001
(202) 393-5041
www.countyengineers.org

New York State Association of Town Superintendents of Highways, Inc.
12 Sheridan Ave.
Albany, NY 12207
(518) 729-2483
www.nystownhwys.org

New York State Conference of Mayors and other Municipal Officials (NYCOM)
119 Washington Avenue
Albany, NY 12210
(518) 463-1185
http://nycom.org

New York State County Highway Superintendents' Association
136 Everett Road
Albany, NY 12205
(518) 465-1694
www.countyhwys.org

Public Works Magazine
(Free to public works officials)
8725 W. Higgins Road, Suite 600
Chicago, IL 60631
(773) 824-2400
www.pwmag.com

Roads and Bridges Magazine
(Subscription free to public works officials)
3030 W. Salt Creek Lane, #201
Arlington Heights, IL 60005
(847) 391-1036
www.roadsbridges.com

StreamStats
(Web based stream flow calculation tool)
http://water.usgs.gov/osw/streamstats

USGS Natural Resources Conservation Service
(USDA) NY Office
441 South Salina Street, Suite 354
Syracuse, NY 13202-2450
(315) 477-6560
www.nrcs.usda.gov/wps/portal/nrcs/site/ny/home

Web Soil Survey (WSS)
http://websoilsurvey.nrcs.usda.gov/app

Federal Emergency Management Agency (FEMA)
Region II
26 Federal Plaza
New York, NY 10278-0002
(212) 280-3600
FEMA-R2-ExternalAffairs@fema.dhs.gov

New York State Emergency Management Association
http://nysema.org/index.html

ARMY CORPS OF ENGINEERS
Regulatory Offices/Permits

New York District Office: Eastern Counties:
(NYSDEC Regions: 1, 2, 3, 4, 5)
Jacob K. Javits Federal Building
26 Federal Plaza, Room 2109
New York, NY 10278-0090
(917) 790-8411

Eastern Upstate Field Office
1 Buffington Street
Watervliet, NY 12189-4000
(518) 266-6350

Buffalo District Office: Western Counties
(NYSDEC Regions: 6, 7, 8, 9)
1776 Niagara Street
Buffalo, NY 14207
(716) 879-4330

Western Auburn Field Office
7413 County House Road
Auburn, NY 13021
(315) 255-8090

NYS SOIL AND WATER CONSERVATION DISTRICTS

NYS Soil and Water Conservation Committee
(518) 457-3738
www.agriculture.ny.gov/soilwater/contacts/county_offices.html

Albany	(518) 765-7923
Allegany	(585) 268-5840
Broome	(607) 724-9268
Cattaraugus	(716) 699-2326 (716) 699-2327
Cayuga	(315) 252-4171 (315) 252-0793
Chautauqua	(716) 664-2351 ext. 5
Chemung	(607) 739-4392 (607) 739-2009
Chenango	(607) 334-4632 (607) 334-8634
Clinton	(518) 561-4616 ext. 3
Columbia	(518) 828-4386 (518) 828-4385
Cortland	(607) 756-5991 ext.3
Delaware	(607) 865-7161 (607) 865-7162
Dutchess	(914) 677-8011 (914) 677-8199
Erie	(716) 652-8480 (716) 652-8830
Essex	(518) 962-8225
Franklin	(518) 483-4061 ext. 5
Fulton	(518) 762-0077 ext. 3
Genesee	(716) 343-2362
Greene	(518) 622-3620
Hamilton	(518) 548-3991
Herkimer	(315) 866-2520 ext. 3
Jefferson	(315) 782-2749 (315) 786- 0486
Lewis	(315) 376-6122
Livingston	(585) 283-0043
Madison	(315) 824-9849 (315) 824-9073
Monroe	(585) 753-7380
Montgomery	(518) 853-4015
Nassau	(516) 364-5860
New York City	(212) 431-9676
Niagara	(716) 434-4949 ext. 4
Oneida	(315) 736-3334 (315) 736-3335
Onondaga	(315) 457-0325
Ontario	(585) 396-1450 (585) 396-1455
Orange	(845) 343-1873
Orleans	(585) 589-5959 (585) 589-6504
Oswego	(315) 592-9663
Otsego	(607) 547-8337 ext. 4
Putnam	(845) 878-7918
Rensselaer	(518) 271-1740 (518) 271-1764
Rockland	(845) 364-2670
St. Lawrence	(315) 386-3582 (315) 386-2401
Saratoga	(518) 885-6900 ext. 3
Schenectady	(518) 399-6980 (518) 399-5040
Schoharie	(518) 295-8811 (518) 295-8600
Schuyler	(607) 535-9650
Seneca	(315) 568-4366 (315) 568-6346
Steuben	(607) 776-7398 ext. 3
Suffolk	(631) 727-2315 ext. 3
Sullivan	(845) 292-6552 ext. 101
Tioga	(607) 687-3553 (607) 687-2240
Tompkins	(607) 257-2340
Ulster	(845) 883-7162 ext. 5
Warren	(518) 623-3119
Washington	(518) 692-9940 ext. 3
Wayne	(315) 946-4136 (315) 946-4137
Westchester	(914) 995-4407 (914) 995-4423
Wyoming	(585) 786-5070
Yates	(315) 536-5188

Appendix 7 - Minimum Control Measures

MCM #1: Public Education and Outreach

- Identify pollutants, water bodies & geographic areas of concern
- Identify target audience
- Develop and implement public education and outreach

MCM #2: Public Involvement and Participation

- Comply with State Open Meetings Law
- Comply with public notice requirements
- Develop and implement a public Involvement/participation program
- Identify a local stormwater contact; Include on outreach and participation materials
- Publicly present annual report with prior public notice
- Annual report to:
    - Include responses to comments
    - Be made available to the public with Stormwater Management Plan

MCM #3: Illicit Discharge Detection and Elimination

- Develop implement and enforce a program to detect and eliminate illicit discharges
- Map storm sewer shed and outfalls
- Field verify outfalls
- Conduct outfall inventory
- Prohibit illicit discharges
- Public notification of hazards of illicit discharges
- Adopt and enforce law to prohibit illicit discharges
- Adopt available mechanisms to prohibit illicit discharges

MCM #4: Construction Site Runoff Control

- Develop, implement and enforce a program equivalent to the GP for Stormwater Discharges from Construction Activity (*GP-0-10-001*)
- Implement local law equivalent to the NYS DEC Sample Local Law for Stormwater Management and Erosion and Sediment Control
- Apply to extents of municipal boundary
- Document/certify equivalence of local law
- Require SWPPPs to meet current NYS DEC Erosion and Sediment Control Technical standards
- Require construction site operators to implement current NYS DEC Erosion and Sediment Control technical standards
- Develop procedures for SWPPP review and the issuance of SWPPP Acceptance Form
- Implement site inspections and enforcement
- Require a complete site construction waste management program

- Educate construction site owner/operators about the MS4’ss construction stormwater requirements
- Ensure construction site owners/operators receive erosion and sediment control training
- Maintain an inventory of active construction sites

MCM #5: Post-Construction Stormwater Management

- Develop, implement and enforce a program equivalent to the GP for Stormwater Discharges from Construction Activity (*GP-0-10-001*)
- Implement local law equivalent to the NYS DEC Sample Local Law for Stormwater Management and Erosion and Sediment Control
- Apply to extents of municipal boundary
- Document/certify equivalence of local law
- Include structural and non-structural management practices
- Ensure long-term operation and maintenance of post-construction stormwater management practices
- Provide adequate resources for inspection and enforcement
- Educate Town Boards, Planning and Zoning Boards on LID, BSD & GI infrastructure requirements

MCM #6: Pollution Prevention and Good Housekeeping of Municipal Operations

- Develop and implement a pollution prevention program that addresses operations and facilities that contribute Pollutants of Concern (POC) to the MS4
- Assess all operations addressed by the SWMP every three years
- Employee Pollution Prevention Training
- Require third party contractors to certify that the services/activities they perform meet the requirements of the MS4 General Permit
- Require operations and facilities otherwise subject to NYS Multi-Section General Permit (MSGP) to prepare and implement provisions in the SWMP that comply with Parts III,A, C, D, J, K, L and Part IV of the MSGP
- Street maintenance
- Bridge maintenance
- Winter road maintenance
- Salt storage
- Solid waste management
- New municipal construction and land disturbance
- Right of way maintenance
- Marine operations
- Hydraulic habitat modification
- Parks and open space
- Municipal buildings
- Stormwater system maintenance
- Vehicle and fleet maintenance

Appendix 8 - Roles and Responsibilities

MUNICIPAL OFFICIALS & DEPARTMENTS

The roles identified are responsibilities that are required of municipal officials within an MS4. However, this does not mean that the implementation of practices and responsibilities listed below can only be done by an MS4. Developing and following the practices that directly apply to a municipality, although not required by designation, should be considered to better address the issues related to that municipality.

- **Planning Boards:**
  - Construction Site Runoff Control and Post-Construction Stormwater Management (MCM #4 and MCM #5)“Administrative Review” of Stormwater Pollution Prevention Plans (SWPPPs) submitted by developers for construction projects (checks to verify all components are present)
  - Can rely on recommendations of PE to provide technical aspects
    - SWPPP Completeness Checklist developed by NYSDEC is available from Regional Division of Water
    - Municipality provides SWPPP Acceptance Form to Developer or engineer to submit along with SWPPP to NYSDEC for final review.
      - Developer must also apply for coverage under the SPDES General Permit for Stormwater Discharges from a Construction Activity (GP-0-10-001)
      - Planning Board must complete the MS4 SWPPP Acceptance Form for the project to receive State coverage under GP-0-10-001
        - Developer is responsible for submitting the MS4 SWPPP Acceptance form to the NYSDEC, it is not the municipality’s responsibility to do this
      - Issue approvals for compliant SWPPPs
      - Include and encourage Public Involvement and Participation (MCM #2)
        - Citizens have opportunity to comment on development proposals
      - Planning boards take public input into account in their review

- **Code Enforcement Officers:**
  - Construction Site Runoff Control and Post-Construction Stormwater Management (MCM #4 and MCM #5)
    - Site Inspections during construction
    - Issue violations notices, enforcement actions
  - Illicit Discharge Detection and Elimination (MCM #3)
    - Identify illicit connections to the drainage system and eliminate through voluntary compliance or enforcement action
  - Public Involvement and Participation (MCM #2)
    - Response to complaints regarding polluted runoff or discharges, flooding and drainage concerns
- **Highway Departments:**
  - Illicit Discharge Detection and Elimination (MCM #3)

        - Monitor dry-weather flows from stormwater outfalls
  - Pollution Prevention and Good Housekeeping (MCM #6)
    - Conduct day-to-day operations so as to minimize pollution
    - Document and quantify activities such as street sweeping, catch basin cleaning, deicer application, fleet maintenance
    - Train all staff in pollution prevention
  - Post-Construction Stormwater Management (MCM #5)
    - Maintenance of ponds and other stormwater practices
  - Public Involvement and Participation (MCM #2)
    - Response to resident complaints (flooding, drainage, etc.)