CHAPTER 5 – STORMWATER AND WATER QUALITY IMPACTS

Stormwater is the flow of water that results from precipitation and usually occurs immediately following a rainfall event or is produced during snowmelt. Common stormwater pollutants include sediment, nutrients, organic matter, bacteria, oil and grease, and toxic substances (i.e., metals, pesticides, herbicides, hydrocarbons). Stormwater can also impact the temperature of a surface waterbody, which can affect the water's ability to support healthy aquatic communities. This chapter provides an overview of stormwater runoff and its impacts to water quality. It also provides information related to state and federal regulations and management practices that can be employed to control stormwater from individual properties and large urbanized areas.

5.1 INTRODUCTION TO STORMWATER RUNOFF

During a rain event, a portion of the precipitation (water) will absorb into the soil surface where it is used by plants. The portion that is not used by plants will reenter the atmosphere through evaporation, recharge a groundwater aquifer or move through the shallow soil layer to a surface waterbody. Stormwater is that portion of the precipitation that runs off of the ground or impervious surfaces. Impervious surfaces are hardened surfaces such as pavement, building rooftops, roads and parking lots. Impervious surfaces prevent rainwater infiltration into the ground (soil) surface. In some cases, stormwater drains directly into streams, rivers, lakes and oceans. In other cases, particularly in urbanized areas, stormwater drains into streets and manmade drainage systems consisting of inlets and underground pipes, commonly referred to as a storm sewer system. In North Carolina, there is no pre-treatment of stormwater. Storm sewer systems are designed simply to capture the stormwater and convey it to the nearest surface waterbody. These sewers should not be confused with sanitary sewers, which transport human and industrial wastewaters to a treatment plant before discharging into surface waters.

Uncontrolled stormwater runoff can impact humans and the environment. Cumulative effects include flooding, undercut and eroding streambanks, widened stream channels, threats to public health and safety, impaired recreational use, and increased costs for drinking and wastewater treatment. For more information on stormwater runoff, visit the DWQ Stormwater Unit Web site (http://h2o.enr.state.nc.us/su/stormwater.html) or the NC Stormwater information page (www.ncstormwater.org). Additional fact sheets and information can also be found on the following Web site: www.stormwatercenter.net/intro_factsheets.htm and www.bae.ncsu.edu/stormwater/index.html.

5.2 IMPACTS TO WATER QUALITY

As development in surrounding metropolitan areas consumes neighboring forests and fields, the impacts on rivers, lakes and streams can be significant and permanent if stormwater runoff is not controlled (Orr and Stuart, 2000). This often results in negative impacts that can affect both humans and aquatic communities. Several of these water quality impacts are identified throughout this document and a more refined list can be found on the DWQ Stormwater Unit Web site (http://h2o.enr.state.nc.us/su/stormwater.html).

5.2.1 SEDIMENT

Sediment is often viewed as the largest pollutant associated with stormwater runoff. Overloading of sediment in the form of sand, silt and clay particles fills pools and covers or embeds riffles that are vital to benthic and fish communities. Suspended sediment can decrease primary productivity (i.e., photosynthesis) by shading sunlight from aquatic plants, thereby affecting the overall productivity of a stream system. Suspended sediment also has several effects on various fish species including avoidance and redistribution, reduced feeding efficiency which leads to reduced growth by some species, respiratory impairment, reduced tolerance to diseases and toxicants and increased physiological stress (Roell, 1999).

Sediment filling rivers, streams and reservoirs decreases their storage capacity and increases the frequency of floods (NCDLR, 1998). Sediment also carries nutrients, fertilizers, pesticides, metals and other potentially toxic substances to a surface waterbody. The pollutants consequently increase the cost of treating municipal drinking water and impact aquatic communities. Sediment loading can be exceptionally high in areas of heavy construction activity if sediment and erosion control measures are not properly installed and maintained.

5.2.2 NUTRIENTS

The nutrients most often identified in stormwater runoff are nitrogen (N) and phosphorus (P). While nutrients are beneficial to aquatic life in small amounts, excessive levels can stimulate algal blooms and plant growth, which can lead to low dissolved oxygen levels and eutrophication (especially in reservoirs and small impoundments). Nutrients in surface waters come from both point and nonpoint sources. In an urban environment, nutrients are often associated with landscaping practices (commercial and home lawn management), leaking sanitary sewers and failing on-site waste management systems and waste from domesticated pets (i.e. dogs and cats) and urban wildlife (i.e., pigeons, raccoons, rats, squirrels, etc.).

5.2.3 ORGANIC MATTER

Sources of organic matter include leaking sanitary sewers and failing on-site wastewater (septic) systems, garbage, yard waste, waste from animals and natural materials such as leaves, grass and tree branches. Decomposition of this material by several different types organisms in surface waters decreases the amount of dissolved oxygen available for other aquatic organisms. Too much or not enough can severely impact water quality and aquatic habitats.

5.2.4 BACTERIA

Sources of bacteria include leaking sanitary sewers and failing on-site wastewater (septic) systems, garbage, waste from animals and naturally occurring microbes within urban and rural environments. High levels of bacteria will impact recreational use and aquatic habitats and may pose an environmental health risk.

5.2.5 OIL AND GREASE

Oil, grease and lubricating agents can be readily transported by stormwater to the nearest surface waterbody. The intensity of activities, such as vehicle traffic, automotive maintenance and fueling, leaks and spills and manufacturing processes, contribute heavily to the level of these pollutants present in the adjacent stream.

5.2.6 TOXIC SUBSTANCES

Metals, pesticides, herbicides and hydrocarbons are toxic substances that can potentially enter a surface waterbody through stormwater runoff. Such toxic substances can immediately impact an aquatic community and potentially accumulate in the bottom sediments.

5.2.7 HEAVY METALS

Heavy metals such as copper, lead, zinc, arsenic, chromium and cadmium are often found in stormwater runoff from heavily urbanized areas. Metals in stormwater may be toxic to some aquatic life and may accumulate in the bottom sediments and in the tissue of some fish. Urban sources of metals in stormwater may include automobiles, paints, preservatives, motor oil and various industrial activities.

5.2.8 TEMPERATURE (THERMAL POLLUTION)

The temperature of stormwater runoff increases as it flows over impervious surfaces. Also, the removal of natural vegetation along streambanks (especially trees) can dramatically influence the temperature of a waterbody by direct solar radiation. Water temperature can also increase in shallow ponds and impoundments if they are not shaded. In some cases, higher temperatures may also promote plant and algal growth, which in turn will impact primary producers by reducing oxygen levels and reducing light availability. Higher temperatures over time will impact and even change the aquatic community within a waterbody.

5.2.9 HABITAT DEGRADATION

Because water cannot adsorb into the ground, pollutants are delivered directly to surface waterbodies. During rain events, streamflow often increases and peaks earlier than in undeveloped watersheds. Streambank scour from these frequent high flow events tends to enlarge streams and increase suspended sediment. Scouring also destroys aquatic habitat, leading to degradation of aquatic insect populations and the loss of fisheries. Flooding frequency also increases in developed watersheds and can be devastating when small streams are channelized (straightened) or piped, and storm sewer systems are installed to readily transport stormwater downstream (EPA, 1999). It is well established that stream degradation begins to occur when 10 percent or more of a watershed is covered with impervious surfaces (Schueler, 1995).

Too much paving and surface compaction in a watershed also reduces infiltration and groundwater levels. This reduction decreases the availability of aquifers, streams and rivers for drinking water supplies. Greater numbers of homes, stores and businesses require greater quantities of water. They also lead to more discharge and runoff of waste and pollutants into the state's streams, rivers, lakes and estuaries. Thus, just as demand and use increases, some of the potential water supply is also lost (Orr and Stuart, 2000).

5.3 STORMWATER PROGRAMS

The goal of federal and state stormwater discharge permitting regulations and programs is to prevent pollution from entering the waters of the nation via stormwater runoff. These programs try to accomplish this goal by controlling the source(s) of pollutants. Federal programs include regulations under the Phase I and Phase II National Pollutant Discharge Elimination System (NPDES) Stormwater Program. The US Environmental Protection Agency (EPA) established the Phase I program in 1990 in response to amendments to the Clean Water Act. Phase II was enacted in 1999 and expanded the NPDES Stormwater Program.

In North Carolina, the State Stormwater Management Program was established in the late 1980s under the authority of the North Carolina Environmental Management Commission (EMC) and North Carolina General Statute 143-214.7. The program codified in 15A NCAC 2H .1000 affects development activities that require an Erosion and Sediment Control Plan (for disturbances of one or more acres) or a major permit required under the Coastal Area Management Act (CAMA) within one of the 20 coastal counties and/or development draining to Outstanding Resource Waters (ORW) or High Quality Waters (HQW). Waters of the state are also protected under the Water Supply Watershed Program.

EPA Stormwater Rules

Phase I – December 1990

- Requires a NPDES permit for municipal storm sewer systems (MS4s) serving populations of 100,000 or more.
- Requires a NPDES stormwater permit for ten categories of industries.
- Requires a NPDES stormwater permit for construction sites that are 5 acres or more.

Phase II – December 1999

- Requires a NPDES permit for some municipal storm sewer systems serving populations under 100,000, located in urbanized areas.
- Provides a "no stormwater exposure" exemption to industrial facilities covered under Phase I.
- Requires a NPDES stormwater permit for construction sites that disturb one to five acres of land.

5.3.1 NPDES PHASE I

Phase I of the EPA stormwater program started in 1990 in response to amendments to the Clean Water Act. Phase I required NPDES permit coverage to address stormwater runoff from medium and large stormwater sewer systems serving populations of 100,000 or more people.

Phase I also has requirements for ten categories of industrial sources to be covered under stormwater permits. Industrial activities which require permitting are defined in categories ranging from sawmills and landfills to manufacturing plants and hazardous waste treatment, storage or disposal facilities. Construction sites disturbing greater than five acres are also required to obtain an NPDES stormwater permit under Phase I. North Carolina's DWQ is responsible for implementing the Phase I NPDES Stormwater Program. More information about Phase I can be found on the

DWQ Stormwater Unit Web Site (http://h2o.enr.state.nc.us/su/NPDES_Phase_I_Stormwater_Program.htm) and on the EPA Web Site (http://cfpub.epa.gov/npdes/stormwater/swphases.cfm).

5.3.2 NPDES PHASE II

Phase II of the NPDES Stormwater Program was signed into law in December 1999. The law builds upon the existing Phase I program by requiring smaller communities and public entities that own and operate a municipal storm sewer system (MS4) to apply and obtain an NPDES permit for stormwater discharge. Construction sites greater than one acre are also required to obtain an NPDES stormwater permit under Phase II in addition to establishing erosion and sedimentation controls.

Local governments permitted under Phase II are required to develop and implement a comprehensive stormwater management program that includes six minimum measures:

1) Public education and outreach on stormwater impacts.
2) Public involvement/participation.
3) Illicit discharge detection and elimination.
4) Construction site stormwater runoff control.
5) Post-construction stormwater management for new development and redevelopment.
6) Pollution prevention/good housekeeping for municipal operations.

Those municipalities and counties required to obtain a NPDES stormwater permit under the Phase II rules are identified using the 1990 US Census for Designated Urban Areas and the results of the 2000 US Census. Based on federal census data, EPA identified 123 cities and 33 counties in North Carolina that may be required to obtain permits under Phase II.

EPA delegated Phase II implementation to each state, and in 1999, DWQ, under the direction of the EMC, initiated a rulemaking process. In 2002, the EMC adopted temporary stormwater rules and by 2003 had adopted permanent rules that were to become effective August 1, 2004.

In early 2004, the Rules Review Commission (RRC) objected to the proposed Phase II stormwater rules for failure to comply with the Administrative Procedures Act and lack of statutory authority. The EMC challenged the decision of the RRC in court (EMC v. RRC 04 CVS 3157). A Wake County Superior Court ruled in the EMC's favor, and the RRC subsequently approved the EMC's rules. However, while the case was pending, the legislature enacted a separate set of requirements in 2004 that were designed to replace the EMC rules. These rules included NPDES stormwater rules covering owners and operators of storm sewer systems and State stormwater rules covering activities in urbanizing areas. The EMC amended the rules at their November 10, 2005 meeting to address objections raised by the RRC during the October 2005 EMC meeting. The inconsistency between the legislative requirements and the EMC rules necessitated consideration of Senate Bill 1566 in the 2006 short session.

The legislature approved Session Law 2006-246, Senate Bill 1566. It includes provisions for development projects that cumulatively disturb one acre or more of land in Phase II municipalities and counties. The development projects must comply with the post-construction

stormwater standards set out in the bill. The bill also sets criteria whereby unincorporated areas of counties will be subject to Phase II requirements. Under these criteria, 25 counties are fully covered and eight counties have portions that are subject to Phase II stormwater requirements. The bill also provides a designation and petition process by which additional local governments and other entities may be required to obtain a stormwater permit.

The bill provides an implementation schedule that requires regulated entities to apply for an NPDES stormwater management permit within 18 months of being notified that it is a regulated entity subject to the requirements of this act. A regulated entity must implement its post-construction program no later than 24 months from the date the permit is issued and fully implement its permitted program within five years of permit issuance.

The bill also authorizes the EMC to adopt Phase II stormwater management rules. If the EMC adopts rules, the rules must be substantially identical to the provisions of this act and will be automatically subject to review by the General Assembly and not subject to review by the RRC. The bill became effective retroactively to July 1, 2006. The 2006 Stormwater Requirements under Senate Law 2006-246 are listed in Table 5-1.

More information about Phase II can be found on the DWQ Stormwater Unit Web site (http://h2o.enr.state.nc.us/su/NPDES_Phase_II_Stormwater_Program.htm) and the EPA Web site (http://cfpub.epa.gov/npdes/stormwater/swphases.cfm). The DWQ Web site includes a detailed history of the rulemaking process and lists those municipalities and counties that may be subject to Phase II stormwater permits.

5.3.3 STORMWATER MANAGEMENT IN THE COASTAL COUNTIES

In the 2006 session of the NC General Assembly, Session Law 2006-246 was adopted and introduced additional stormwater controls in coastal counties. Session Law 2008-211 became law in October 1, 2008 and extended more stringent post-construction stormwater controls to lands adjacent to SA and ORW waters and throughout the 20 coastal counties. The 2008 legislation implements a lower threshold as to where the stormwater treatment requirements apply. Table 5-1 compares the new requirements to those that were implemented by Session Law 2006-246. All residential development requiring a sedimentation and erosion control plan approval from the Division of Land Resources or a Coastal Area Management Act permit continues to require a stormwater control permit.

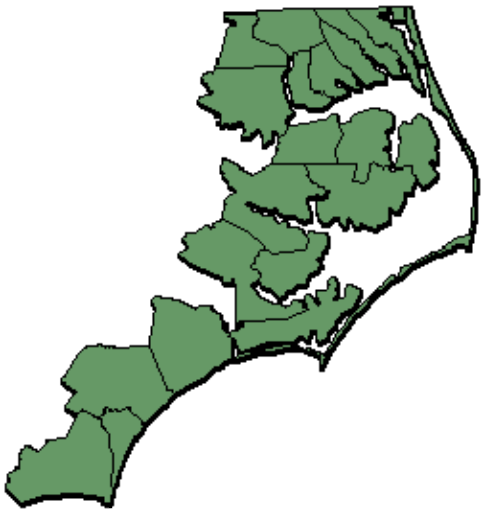

Figure 5-1 Twenty Coastal Counties
Source: http://dcm2.enr.state.nc.us/

Low-Density Projects: Development projects that are located within one-half mile of and draining to SA Waters are considered low density if they contain no more than 12 percent built-upon area. A project that is not located within one-half mile of SA Waters is a low-density project if it contains no more than 24 percent built-upon area or no more than two dwelling units per acre.

Table 5-1: Coastal Stormwater Rules Chart

Includes ALL Areas within the 20 Coastal Counties

	Old Requirements	Requirements as of Oct. 1, 2008
Threshold for Permit Coverage for Any and All Development	Activities that require a CAMA major permit or an Erosion & Sedimentation Control Plan (sites that disturb one acre or greater)	Activities that require a CAMA major permit or an Erosion & Sedimentation Control Plan (sites that disturb one acre or greater)
Threshold for Permit Coverage for Non-Residential Development	Same coverage requirements as above.	In addition to the coverage requirements above, activities that add more than 10,000 square feet of built upon area.
Vegetative Setback Requirement – Re-development	30 feet from surface waters (for Low Density projects only)	30 feet from surface waters for redevelopment projects (for both Low and High Density projects)
Vegetative Setback Requirement – New development	30 feet from surface waters (for Low Density projects only)	50 feet from surface waters for new development projects (for both Low and High Density projects)
Wetlands & Impervious Calculations	Portions of wetlands may be included in the calculations to determine the built upon area percentage per DWQ Policy (Oct. 5, 2006)	No CAMA-jurisdictional wetlands areas may be included in the calculations to determine the built upon area percentage. All other wetlands can be included in the calculations.

Within the 20 Coastal Counties and within ½ Mile of Shellfishing Waters (SA waters) & within 575 ft. of ORW

	Old Requirements	New Requirements
Low Density Threshold *	Built upon area of 25% or less	Built upon area of 12% or less (Maximum built upon area of 25% for ORW)
Stormwater Control Requirement for High Density Projects	Control and treat the runoff from the first 1.5 inches of rainfall.	Control and treat runoff generated by 1.5 inches of rainfall –OR– the difference in runoff from the pre and post development conditions for the 1-year, 24-hour storm (whichever is greater*)
Discharge Requirements	No discharge for the first 1.5 inches of rainfall	No new points of discharge for the design storm (see above)
Types of Stormwater Controls	Infiltration is the only control allowed	All types of stormwater controls are allowed, with some restrictions

Within the 20 Coastal Counties and NOT within ½ Mile of Shellfishing Waters (non-SA waters)

	Old Requirements	New Requirements
Low Density Threshold *	Built upon area of 30% or less	Built upon area of 24% or less
Stormwater Control Requirement for High Density Projects	Control the runoff generated by 1.0 inches of rainfall	Store, control and treat runoff generated by 1.5 inches of rainfall

Low-density projects must use vegetated conveyances to the maximum extent practicable to transport stormwater runoff from the project area.

High-Density Projects: Projects that are located within one-half mile of and draining to Shellfish Waters are considered high density if they contain more than 12 percent built-upon area. A project that is not located within one-half mile of shellfish waters is a high-density project if it contains more than 24 percent built-upon area or more than two dwelling units per acre. High-density projects must use structural stormwater management systems that will control and treat runoff from the first 1.5 inches of rain. In addition, projects that are located within one-half mile and draining to shellfish waters must control and treat the difference in the stormwater runoff from the pre-development and post-development conditions for the one-year twenty-four hour storm as well as meet certain design standards.

Additional Projects: Non-residential properties are required to treat stormwater if the built-upon area is increased by 10,000 square feet. Residential development within one-half mile of Shellfish Resource Waters that expands the built-upon area by 10,000 square feet will also have to manage stormwater by reduce impervious surfaces or collecting it.

5.3.4 STORMWATER MANAGEMENT NEAR SENSITIVE WATERS (HQW/ORW)

The Statewide Stormwater Management Program requires developments to protect Outstanding Resource Waters (ORW) or High Quality Waters (HQW) by maintaining a low density of impervious surfaces, maintaining vegetative buffers and transporting runoff through vegetative conveyances. The program, codified in 15A NCAC 2H .1000, affects development activities that require an Erosion and Sediment Control Plan for disturbances of one or more acres. It also pertains to the 20 coastal counties that are required to obtain major permits under CAMA.

Under the statewide stormwater program, low-density development thresholds vary from 12 to 30 percent built-upon area (impervious surface) depending on the classification of the receiving stream. If low-density design criteria cannot be met, then high-density development requires the installation of structural best management practices (BMPs) to collect and treat stormwater runoff from the project. High-density BMPs must control runoff from the 1- or 1.5-inch rain event (depending on the receiving stream classification) and remove 85 percent of the total suspended solids. More information about the Statewide Stormwater Management Program can be found on the DWQ Stormwater Unit Web site (http://h2o.enr.state.nc.us/su/state_sw.htm).

5.3.5 Water Supply Watershed Stormwater Management

The purpose of the Water Supply Watershed Protection Program is to provide a proactive drinking water supply protection program for communities. Local governments administer the program based on state minimum requirements. There are restrictions on wastewater discharges, development, landfills and residual application sites to control the impacts of point and nonpoint sources of pollution. The program attempts to minimize the impacts of stormwater runoff by utilizing low-density development or stormwater treatment in high-density areas. More information about water supply watersheds can be found on the DWQ Water Supply Watershed Protection Program Web site (http://h2o.enr.state.nc.us/wswp/).

5.3.6 Universal Stormwater Management Program (USMP)

The Universal Stormwater Management Program (USMP) is an optional, voluntary stormwater management program developed by DWQ that will allow local governments to adopt and implement a single, simplified set of stormwater rules within their jurisdiction. The USMP is available to local governments that adopt an ordinance that complies with the rule and receives approval from the EMC. For those entities that adopt the program the rule outlines requirements that apply to development and redevelopment activities that meet defined thresholds. In the 20 coastal counties, the threshold is projects that disturb 10,000 square feet or more or disturb less than 10,000 square feet but are part of a larger common plan of development or sale. For the 80 non-coastal counties, the thresholds are:

- Residential development activity that disturbs one or more acres of land.
- Residential development activity that disturbs less than one acre of land but is part of a larger common plan of development or sale.
- Non-residential development activities that disturb 0.5 acre or more.

The USMP incorporates the latest research regarding the most effective control and treatment of stormwater pollution. It requires stormwater controls, such as the detention of stormwater to settle solids and modify its force and volume, for projects that meet or exceed the thresholds. In areas where stormwater drains to shellfish resource waters or those waters designated for shellfish harvesting (Class SA), measures must be taken to control fecal coliform. New and expanded stormwater outfalls are also prohibited.

The USMP became effective January 1, 2007. More information about USMP can be found on the DWQ Stormwater Unit Web site (http://h2o.enr.state.nc.us/su/usmp.htm).

5.4 REDUCING STORMWATER IMPACTS TO WATER QUALITY

5.4.1 PERVIOUS VS. IMPERVIOUS

Impervious surfaces are materials that prevent infiltration of water into the soil and include roads, rooftops and parking lots (Figure 5-2). Impervious surfaces alter the natural hydrology, prevent the infiltration of water into the ground, and concentrate the flow of stormwater over the landscape. In undeveloped watersheds, stormwater filters through the soil, replenishing groundwater quantity with water of good quality. Vegetation in any watershed holds soil in place, slows the flow of stormwater over land and filters out some pollutants, by both slowing the flow of the water and trapping some pollutants in the root system.

Wide streets, large cul-de-sacs, long driveways and sidewalks lining both sides of the street are all features of urban development that create excess impervious cover and replace natural areas. To reduce the amount of imperviousness in a watershed, new construction designs should include plans to prevent or minimize the amount of runoff leaving the site. In many instances, the presence of intact riparian (vegetative) buffers and/or wetlands in urban areas can reduce the impacts of urban development. Establishing and protecting riparian buffers should be considered

and incorporated in to design plans when practicable, and the amount of impervious cover should be limited as much as possible.

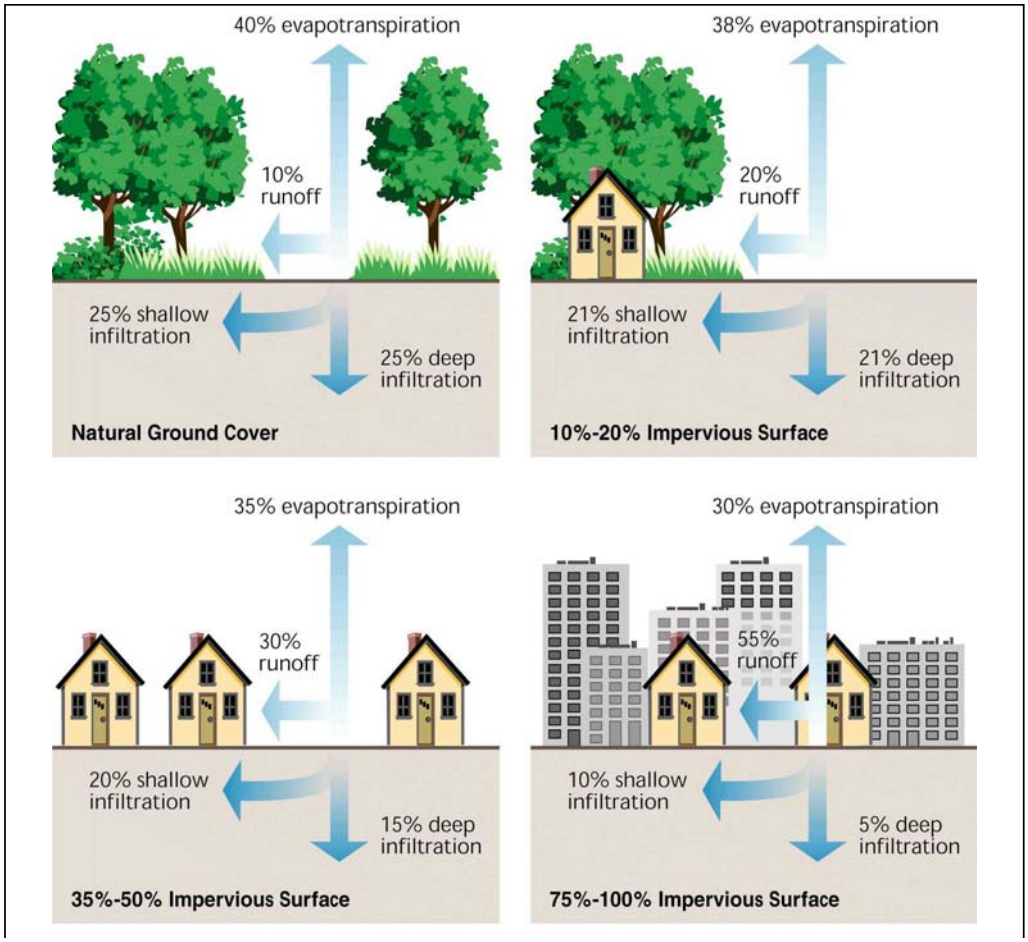

Figure 5-2 Impervious Surfaces and Surface Runoff

Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation (FISRWG, October 1998).

5.4.2 STORMWATER CONTROL MEASURES

Mechanisms for controlling stormwater runoff can be grouped into preventative measures and control measures. Preventative measures, or non-structural best management practices (BMPs), work to reduce the impacts of stormwater runoff through changes in design, operation or management to minimize or prevent the generation of runoff and the contamination of runoff from pollutants. Preventative measures include land use management practices and source reduction practices. Land use management practices use methods to best plan the way to locate land uses within a jurisdictional area or project site to avoid environmental impacts. Source reduction practices focus on locating the sources of the pollutants and implementing design and operation changes that minimize or completely remove these sources. Preventative measures can be very efficient and effective since they are implemented to keep pollutants from ever getting

into stormwater. The advantages of preventive measures are that they typically do not require maintenance or technical or engineering designs. However, they do require administrative resource commitments to ensure that they are continually implemented.

Control measures, or structural BMPs, are devices that are put in place to capture stormwater flows and provide pollutant removal through filtering, infiltration, detention or some related process. These measures may be limited in their ability to efficiently remove some pollutants and may be fairly costly, but they often protect the riparian ecosystem, stabilize streambanks, provide shade and reduce the likelihood of excessive water temperatures. Control measures require jurisdictional commitments to long-term operation and maintenance to assure that the measures continue to function properly.

Table 5-2 provides a list of structural and non-structural BMPs identified in the updated draft of the *Stormwater Best Management Practices Manual* (July 2005) published by DWQ. The manual provides a detailed discussion of each of the BMPs, including its characteristics, pollutant-specific effectiveness, reliability, feasibility, costs, unknown use factors, design considerations and references for more information. The manual and several stormwater factsheets can be found on the DWQ Stormwater Unit Web site (http://h2o.enr.state.nc.us/su/Manuals_Factsheets.htm#StormwaterManuals).

Table 5-2 Examples of Structural and Non-Structural (Preventative) Stormwater BMPs

STRUCTURAL BMPS	NON-STRUCTURAL BMPS	
Stormwater Wetlands	Public Education/Participation	Illicit Connection Prevention
Bioretention	Land use Planning/Management	Controlling Leaking Sewer Lines
Wet Detention Basin	Housekeeping Practices	Vegetated Buffers
Dry Detention Basin	Safer Alternative Products	Household Hazardous Waste Collection
Grassed Swale	Turf & Lawn Education/Management	Used Oil Collection
Filter Strip	Material Storage Control	Spill Control (Vehicle and Aboveground
Infiltration Devices	Vehicle-Use Reduction	Storage Tanks)
Manufactured BMP Systems	Storm Drain Stenciling	Roadway Cleaning
Vegetated Buffer		
Permeable Pavement		
Rooftop Runoff Management		
Sand Filter		

5.4.3 PUBLIC EDUCATION/AWARENESS

Pubic awareness is an important part of reducing stormwater impacts. Unfortunately, not everyone knows that the decisions they make today can have a significant impact on water quality. A recent survey by NCDENR found that most North Carolinians are not familiar with stormwater runoff and that is the primary source of water pollution in the state and across the nation. The survey was administered by East Carolina University (ECU) Center for Survey Research and found that:

- Thirty-seven percent of respondents knew that stormwater is not treated but instead routed directly to the nearest surface waterbody.
- Forty percent of respondents washed their car on their driveway instead of in the grass. Car washing can introduce soap, brake dust and road dirt to surface waterbodies.
- Five percent of respondents applied fertilizer to their yards monthly. Over application can result in increase nitrogen and phosphorus levels in surface waterbodies.
- The majority of the respondents did not clean up after their pets. Pet waste introduces bacteria and nutrients to surface waterbodies during a rain event (Bartlett, 2005).

"Good housekeeping" in our own backyards is essential and reduces the volume of stormwater leaving an individual site. Reducing the amount of pollutants used in our own backyards can also minimize the impact of stormwater runoff. DWQ has published a pamphlet entitled *Improving Water Quality in Your Own Backyard: Stormwater Management Starts at Home*. The pamphlet provides information on how homeowners and businesses can reduce the amount of runoff leaving their property and how to reduce the amount and types of pollutants in that runoff. This pamphlet is available on the DWQ Web site (http://h2o.enr.state.nc.us/nps/documents/BackyardPDF.pdf).

Table 5-3 identifies several additional recommendations for controlling stormwater runoff. Several stormwater BMP fact sheets and manuals are also available on-line, including:

- EPA Stormwater Outreach Materials and Reference Documents http://cfpub.epa.gov/npdes/stormwatermonth.cfm
- City of Raleigh Stormwater Management Design Manual http://www.raleighnc.gov/portal/server.pt?space=Dir&spaceID=2&in_hi_userid=2&control=OpenSubFolder&subfolderID=1786&DirMode=1
- City of Wilmington – Stormwater Services www.wilmingtonnc.gov/bmps/tabid/93/Default.aspx
- A Citizens Guide to Protection Wilmington's Waterways www.wilmingtonnc.gov/publications/tabid/92/Default.aspx
- Charlotte-Mecklenburg Land Development Standards Manual www.charmeck.org/Departments/StormWater/home.htm
- North Carolina Cooperative Extension Publications through Urban Waterways and Home*A*System www.ces.ncsu.edu

Table 5-3 Recommendations for controlling stormwater runoff

LOCAL GOVERNMENTS	Create public education programs advising citizens on how to minimize stormwater pollution. Support stream cleanup programs such as Big Sweep. Create and enforce strict penalties for improper waste disposal. Fence dumpsters and clean them regularly. Institute land use planning, which reduces flooding by limiting impervious surfaces, directs runoff into vegetated areas or stormwater control devices, and directing growth away from sensitive areas. These actions will help protect water quality. Review local ordinances pertaining to parking, curb and gutter locations. Design parking lots with overflow areas in grass. Eliminate curbs and gutters to allow runoff to flow in sheetflow. Protect open spaces and streamside buffers by preserving recreational areas and significant natural resources. Attend stormwater workshops. Map the storm sewer system to identify stormwater problems. Offer hazardous waste collection days.
CITIZENS	Participate in stream cleanup programs such as Big Sweep. Practice environmentally friendly lawn care. Use less-harmful substances in the home for cleaning or painting to reduce the risk of problems with septic tanks and sanitary sewers. Educate adults and children on protecting water quality. For information contact the NC Office of Environmental Education (www.eenorthcarolina.org). Use hazardous waste collection centers for paints, petroleum products and other chemicals. Never dispose of oil, yard wastes or other materials in storm drain inlets or on lands which drain directly to nearby streams. Maintain and protect riparian buffers on private property. Buffers remove pollutants, including sediment, nutrients and toxic substances. They are also a cost-effective form of flood insurance and can increase property value. Support your local government's land use planning initiatives.
DEVELOPERS	Incorporate stormwater management in project planning and avoid environmentally sensitive areas, such as floodplains and wetlands. Maintain natural drainage ways and buffers along streams.
BUSINESSES	Maintain and protect riparian buffers on commercial property. Buffers remove sediment, nutrients and toxic substances. Cover and contain waste materials to prevent contaminated runoff from disposal areas. Practice good housekeeping and promote good water quality by operating a clean and litter-free facility. Institute hazardous waste collection sites for used oil, antifreeze, paint and solvents.

5.4.4 INTERNATIONAL STORMWATER BMP DATABASE

Through an agreement between the EPA and the American Society of Civil Engineers (ASCE) an international stormwater BMP database has been created to scientifically improve the design, selection and performance of stormwater BMPs. Over 200 stormwater BMPs can be found here along with in-depth information about each one. The database and more information can be found at ISBMPD Web site (www.bmpdatabase.org/).

REFERENCES

Bartlett, Chrystal. 2005. *Stormwater Knowledge, Attitude and Behaviors: A 2005 Survey of North Carolina Residents.* Raleigh: NC.

Federal Interagency Stream Corridor Restoration Working Group (FISCRWG). October 1998. *Stream Corridor Restoration: Principles, Processes and Practices.* U.S. Government Printing Office Item No. 0120-A; SuDOCs No. A 57.6/2:EN 3/PT.653. ISBN 0-934213-59-3.

North Carolina Department of Environment and Natural Resources (NCDENR). Division of Land Resources (DLR). Land Quality Section. 1998. *What is Erosion and Sedimentation?* Raleigh, NC.

___. Division of Water Quality (DWQ). Stormwater Unit. July 2007. *Updated Draft Manual of the Stormwater Best Management Practices*. http://h2o.enr.state.nc.us/su/Manuals_Factsheets.htm#StormwaterManuals

Orr, D.M., Jr. and A.W. Stuart. 2000. *The North Carolina Atlas*. The University of North Carolina Press: Chapel Hill, NC.

Roell, Michael J. June 1999. *Sand and Gravel Mining in Missouri Stream Systems: Aquatic Resource Effects and Management Alternatives*. Missouri Department of Conservation. Conservation Research Center. Columbia, MO.

Schueler, T.R. 1995. *Site Planning for Urban Stream Protection*. Metropolitan Washington Council of Governments: Washington D.C.

US Environmental Protection Agency (EPA). 1999. Watershed Academy Web site: www.epa.gov/OWOW/watershed/wacademy/.