CHAPTER

1

THE NEED FOR STORMWATER QUALITY MANAGEMENT

1.1 Impacts of Development and Stormwater Runoff

Land development changes not only the physical, but also the chemical and biological conditions of Tennessee's streams. This chapter describes the changes that occur due to development and the resulting stormwater runoff impacts.

1.1.1 Development Changes Land and Runoff

When land is developed, the hydrology, or the natural cycle of water is disrupted and altered. Clearing removes the vegetation that intercepts, slows and returns rainfall to the air through evaporation and transpiration. Grading flattens hilly terrain and fills in natural depressions that slow and provide temporary storage of stormwater runoff. The topsoil and sponge-like layers of decaying leaves and other organic materials are scraped and removed and the remaining subsoil is compacted. Rainfall that once soaked into the ground now runs off the surface. The addition of buildings, roadways, parking lots and other surfaces that are impervious to rainfall further reduces infiltration and increases runoff.

Depending on the magnitude of changes to the land surface, the total runoff volume can increase dramatically. These changes not only increase the total volume of runoff, but also accelerate the rate at which runoff flows across the land. This effect is further exacerbated by drainage systems such as gutters, storm sewers and lined channels that are designed to quickly carry runoff to rivers and streams.

Development and impervious surfaces also reduce the amount of water that infiltrates into the soil and groundwater, thus reducing the amount of water that can recharge aquifers and feed streamflow during periods of dry weather.

Finally, development and urbanization affect not only the quantity of stormwater runoff, but also its quality. Development increases both the concentration and types of pollutants carried by runoff. As it runs over rooftops and lawns, parking lots and industrial sites, stormwater picks up and transports a variety of contaminants and pollutants to downstream waterbodies. The loss of the original topsoil and vegetation removes a valuable filtering mechanism for stormwater runoff.

The cumulative impact of development and urban activities, and the resultant changes to both stormwater quantity and quality in the entire land area that drains to a stream, river, lake or estuary determines the conditions of the waterbody. This land area that drains to the waterbody is known as its *watershed*. Urban development within a watershed has a number of direct impacts on downstream waters and waterways. These impacts include:

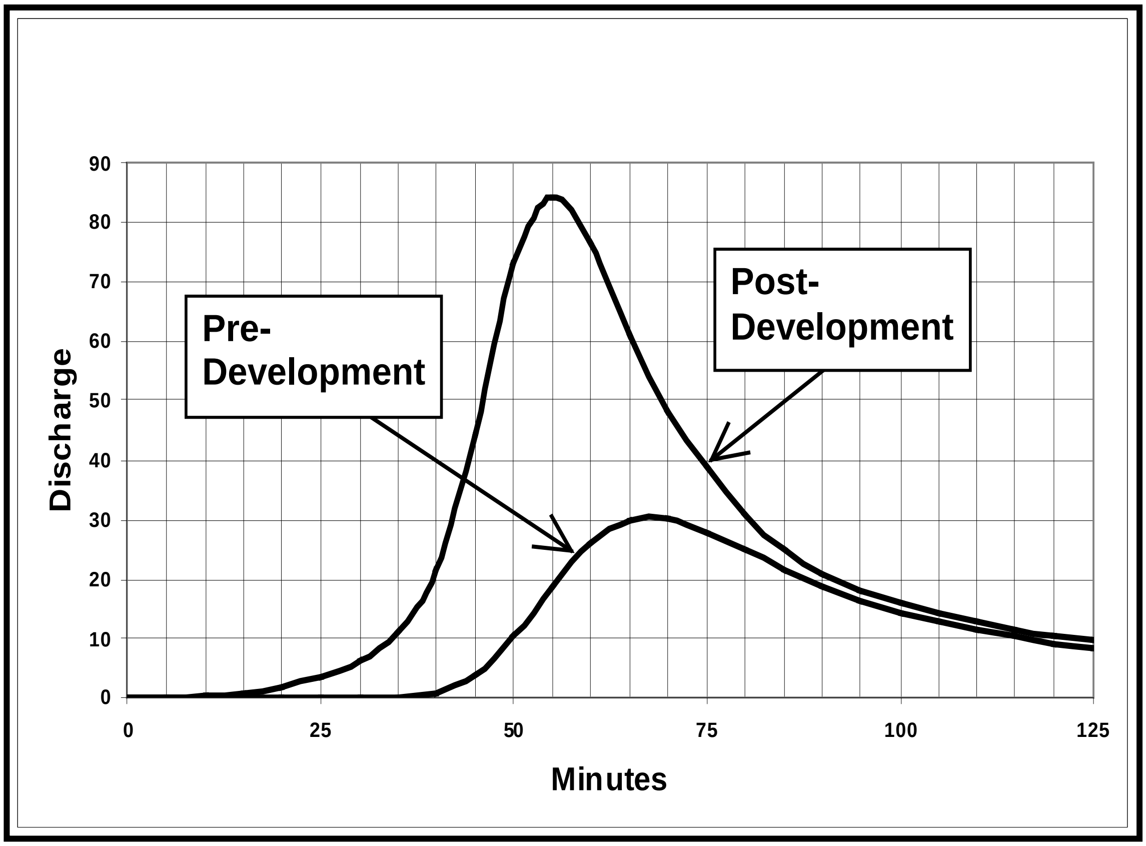
- Changes to stream flow;
- Changes to stream geometry;
- Degradation of aquatic habitat; and,
- Water quality impacts.

1.1.2 Changes to Stream Flow

Urban development alters the hydrology of watersheds and streams by disrupting the natural water cycle. This results in:

- Increased Runoff Volumes – Land surface changes can dramatically increase the total volume of runoff generated in a developed watershed.
- Increased Peak Runoff Discharges – Increased peak discharges for a developed watershed can be two to five times higher than those for a watershed prior to development. This is depicted in Figure 1-1.
- Greater Runoff Velocities – Impervious surfaces and compacted soils, as well as improvements to the drainage system such as storm drains, pipes and ditches, increase the speed at which rainfall runs off land surfaces within a watershed.
- Timing – As runoff velocities increase, it takes less time for water to run off the land and reach a stream or other waterbody.
- Increased Frequency of Bankfull and Near Bankfull Events – Increased runoff volumes and peak flows increase the frequency and duration of smaller bankfull and near bankfull events which are the primary channel forming events.
- Increased Flooding – Increased runoff volumes and peaks also increase the frequency, duration and severity of out-of-bank flooding.
- Lower Dry Weather Flows (Baseflow) – Reduced infiltration of stormwater runoff causes streams to have less baseflow during dry weather periods and reduces the amount of rainfall recharging groundwater aquifers.

Figure 1-1. Runoff Hydrograph under Pre-and Post-Development Conditions



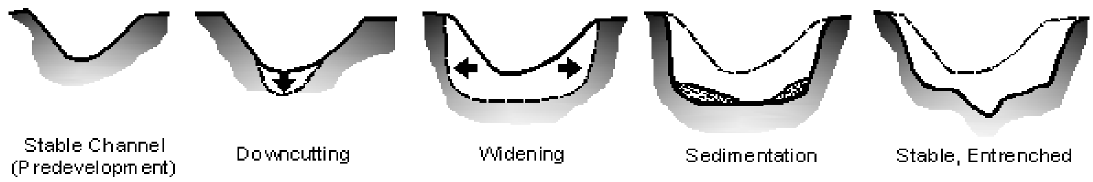
1.1.3 Changes to Stream Geometry

The changes in the rates and amounts of runoff from developed watersheds directly affect the morphology, or physical shape and character, of Tennessee's creeks and streams. This is depicted graphically in Figure 1-3. Some of the impacts due to urban development include:

- Stream Widening and Bank Erosion – Stream channels widen to accommodate and convey the increased runoff and higher stream flows from developed areas. More frequent small and moderate runoff events undercut and scour the lower parts of the streambank, causing the steeper banks to slump and collapse during larger storms. Higher flow velocities further increase streambank erosion rates. A stream can widen many times its original size due to post-development runoff. The photo in Figure 1-2 shows a good example of bank erosion.
- Stream Downcutting – Another way that streams accommodate higher flows is by downcutting their streambed. This causes instability in the stream profile, or elevation along a stream's flow path, which increases velocity and triggers further channel erosion both upstream and downstream.
- Loss of Riparian Tree Canopy – As streambanks are gradually undercut and slump into the channel, the trees that had protected the banks are exposed at the roots. This leaves them more likely to be uprooted during major storms, further weakening the bank structure.
- Changes in the Channel Bed Due to Sedimentation – Due to channel erosion and other sources upstream, sediments are deposited in the stream as sandbars and other features, covering the channel bed, or substrate, with shifting deposits of mud, silt and sand.
- Increase in the Floodplain Elevation – To accommodate the higher peak flow rate, a stream's floodplain elevation typically increases following development in a watershed due to higher peak flows. This problem is compounded by building and filling in floodplain areas, which cause flood heights to rise even further. Property and structures that had not previously been subject to flooding may now be at risk.

Figure 1-2. Example of Significant Streambank Erosion

Figure 1-3. Physical Stream Changes Due to Watershed Development



1.1.4 Impacts to Aquatic Habitat

Along with changes in stream hydrology and morphology, the habitat value of streams diminishes due to development in a watershed. Impacts on habitat include:

- Degradation of Habitat Structure – Higher and faster flows due to development can scour channels and wash away entire biological communities. Streambank erosion and the loss of riparian vegetation reduce habitat for many fish species and other aquatic life, while sediment deposits can smother bottom-dwelling organisms and aquatic habitat.
- Loss of Pool-Riffle Structure – Streams draining undeveloped watersheds often contain pools of deeper, more slowly flowing water that alternate with "riffles" or shoals of shallower, faster flowing water. These pools and riffles provide valuable habitat for fish and aquatic insects. As a result of the increased flows and sediment loads from urban watersheds, the pools and riffles disappear and are replaced with more uniform, and often shallower, streambeds that provide less varied aquatic habitat.
- Decline of Abundance and Biodiversity – When there is a reduction in various habitats and habitat quality, both the number and the variety, or diversity, of organisms (wetland plants, fish, macroinvertebrates, etc.) are also reduced. Sensitive fish species and other life forms disappear and are replaced by those organisms that are better adapted to the poorer conditions. The diversity and composition of the benthic, or streambed, community have frequently been used to evaluate the quality of urban streams. Aquatic insects are a useful environmental indicator as they form the base of the stream food chain.

Fish and other aquatic organisms are impacted not only by the habitat changes brought on by increased stormwater runoff quantity, but are often also adversely affected by water quality changes due to development and resultant land use activities in a watershed.

1.1.5 Water Quality Impacts

Nonpoint source pollution, which is the primary cause of polluted stormwater runoff and water quality impairment, comes from many diffuse or scattered sources, many of which are the result of human activities within a watershed. Development concentrates and increases the amount of these nonpoint source pollutants. As stormwater runoff moves across the land surface, it picks up and carries away both natural and human-made pollutants, depositing them into streams, rivers, lakes, wetlands, and groundwater. Nonpoint source pollution is the leading source of water quality degradation in northeast Tennessee. According to the State of Tennessee's list of impaired waters, sediment and habitat alteration are considered two major pollutants for streams in northeast Tennessee.

Water quality degradation in urbanizing watersheds starts when development begins. Erosion from construction sites and other disturbed areas contribute large amounts of sediment to streams. As construction and development proceed, impervious surfaces replace the natural land cover and pollutants from human activities begin to accumulate on these surfaces. During storm events, these pollutants are then washed off into the streams. Stormwater also causes discharges from sewer overflows and leaching from septic tanks. There are a number of other causes of nonpoint source pollution in urban areas that are not specifically related to wet weather events including leaking sewer pipes, sanitary sewage spills, and illicit discharge of commercial/industrial wastewater and wash waters to storm drains.

Due to the magnitude of the problem it is important to understand the nature and sources of urban stormwater pollution. Table 1-1 summarizes the major stormwater pollutants and their effects. Some of the most frequently occurring pollution impacts to urban streams and their sources are:

- Reduced Oxygen in Streams – The decomposition process of organic matter uses up dissolved oxygen (DO) in the water, which is essential to fish and other aquatic life. As organic matter is washed off by stormwater, dissolved oxygen levels in receiving waters can be rapidly depleted. If the DO deficit is severe enough, fish kills may occur and stream life can weaken and die. In addition, oxygen depletion can affect the release of toxic chemicals and nutrients from sediments deposited in a waterway.

  All forms of organic matter in urban stormwater runoff such as leaves, grass clippings and pet waste contribute to the problem. In addition, there are a number of non-stormwater discharges of organic matter to surface waters such as sanitary sewer leakage and septic tank leaching.

- Microbial Contamination – The level of bacteria, viruses and other microbes found in urban stormwater runoff often exceeds public health standards for water contact recreation such as swimming and wading. Microbes can also contaminate shellfish beds, preventing their harvesting and consumption, as well as increasing the cost of treating drinking water. The main sources of these contaminants are sewer overflows, septic tanks, pet waste, and urban wildlife such as pigeons, waterfowl, squirrels, and raccoons.

Table 1-1. Major Stormwater Pollutants and Their Potential Effects

Constituents	Effects
Sediments - Suspended Solids, Dissolved Solids, Turbidity	Stream turbidity Habitat changes Recreation/aesthetic loss Contaminant transport Filling of lakes and reservoirs
Nutrients - Nitrate, Nitrite, Ammonia, Organic Nitrogen, Phosphate, Total Phosphorus	Algae blooms Eutrophication Ammonia and nitrate toxicity Recreation/aesthetic loss
Microbes - Fecal Coliforms, Fecal Streptococci, Viruses, E.Coli, Enterocci	Ear/intestinal infections Shellfish toxicity Recreation/aesthetic loss
Organic Matter - Vegetation, Sewage, Other Oxygen Demanding Materials	Dissolved oxygen depletion Odors Fish kills
Toxic Pollutants - Heavy Metals (cadmium, copper, lead, zinc), Organics, Hydrocarbons, Pesticides/Herbicides	Human & aquatic toxicity Bioaccumulation in the food chain
Thermal Pollution	Dissolved oxygen depletion Habitat changes
Trash and debris	Recreation/aesthetic loss

- Nutrient Enrichment – Runoff from urban watersheds contains increased nutrients such as nitrogen or phosphorus compounds. Increased nutrient levels are a problem as they promote weed and algae growth in lakes, streams and estuaries. Algae blooms block sunlight from reaching underwater grasses and deplete oxygen in bottom waters. In addition, nitrification of ammonia by microorganisms can consume dissolved oxygen, while nitrates can contaminate groundwater supplies. Sources of nutrients in the urban environment include washoff of fertilizers and vegetative litter, animal wastes, sewer overflows and leaks, septic tank seepage, detergents, and the dry and wet fallout of materials in the atmosphere.

- Hydrocarbons – Oils, greases and gasoline contain a wide array of hydrocarbon compounds, some of which have shown to be carcinogenic, tumorigenic and mutagenic in certain species of fish. In addition, in large quantities, oil can impact drinking water supplies and affect recreational use of waters. Oils and other hydrocarbons are washed off roads and parking lots, primarily due to leakage from vehicle engines. Other sources include the improper disposal of motor oil in storm drains and streams, spills at fueling stations and restaurant grease traps.

- Toxic Materials – Besides oils and greases, urban stormwater runoff can contain a wide variety of other toxicants and compounds including heavy metals such as lead, zinc, copper, and cadmium, and organic pollutants such as pesticides, PCBs, and phenols. These contaminants are of concern because they are toxic to aquatic organisms and can bioaccumulate in the food chain. In addition, they also impair drinking water sources and human health. Many of these toxicants accumulate in the sediments of streams and lakes. Sources of these contaminants include industrial and commercial sites, urban surfaces such as rooftops and painted areas, vehicles and other machinery, improperly disposed household chemicals, landfills, hazardous waste sites and atmospheric deposition.

- Sedimentation – Eroded soils are a common component of urban stormwater and a pollutant in their own right. Excessive sediment can be detrimental to aquatic life by interfering with photosynthesis, respiration, growth and reproduction. Sediment particles transport other pollutants that are attached to their surfaces including nutrients, trace metals and hydrocarbons. High turbidity due to sediment increases the cost of treating drinking water and reduces the value of surface waters for industrial and recreational use. Sediment also fills ditches and small streams and clogs storm sewers and pipes, causing flooding and property damage. Sedimentation can reduce the capacity of reservoirs and lakes, block navigation channels, fill harbors and silt estuaries. Erosion from construction sites, exposed soils, street runoff, and streambank erosion are the primary sources of sediment in urban runoff.

- Higher Water Temperatures – As runoff flows over impervious surfaces such as asphalt and concrete, it increases in temperature before reaching a stream or basin. Water temperatures are also increased due to shallow basins and impoundments along a watercourse as well as fewer trees along streams to shade the water. Since warm water can hold less dissolved oxygen than cold water, this “thermal pollution” further reduces oxygen levels in urban streams. Temperature changes can severely disrupt certain aquatic species, such as trout and stoneflies, which can survive only within a narrow temperature range.

- Trash and Debris – Considerable quantities of trash and other debris are washed through storm drain systems and into streams and lakes. The primary impact is the creation of an aesthetic “eyesore” in waterways and a reduction in recreational value. In smaller streams, debris can cause blockage of the channel, which can result in localized flooding and erosion.

1.1.6 Stormwater Hotspots

Stormwater hotspots are areas of the urban landscape that often produce higher concentrations of certain pollutants, such as hydrocarbons or heavy metals, than are normally found in urban runoff. These areas merit special management and the use of specific pollution prevention activities and/or structural stormwater controls. The city has the authority to require additional measures for developments and redevelopments that propose such hotspot land uses. Examples of stormwater hotspots include, but are not limited to:

- Gas/fueling stations
- Vehicle maintenance areas
- Vehicle washing / steam cleaning
- Auto recycling facilities
- Outdoor material storage areas
- Plant nurseries, agricultural areas
- Kennels, feed lots, etc.
- Loading and transfer areas
- Landfills
- Construction sites
- Industrial sites
- Industrial rooftops

1.1.7 Effects on Basins, Lakes and Reservoirs

Stormwater runoff into basins, lakes and reservoirs can have some unique negative effects. A notable impact of urban runoff is the filling in of lakes with sediment. Another significant water quality impact on lakes related to stormwater runoff is nutrient enrichment. This can result in the undesirable growth of algae and aquatic plants. Enclosed or regulated waterbodies such as basins, lakes and reservoirs do not flush contaminants as quickly as streams and act as sinks for nutrients, metals and sediments. This means that lakes can take longer to recover if contaminated.

1.2 Addressing Stormwater Impacts

The focus of the City of Kingsport is effective and comprehensive stormwater management. Stormwater management involves both the prevention and mitigation of stormwater runoff quantity and quality impacts as described in this chapter through a variety of methods and mechanisms.

This manual provides requirements, policies, and guidance for developers in the city to effectively implement stormwater management controls on-site to address the potential impacts of new development and redevelopment, and both prevent and mitigate problems associated with stormwater runoff. This is accomplished by:

- Developing land in a way that minimizes its impact on a watershed by reducing both the amount of runoff and the pollutants generated;
- Using the most current and effective erosion and sedimentation control practices during the *construction* phase of development;
- Controlling stormwater runoff peaks, volumes and velocities to prevent both downstream streambank channel erosion and flooding;
- Treating *post-construction* stormwater runoff before it is discharged to a waterway, and
- Implementing pollution prevention practices to prevent stormwater from becoming contaminated in the first place.

The remainder of Chapter 1 outlines the minimum stormwater management standards that are used to guide the requirements, policies and incentives of the city in establishing an effective stormwater management program.

1.3 Comprehensive Stormwater Management Planning

This section presents a comprehensive and integrated set of stormwater management standards for new development and redevelopment projects in the city. Minimum standards and performance requirements for controlling runoff from development are critical to addressing both the water quantity and quality impacts of post-construction urban stormwater and are required of the City of Kingsport in order to comply with the National Pollutant Discharge Elimination System (NPDES) stormwater regulations. Minimum stormwater management standards must also be supported by a set of design and management tools and an integrated design approach for implementing both structural and nonstructural stormwater controls. The major elements of the stormwater management program are:

- Incentives for Stormwater Better Site Design – The first step in addressing stormwater management begins with the site planning and design process. The goals of better site development design are to reduce the amount of runoff and pollutants that are generated from a development site and provide for some nonstructural on-site treatment and control of runoff by implementing a combination of approaches collectively known as *stormwater better site design practices*. These include maximizing the protection of natural features and resources on a site, developing a site design that minimizes impact, reducing the overall site imperviousness, and utilizing natural systems for stormwater management. General guidance on the types and application of better site design practices is provided in Chapter 5 of this manual.

- Stormwater Credits for Better Site Design – The city has developed a set of stormwater "credits" that can be used to provide developers and site designers' incentives to implement better site design practices that can reduce the volume of stormwater runoff and minimize the pollutant loads from a site. While reducing stormwater impacts, the credit system can also translate directly into cost savings to the developer by reducing the size of structural stormwater control and conveyance facilities. Specific technical guidance on the stormwater credits offered is presented in Chapter 5 of this manual.

- Integrated Stormwater Design Criteria – The Integrated Stormwater Design (ISD) criteria is a combination of design criteria for stormwater quantity and quality management which addresses the entire range of hydrologic events. These criteria allow the site engineer to calculate the stormwater control volumes required for water quality, downstream channel protection, and overbank and extreme flood protection. Specific technical guidance on stormwater design criteria is presented in Chapter 3 of this manual.

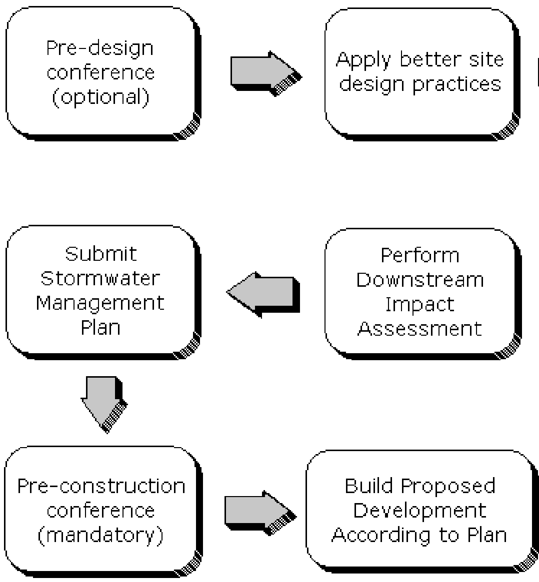
- Downstream Impact Analysis – Downstream peak discharge analyses are required to ensure that a proposed development is not adversely impacting downstream properties after the on-site stormwater management requirements have been addressed. These analyses can potentially be used to modify the requirement for overbank and extreme flood control, should the analysis reveal that such stormwater control measures would cause a negative flood impact on downstream properties. Downstream impact analysis requirements are presented in the Chapter 3 of this manual.

- Guidance on Structural Stormwater Controls – This manual provides requirements and specifications for a set of structural stormwater controls that can be used to meet the city's stormwater management water quantity and quality goals. Specific technical guidance on how to select, size, design, construct and maintain structural controls is provided in Chapter 4 of this manual.

- Stormwater Management Plan – The City of Kingsport requires the preparation of a stormwater management plan for development and redevelopment activities. The plan must be approved by the municipality prior to obtaining a grading or building permit. The purpose, requirements, and contents for this plan are discussed in Chapter 2 of this manual.

Figure 1-4 illustrates how these design tools can be utilized in the development process to address stormwater management in northeast Tennessee.

Figure 1-4. Stormwater Management Planning Process



1.4 Stormwater Quality Treatment Rationale

This section provides an explanation of the requirement for 80% removal of total suspended solids (TSS) from post-construction stormwater runoff for the 85th percentile storm event, as measured on an average annual basis.

1.4.1 Regulatory Overview

The NPDES Phase II regulation requires that Phase II regulated communities develop, implement, and enforce a stormwater management program that reduces the discharge of pollutants from the regulated jurisdiction "to the maximum extent practicable (MEP)". MEP is a technology-based discharge standard that was designed for the reduction of pollutant discharges and established in the Clean Water Act. Using guidance provided by the Environmental Protection Agency (EPA), the City can achieve the MEP standard by instituting a stormwater management program that implements and requires best management practices (BMPs) that are designed to protect water quality. No further guidance on MEP is provided by the EPA or by the Tennessee Department of Environment and Conservation (TDEC).

Control measure 5 of the National Pollutant Discharge Elimination System (NPDES) Phase II Permit presents the requirements for the control of post-construction (i.e., after development) stormwater runoff. Quoting directly from the NPDES Permit for the State of Tennessee, regulated cities and counties must:

> *"Develop, implement, and enforce a program to address storm water runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into your small MS4. Your program must ensure that controls are in place that would prevent or minimize water quality impacts;*
>
> *Develop and implement strategies which include a combination of structural and/or non-structural best management practices appropriate for your community; and*
>
> *Develop and implement a set of requirements to establish, protect and maintain water quality buffers in areas of new development and redevelopment.*

> *Use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State or local law."*

As a result of these requirements, the city must implement a requirement for new developments and redevelopments to control stormwater quality using both structural (i.e., constructed) and non-structural (i.e., site planning) best management practices (BMPs). This requirement must be fully implemented no later than 2008.

The NPDES Phase II regulation also requires that the city focus stormwater management on controlling discharges of pollutants of concern to local impaired streams. Based on the State of Tennessee's 303(d) list of "impaired" streams, one of the largest pollutants in northeast Tennessee is sedimentation. In 2006, over 300 stream miles were considered impaired due to excessive sedimentation.

1.4.2 Attaining the Water Quality Standard

The basic goal of the NPDES Phase II regulation is to reduce the water quality impacts of development. The preferred approach to meet this goal and comply with the NPDES permit is called the "Water Quality Volume method" or "WQv method". The WQv method is based on a minimum water quality control goal of 80% removal TSS, as measured on an average annual basis, from post-construction stormwater runoff (i.e., after construction of a site is completed. TSS is a commonly used representative stormwater pollutant for measuring sedimentation.

There are a number of factors that support the use of an 80% TSS removal standard as a minimum level water quality goal in northeast Tennessee.

1. The Tennessee 303(d) list indicates that sedimentation (i.e., sediment) is a significant pollutant of concern in local streams. This fact alone requires implementation of a stormwater management program that, at least in part, focuses on the removal of sediment from stormwater discharges in order to achieve compliance with the NPDES Phase II regulations to the maximum extent practicable.
2. The use of TSS as an "indicator" pollutant for sediment is well-established.
3. The control of TSS leads to indirect control of other pollutants of concern that can adhere to suspended solids in stormwater runoff. In fact, some research shows that a large fraction of many other pollutants of concern are either reduced along with TSS, or at rates proportional to the TSS reduction.
4. A treatment standard of 80% is not a numeric standard, but a "best available technology" standard. In other words, the 80% TSS removal level is reasonably attainable using properly designed, constructed and maintained structural stormwater BMPs (for typical ranges of TSS concentration found in stormwater runoff). This standard is supported with research data from numerous research projects and compiled by the International Stormwater Best Management Practices (BMP) Database evaluation project, titled Determining Urban Stormwater Best Management Practices Removal Efficiencies, June, 2000.

The WQv method can meet the goal of 80% TSS removal using a two-pronged approach. First, it encourages the reduction of imperviousness (and therefore pollution) from developed sites through incentives for non-structural BMPs, such as natural conservation areas and water quality buffers. Second, it requires treatment of any remaining stormwater runoff with structural controls. This method allows the city to meet its water quality goals and regulatory requirements, yet still allows developers flexibility in their site designs.

There are a number of advantages with the WQv method:

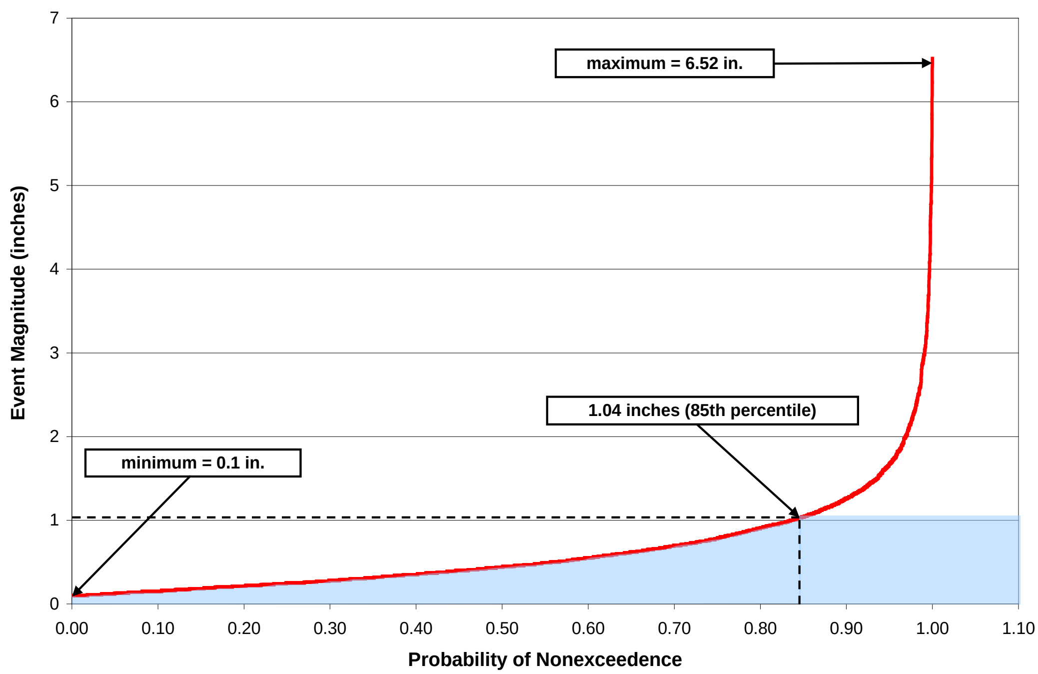
- The WQv method provides a measure of flexibility in site design. The new development or redevelopment site will be required to meet the 80% reduction goal using one or more of a number of locally-acceptable structural BMPs;
- If desired, the developer can also utilize non-structural controls to reduce imperviousness. The WQv method will provide incentives for the reduction of impervious surfaces and the use of non-structural BMPs, such as buffers, natural space preservation, and impervious area disconnection. When utilized, these practices will reduce the amount of stormwater runoff that will require treatment by structural practices, thereby reducing the structural BMP maintenance burden;
- WQv is not a prescriptive approach in that it mandates the use of one specific treatment BMP, such as a first flush pond. Instead, the developer can choose from a menu of BMPs, each of which is assigned a % TSS removal efficiency. When constructed alone, or in combination with other structural and/or non-structural BMPs, the minimum percent TSS removal standard can be attained;
- Research shows that extended release “first flush” ponds, which are often called dry extended detention (ED) basins and are commonly used in northeast Tennessee, cannot attain a TSS removal standard of 80%. Such ponds have a high propensity for sediment resuspension and subsequent discharges, especially during large storm events. Recent studies of the BMP give it an average TSS reduction somewhere between 50% and 70% (Schueler and Holland, 2000). Of course, pollutant removal ability does depend upon geographic location, overall sediment characteristics, hydrology, and storm event size;
- WQv is a performance based approach. If the BMP(s) are designed, constructed and maintained in accordance with guidance and requirements set by the city, then the BMP(s) will be considered “in compliance” with the minimum 80% water quality standard; and
- The WQv method allows a consistent, “apples-to-apples” application of water quality treatment practices on every development site. Each site will be required to design, construct and maintain in accordance with the 80% TSS removal goal.

The WQv is calculated for the 85th percentile storm event using a value of 1.04 inches of rainfall. Thus, a stormwater management system designed for the WQv will treat the runoff from all storm events of 1.04 inches or less, as well as the first 1.04 inches of runoff for all larger storm events. The 85th percentile was chosen because it represents the “knee in the curve” volume that captures a significant number of storms (normally in the 80-90% range of all storms) without attempting to treat the small percentage of much larger storms that result in large volumes of runoff. Such storms would be expensive to treat, are rare in occurrence, and typically diluted in pollution concentration. Figure 1-5 presents a graphical representation of how the 85th percentile rainfall depth was determined, using a “knee-in-the-curve” approach. The value of 1.04 inches for the 85th percentile storm was determined for the city based on analysis of rainfall data collected at the TriCities Airport dating back to 1948.

Detailed information on the calculation of the WQv and % TSS removal for a development or redevelopment site are presented in Chapter 3 of this manual.

It is important to note that the city is not alone in implementing an 80% TSS removal standard, or the WQv method. Many states, including Maryland, Massachusetts, North Carolina, Georgia, and Florida have set similar statewide TSS goals and have research data to support BMPs meeting this reduction goal. Further, a number of communities in Tennessee, the State of Georgia and the Commonwealth of Virginia have implemented a WQv type of method as the statewide water quality control approach. The BMP design and maintenance guidance from these states can be used and modeled as appropriate to implement a water quality control program that is appropriate to meet the city’s needs.

Figure 1-5: Northeast Tennessee 85th Percentile Rainfall Analysis



Probability of Non-exceedence

1.5 References

ARC. *Georgia Stormwater Management Manual Volume 2 Technical Handbook.* 2001.

GeoSyntec Consultants, URS, et al. *Determining Urban Stormwater Best Management Practices Removal Efficiencies*. June, 2000.

Schueler T., and Holland, H. *The Practice of Watershed Protection*. Center for Watershed Protection (CWP), 2000.

1.6 Suggested Reading

North Carolina Department of Environment and Natural Resources, *Stormwater Management Site Planning*. 1998

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