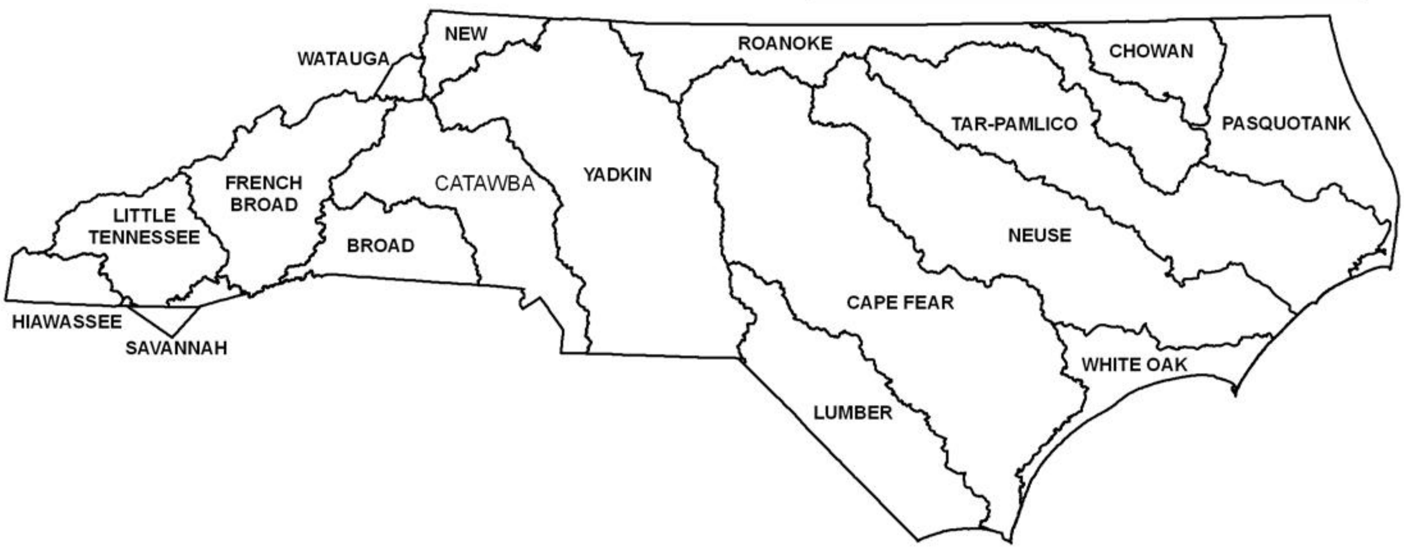

Supplemental Guide to North Carolina's Basinwide Planning

Support Document for Basinwide Water Quality Plans

Second Revision

November 2008

NCDENR

Division of Water Quality

DWQ

Division of Water Quality Planning Section

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INTRODUCTION

Water is in an invaluable natural resource. It is used for drinking, irrigating, producing electricity, transporting merchandise and producing food. It also sustains many diverse and ecologically important species. North Carolina is blessed with many miles and acres of rivers, streams and estuaries. Federal, state and local governments, public and private landowners and local volunteer, civic and conservation groups are working every day to protect water across the state.

This document serves as the second edition to *A Citizen's Guide to Water Quality Management in North Carolina*. It is intended to provide general information about water quality issues in the State of North Carolina. It also provides program descriptions and identifies several best management practices (BMPs) that protect water quality. Information included in this document has historically been incorporated into the *Basinwide Water Quality Plans*, which are developed for each of the seventeen river basins on a five-year cycle.

The document is divided into twelve chapters, each with a different focus. Each chapter identifies a particular water quality issue and provides suggestions on how those issues can be addressed to avoid or minimize future degradation.

CHAPTER 1 – THE IMPORTANCE OF WATER QUALITY

The science of hydrology has evolved to help us understand the complex water systems of the Earth and help solve water quality and quantity problems. Hydrology evaluates the location, distribution, movement and properties of water and its relationship with its environment. We must understand all of the physical, chemical and biological processes involving water as it travels through the water cycle if we are to learn how to protect it. This chapter provides a brief overview of the hydrologic cycle, explores the importance of groundwater and surface water interactions, streamflow and human impacts on water quality and quantity.

CHAPTER 2 – HOW NORTH CAROLINA EVALUATES WATER QUALITY

Basinwide water quality planning is a non-regulatory, watershed-based approach to restoring and protecting the quality of North Carolina's surface waters. This chapter provides an overview of the basinwide planning process and how North Carolina evaluates water quality. It defines water quality classifications, identifies water quality monitoring programs and explains how waters are listed on the State Impaired Waters List as required by Section 303(d) of the Clean Water Act.

CHAPTER 3 – WATER QUALITY STRESSORS

Human activities can negatively impact surface water quality, even when the activity is far removed from the waterbody. The many types of pollution generated by human activities may seem insignificant when viewed separately, but when taken as a whole, can be very stressful to aquatic ecosystems. Water quality stressors are identified when impacts have been noted to biological (benthic and fish) communities and/or water quality standards have been violated. This chapter provides an overview of how stressors are identified in a watershed, defines commonly identified stressors and reviews the water quality standards that can be listed as water quality stressors.

Chapter 4 – Sources of Water Quality Stressors

When evaluating water quality stressors, DWQ evaluates and identifies the source of the stressor as specifically as possible depending on the amount of information available for that particular watershed. Sources are most often associated with the predominant land use where the altered hydrology is able to easily deliver the water quality stressor to the waterbody. Construction, stormwater outfalls, agriculture and impervious surface are just a few of the sources that can be identified in any given watershed. This chapter provides an overview of point and nonpoint sources of pollution, identifies sources of nonpoint source (NPS) pollution and describes several state and federal programs that focus on reducing the impacts of pollution.

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.

Chapter 6 – Agriculture and Water Quality Impacts

Confined animal operations, grazing, plowing, stream access, pesticide spraying, fertilizing, planting and harvesting are all agricultural activities that may impact water quality. The major agricultural nonpoint source pollutants that result from these activities are sediment, nutrients, pathogens (i.e., bacteria), pesticide and salts. Agricultural activities can also damage habitat and stream channels. This chapter includes an overview of how agricultural activities can impact water quality, a summary of key legislative rules that effect animal operations throughout the State of North Carolina, how several federal and state agencies play an active role in protecting water quality, and how conservation and BMPs can protect water quality.

Chapter 7 – Forestry and Water Quality Impacts

Forests are an ideal land use for water quality protection because they stabilize soil and filter stormwater runoff from adjoining, non-forested areas. In order to sustain a forest's ability to protect water quality, some degree of management is often required. Timber harvesting is part of the forest renewal cycle and is usually the most intensive forest management activity that requires special attention to assure water quality is protected. Inappropriate management practices can impact water quality by destabilizing streambanks, reducing riparian vegetation and removing tree canopies. Any one of these impacts can alter the interface of the aquatic and terrestrial ecosystem, influence downstream flooding and change watershed functions. This chapter explores forestry in North Carolina. It includes information on forestland ownership, resources and management. It also includes information related to BMPs and forestry operations.

Chapter 8 – Land-Disturbing Activities and Water Quality Impacts

Land-disturbing activities are often associated with road construction and maintenance, industrial, commercial and residential development and mining operations. All of these can be a major source of pollution because of the cumulative number of acres disturbed at any given time. Even though such activities are short-lived and considered temporary sources of pollution, the impacts to water quality and overall stream function can be severe and long lasting. To avoid potential environmental and financial problems, it is essential to use the proper BMPs to control erosion and sedimentation. It is also imperative that the practices be maintained throughout the duration of the development or land-disturbing activity. This chapter provides an overview of land-disturbing activities and impacts to water quality. In includes definitions of erosion and sediment, reviews the role of state and local governments and provides a list of BMPs for controlling both sediment and erosion.

CHAPTER 9 – WASTEWATER DISPOSAL AND WATER QUALITY IMPACTS

Wastewater is used water. It includes substances such as human waste, food scraps, oils, soaps and chemicals from homes, businesses and industries. Effluent is the treated water discharged from wastewater treatment plants or other point source dischargers such as municipalities and manufacturing facilities. In order to protect water quality and aquatic life, wastewater treatment is subject to local, state and federal rules and regulations. This chapter provides an overview of the wastewater treatment process, identifies water quality impacts associated with wastewater discharge and reviews federal and state programs used to manage wastewater throughout the United States.

CHAPTER 10 – BACTERIA AND WATER QUALITY IMPACTS

Recreational waters, particularly coastal areas, are valued worldwide for their economic, ecological and cultural significance. Like many states, the livelihood of North Carolina communities that cater to water related activities can be severely impacted if bacteria levels are above the water quality standards. This chapter reviews how bacteria are used as a water quality indicator. It includes how bacteria can impact water quality, provides an overview of water quality standards for freshwater and saltwater and reviews BMPs and management strategies that can reduce bacteria numbers in waterbodies throughout the state.

CHAPTER 11 – NUTRIENTS AND WATER QUALITY IMPACTS

Nutrients refer to the elements phosphorus and nitrogen. Both are common components of fertilizers, animal and human wastes, vegetation, aquaculture and some industrial processes. Nutrients in surface waters come from both point and nonpoint sources including agricultural and urban runoff, wastewater treatment plants, forestry activities and atmospheric deposition. Nutrients in nonpoint source runoff come mostly from fertilizer and animal wastes. Nutrients in point source discharges typically come from human waste, food residues, cleaning agents and industrial processes. This chapter provides an overview of nutrients and how they can impact water quality, defines nutrient sensitive waters (NSW) and management strategies that have been adopted by the state to protect those waters, and reviews lake and estuary nutrient monitoring protocols and strategies.

CHAPTER 12 – PROTECTING WATER QUALITY

The future of our rivers, streams, wetlands and estuaries are closely linked to land use decisions made on both a public and private scale. Many of the areas are privately owned and it is the private landowner who can protect our waters through conservation and various management options. This chapter explores various options for protecting water quality and includes information related to local initiatives, planning and funding opportunities.

Protecting water quality is not only healthy for the environment, it is can also lead to societal and economic benefits. By working with landowners, public and private entities and local volunteer, civic and conservation groups, a community can protect its waters from many of the issues identified in this document. Planning on a watershed scale provides a framework to restore impaired waters and protect water quality in healthy streams. Everyone is part of the problem. Everyone must be part of the solution.

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CHAPTER 1 – THE IMPORTANCE OF WATER QUALITY

Water is one of the most important natural resources, but it is not always in the right place, available at the right time or of the right quality. Improperly discarded chemical wastes of the past, stormwater runoff, poorly maintained septic systems and many land-disturbing activities add to the problems of quality and quantity of our water supplies today. The science of hydrology has evolved to help us understand the complex water systems of the Earth and help solve water quality and quantity problems. Hydrology evaluates the location, distribution, movement and properties of water and its relationship with its environment. We must understand all of the physical, chemical and biological processes involving water as it travels through the water cycle if we are to learn how to protect it.

1.1 SUMMARY OF THE HYDROLOGIC CYCLE (A.K.A. WATER CYCLE)

The hydrologic cycle (also known as the water cycle) is complex. It describes the existence and movement of water on, in and above the earth. It involves climatic changes, the earth materials that water flows across and through and land modifications by both natural events and human activities (USGS, September 2006; Winter et al., 1998). Water is always in motion and changing forms, from liquid to vapor to ice and back again. The water cycle has been working for billions of years and all life on Earth depends on it.

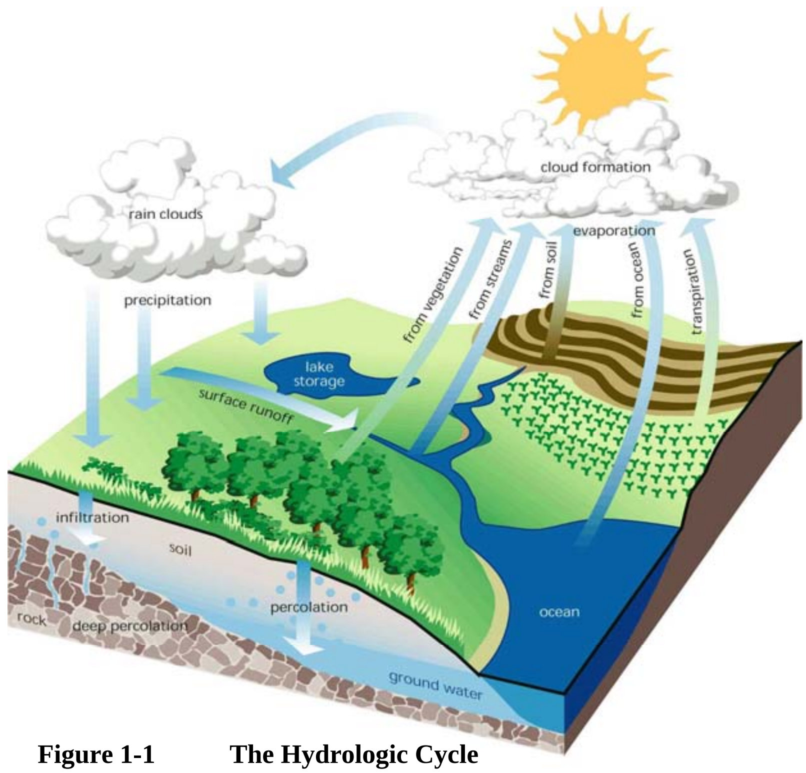

Figure 1-1 The Hydrologic Cycle

The transfer of water from precipitation to surface water and groundwater, to storage and runoff and eventually back to the atmosphere is an ongoing cycle (FISRWG, 1998).

There really is no starting point for the water cycle, and there are many pathways it can travel (Figure 1-1). Water may fall as rain or snow, or it may return to the atmosphere through evaporation. Water can be captured in polar ice caps or flow off the land to rivers and eventually to the sea. It can absorb into the soil and evaporate directly from the soil surface or be transpired by growing plants. Water can percolate through the soil to groundwater reservoirs (aquifers) where it is stored for many years. Water can also be drawn from wells or find openings in the land surface and emerge as freshwater springs. Water keeps moving only to repeat the cycle all over again (USGS, September 2006; USGS, August 2005a).

Precipitation, infiltration, evaporation, transpiration, storage and water use all play a significant role in the water cycle. Precipitation is the amount of rainfall or snowfall. Precipitation can impact streamflow, stormwater runoff, water quality and water quantity. Not all of the precipitation that falls on the land, however, flows off. Instead, some of the water will absorb into the soil where it can be used by plants and/or recharge a groundwater aquifer. Water's ability to infiltrate, or absorb, into the soil depends on many factors. The most important are soil properties, vegetation (amount and type), existing land use, and storm characteristics (i.e., amount and rate of rainfall). These same factors will also determine the quality and quantity of runoff into streams, rivers and oceans. Water that stays in the shallow soil layer will gradually move downhill, through the soil and into a stream through the streambank.

Temperature, solar radiation, wind and atmospheric pressure control the amount of water that returns to the atmosphere through evaporation. Evaporation in turn can influence the amount and type of precipitation. Transpiration is controlled by many of the same factors as evaporation but the type and amount of vegetation present within the watershed are also important. Plant roots absorb water from the surrounding soil. The water then moves through the plant to escape into the atmosphere through the leaves. Vegetation slows runoff from the land surface and allows water to seep into ground.

Reservoirs store water. They also increase the amount of water that evaporates and/or infiltrates. The storage and release of reservoir water can significantly affect streamflow patterns below the outlet. Natural lakes, groundwater aquifers and wetland may also serve as storage areas that can influence streamflow and the water cycle.

Water withdrawal also impacts how a watershed functions and interacts with the water cycle. Use might range from a few homeowners or businesses pumping small amounts of water to irrigate lawns. It could also include large municipalities, industries, mining operations and agricultural producers pumping large amounts of water to support water demands in the region (USGS, August 2005c). Either way, withdrawing water will affect the rate of evaporation, transpiration and infiltration in a watershed.

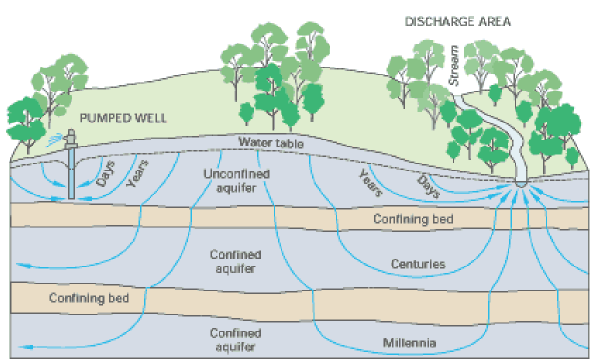

Figure 1-2 Groundwater Movement

Groundwater flow paths vary greatly in length, depth and traveltime from points of recharge to points of discharge (Winter et al., 1998).

1.1.1 GROUNDWATER

Infiltration is the downward movement of water from the land surface into soil or porous rock. Whenever water falls as rain or snow, some of the water absobs into the subsurface soil and rock. Part of the water that infiltrates will remain in the shallow soil layer. Here, it will gradually move vertically and horizontally through the soil and subsurface material. Plants, grass and trees will use some of the water in the shallow soil layer (unsaturated zone), but some of the water will move deeper, recharging groundwater aquifers (Winter et al., 1998).

Like water in the shallow soil layer, groundwater can move both vertically and horizontally (Figure 1-2). Water moving downward may meet more dense and water-resistant, non-porous rock and soil (confining bed). When this happens, groundwater flows in a more horizontal direction, generally towards streams and oceans (Winter et al., 1998).

Depending on the geography and geology of the area, groundwater can also move into deeper aquifers. Downward movement depends on the permeability and the porosity of the subsurface rock. If the characteristics of the rock allow water to move freely, groundwater can move significant distances in a matter of days. Groundwater that sinks into deep aquifers can take thousands of years to move back to the surface and into the water cycle. When it reenters the water cycle, groundwater is a major contributor to streamflow, influencing river and wetland habitats for plants and animals (Winter et al., 1998).

1.1.2 GROUNDWATER AND SURFACE WATER INTERACTIONS

Nearly all surface waters (i.e., lakes, streams, reservoirs, wetlands, estuaries) interact with groundwater. As a result, removing water from streams can deplete groundwater supplies, and conversely, groundwater pumped from an aquifer can deplete water from streams, lakes or wetlands. For these reasons, polluted surface water can degrade groundwater just as contaminated groundwater can degrade surface water (Winter et al., 1998). These interactions can influence water supplies, water quality and aquatic environments characteristics. Both groundwater and surface water are essential for watershed management and water quality protection.

Until recently, scientific understanding of groundwater and surface water interactions was limited to large alluvial stream and aquifer systems. In recent years, however, interest in interactions between groundwater and surface water has grown. This interest is the result of widespread concerns related to water supply, contamination of drinking water supplies, acidification of surface waters caused by atmospheric deposition, eutrophication of lakes, loss of wetlands due to development and other changes in aquatic environments. Because of these concerns, groundwater and surface water studies have expanded to include many other settings, including headwater streams, lakes, wetlands and coastal areas (Winter et al., 1998).

STREAMS

Streams interact with groundwater in three ways. Streams can gain water from the inflow of groundwater through the streambed (gaining stream, Figure 1-3*A*); streams can lose water to groundwater by outflow through the streambed (losing streams, Figure 1-3*B*); or they can do both, gaining in some reaches and losing in others. In gaining streams, the water table near the stream must be higher than the altitude of the stream itself. The opposite is true for losing streams. Losing streams can be connected to the groundwater system by a continuous saturated zone, or it can be "disconnected" (Figure 1-3*C*). Water withdrawn from either the groundwater or surface water can influence the water level in the stream. Streamflow in streams that are disconnected from the groundwater system, however, are not affected when water is withdrawn (Winter et al., 1998).

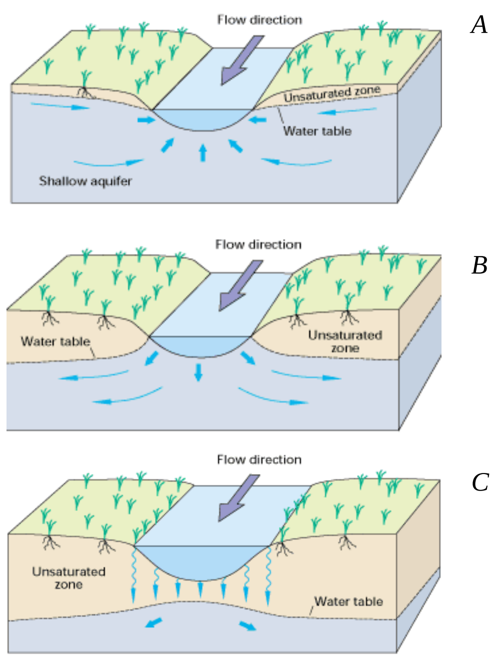

Figure 1-3 Groundwater and Stream Interactions

Gaining streams receive water from groundwater systems (*A*) and losing streams lose water to groundwater systems (*B*). Disconnected streams are separated from the groundwater system by an unsaturated zone (*C*) (Winter et *al*., 1998).

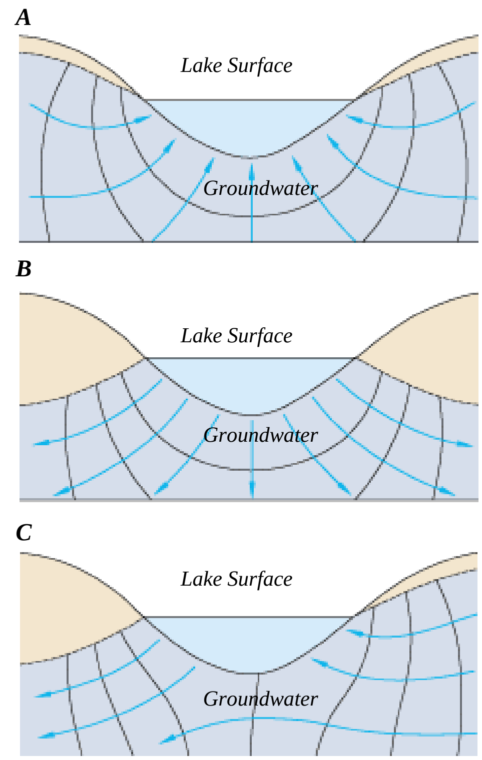

Figure 1-4 Groundwater and Lake Interactions

Lakes can receive groundwater inflow (*A*), lose water (*B*) or both (*C*) (Winter et *al*., 1998).

LAKES

Like streams, lakes interact with groundwater systems in three basic ways. Some lakes receive groundwater inflow throughout the entire lakebed; some lose water throughout the lakebed; and (perhaps most) lakes receive inflow and lose water at the same time (Figure 1-4). The water levels in natural lakes do not change as quickly as levels in streams. They also take longer to replenish. Lakes have a larger surface area and often less shaded than stream segments.

Consequently, evaporation has a greater influence on lakes than on streams. Lake sediments can play a significant role in the amount of inflow or loss. Sediments can also influence the cycling of chemical and biological material (Winter et al., 1998).

Reservoirs

Reservoirs are man-made lakes designed primarily to control the flow and distribution of surface water. Since most reservoirs are constructed in stream valleys, they share many characteristics with streams and lakes when it comes to groundwater interactions. Like streams, reservoirs can have widely fluctuating water levels. The continuous flushing of water is affected by climatic events and water use. Like lakes, reservoirs can experience significant water loss to evaporation. They also direct the cycling of chemical and biological materials (Winter et al., 1998).

Wetlands

Wetlands can be found in climates and landscapes that cause groundwater to discharge directly to the land surface or in areas that prevent water from draining from the land. Wetlands can receive groundwater inflow, recharge groundwater or both. Those found on low points or depressions in the landscape interact with groundwater much like streams and lakes. Unlike streams, lakes and reservoirs, however, wetlands do not always occupy low points or depressions in the landscape. They can also be found on slopes (i.e., fens) or on drainage divides (i.e., some types of bogs). Wetlands found on slopes commonly receive a continuous supply of water from a groundwater source. Wetlands on drainage divides, uplands or extensive flat areas, receive much of their water from precipitation (Winter et al., 1998). Different water sources often lead to very different chemical and biological characteristics.

Coastal Systems

Because coastal freshwater aquifers are so physically close to saltwater, unique issues arise. Two primary issues are saltwater intrusions into freshwater aquifers and changes in the amount and quality of freshwater discharging to coastal saltwater ecosystems. Saltwater intrusion is the movement of saline water into freshwater aquifers.

In coastal areas where groundwater is the primary source of drinking water, saltwater can enter into the freshwater aquifer especially in areas of heavy groundwater use. It is most often caused by groundwater pumping from coastal wells but can also occur during times of drought. Saltwater intrusion is unique because it reduces the freshwater storage capacity and can lead to the abandonment of water supply wells where concentrations of dissolved ions exceed drinking water standards. Salinity and nutrient concentrations can also significantly alter a coastal ecosystem. Excess nitrogen and phosphorus from groundwater or surface water can lead to red tides, fish kills and destroy coral reefs, sea grass habitats and shellfish growing areas (Barlow, 2003).

1.1.3 STREAMFLOW

Streamflow is the movement of water in a natural channel. A major element of the water cycle, it is always changing. It is also the main pathway by which water moves from the land to the ocean. Streamflow is largely influenced by the amount of precipitation (i.e., rain, snow, hail, sleet) that runs off of the land surface and into streams or rivers. Streamflow also determines the size and shape of a stream channel.

Nature and humans can impact streamflow. Surface runoff, evaporation, transpiration, groundwater discharge, groundwater recharge, sedimentation, the formation or dissipation of glaciers, snowfields and permafrost are all natural mechanisms influencing streamflow. Human impacts include surface water withdrawals and interbasin transfers, construction and removal of reservoirs and stormwater detention ponds, stream channelization, drainage or restoration of wetlands, land-use changes (i.e., urbanization of forests and agricultural lands) and wastewater outfalls (USGS, August 2005b).

Baseflow is precipitation that infiltrates the ground and moves slowly through the substrate before it reaches the stream channel. Baseflow and stormflow can greatly influence the quantity and speed of water moving through a stream channel. Groundwater sustains streamflow during periods of little or no precipitation. Stormflow, on the other hand, is precipitation that reaches a stream channel within a short period of time through overland or underground routes. At any given time, streamflow may contain water from one or both sources. Streams can be categorized based on the balance and timing of baseflow and stormflow.

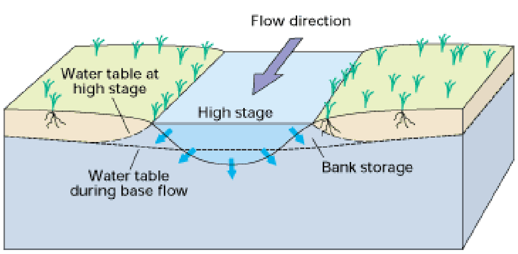

Figure 1-5 Streamflow and Bank Storage

When stream levels rise higher than adjacent groundwater levels, stream water moves into streambanks as bank storage (Winter et *al*., 1998).

Under normal weather conditions, streamflow is largely composed of groundwater (baseflow), and it follows the natural flow and movement of the stream channel. Bank storage, or bankfull stage, occurs when there is a rapid rise in the stream's water level. This causes water to move from the stream into the streambanks. Bank storage usually occurs during storm events, rapid snowmelt or release of water from an upstream reservoir. The water absorbs into the streambanks, maintaining streamflow and keeping the stream within its channel. As long as the water does not overtop the streambanks, most of the water that enters the streambanks returns to the stream within a few days or weeks.

Bank storage tends to reduce flood peaks and supplements streamflow during low flow conditions. If the rise in water overtops the streambanks and exceeds the stream's carrying capacity, flooding occurs on the land surface. Depending on the frequency, magnitude and intensity of the flooding, water may infiltrate and recharge groundwater aquifers or it can slowly return to the stream channel (USGS, September 2006; Winter et al., 2006).

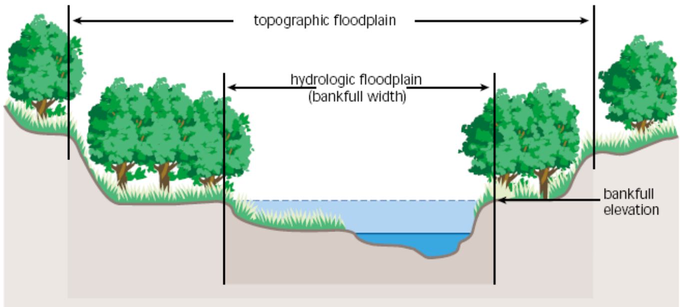

Figure 1-6 Hydrologic and Topographic Floodplains

A hydrologic floodplain is defined by the bankfull elevation. The topographic floodplain includes the hydrologic floodplain and other land features up to a defined elevation. Both floodplains store water and sediment during heavy rain events (FISCRWG, October 1998).

Almost all natural streams have a bankfull stage with a recurrence interval of one to 1½ years. This means that during a two-year storm event, unaltered or natural stream channels will flood. Water will move through the channel and the floodplain until the stream is back to its normal elevation. Depending on the amount of precipitation or snowmelt, excess streamflow will either enter the hydrologic or topographic floodplain. The hydrologic floodplain is land adjacent to the baseflow channel, but below the bankfull stage (Figure 1-6). Because many streams have been channelized over the years, not every stream has a hydrologic floodplain. The topographic floodplain is land adjacent to the channel. It includes the hydrologic floodplain and other land features up to an elevation based on the flood peaks and frequency (i.e., 100-year and 500-year flood). Floodplains provide temporary storage for water and sediments moving through the watershed during rain events (FISCRWG, October 1998).

Rivers react differently to storms and rain events depending on their size. In a small watershed, a storm can cause 100 times more water to flow by each minute, compared to normal flow conditions. Water levels in small rivers tend to rise and fall in just minutes or hours. Larger rivers, however, may take days to rise and fall. The flooding can last for a number of days because it may take several hours or even days for water to travel from the upper part of the watershed to the lower part of the watershed.

Streams are classified as ephemeral, intermittent or perennial based on their baseflow. Ephemeral streams flow only during or immediately after periods of precipitation. Ephemeral streams usually flow less than 30 days per year. Intermittent streams flow only during certain times of the year (i.e., seasonal streams) and streamflow usually lasts longer than 30 days per year. Perennial streams flow continuously. If neither baseflow nor stormflow provides water to a channel, the stream will go dry (FISCRWG, October 1998).

Stream ecosystems depend on variable streamflow. High flows carry and disperse nutrients and sediments. High flows also reconnect floodplain wetlands to the stream channel. Low flows, especially in large rivers, allow stream vegetation to disperse so that populations of a single species exist in several locations along the stream corridor (FISCRWG, October 1998). Both high flows and low flows are important. Each improves biological productivity and maintains diversity throughout the stream corridor.

1.1.4 MINIMUM STREAMFLOW

Because stream ecosystems depend on streamflow, conditions may be placed on dam operations. Some conditions specify mandatory minimum releases in order to maintain adequate water quantity and quality in the length of stream affected by an impoundment. One of the primary purposes of the North Carolina dam safety law is to ensure minimum streamflows below dams. The North Carolina (NC) Division of Water Resources (DWR), in conjunction with the Wildlife Resources Commission (WRC), recommend conditions related to flow release to satisfy minimum instream requirements. The NC Division of Land Resources (DLR) issues permits for dam construction, repair and maintenance. The permits specify minimum release requirements.

Under the authority of the U.S. Federal Power Act, the Federal Energy Regulatory Commission (FERC) licenses all non-federal dams located on navigable United States waters that produce hydropower for interstate commerce. The license may include requirements for flows for either designated in-stream or off-stream uses.

Under the authority of Section 404 of the Clean Water Act (CWA), the U.S. Army Corps of Engineers (USACE) issues permits for the discharge of fill material into navigable waters. The permit may also include requirements for flows for designated in-stream or off-stream uses. A Section 404 permit applies to dams under state and federal regulatory authorities mentioned above. It also covers structures (i.e., weirs, diversions, small dams) not under the USACE authority.

1.1.5 STREAMFLOW AND WATER QUALITY UNDER DROUGHT CONDITIONS

Water quality problems associated with rainfall events usually involve degradation of aquatic habitats. High flows may carry increased amounts of substances like metals, oils, herbicides, pesticides, sand, clay, organic material, bacteria and nutrients. These substances may be toxic to aquatic life (fish and insects), deplete oxygen and/or cause sedimentation. During drought conditions, these pollutants become more concentrated in streams due to reduced flow. Summer months are generally the most critical months for water quality. Dissolved oxygen is naturally lower due to higher water temperatures, algae grow more readily due to longer periods of sunlight, and streamflows are reduced. Long-term drought can compound these problems and impacts to water quality and aquatic life can be catastrophic.

Acute impacts due to stormwater runoff are actually minimized during a drought. However, when rain events do occur, the pollutants collected on the land surface are quickly delivered to streams. When streamflows are below normal, the polluted runoff makes up a larger percentage of the water flowing in the stream.

Point sources may also have water quality impacts during a drought, even though permit limits are being met. Facilities that discharge wastewater have permit limits based on the historic low flow conditions. During droughts, these wastewater discharges make up a larger percentage of the water in streams. Consequently, this may result in lower dissolved oxygen concentrations and a temporary increase in other pollutants.

As streamflow decreases during drought conditions, habitat areas decrease, particularly along lake shorelines. Dry conditions combined with increased water withdrawals strains available water resources even further. Less habitat, lower streamflows, low dissolved oxygen levels and higher water temperatures increases the potential for large fish kills. These conditions may stress fish to the point where they become more susceptible to disease and stressors that normally would not harm them.

These are also areas where longer retention times due to decreased flows allow algae to take full advantage of the nutrients present. The result is algal blooms. During the daylight hours, algae greatly increase the amount of dissolved oxygen in the water, but at night, algal respiration and die off may cause dissolved oxygen levels to drop low enough to cause fish kills. Besides increasing the frequency of fish kills, algal blooms may also cause problems for water treatment plants because of taste and odor problems in the finished drinking water.

1.2 WATERSHEDS

A watershed is the geographic area where all water, sediment and dissolved materials running off of the land drain to a given stream, river, lake, wetland or coastal water (Figure 1-7). Surface water and all of the underlying groundwater make up a watershed. The terms catchment (catchment area, catchment basin), drainage area and river basin are often used interchangeably with the word watershed.

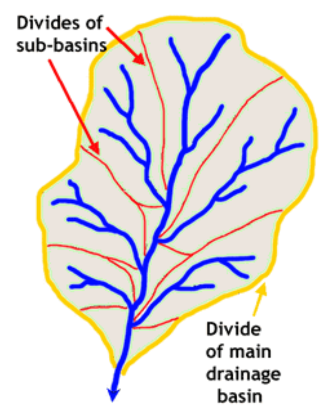

Figure 1-7 Watersheds

Larger watersheds contain many smaller watersheds. Here, the main watershed (yellow boundary) contains several smaller watersheds or catchment areas (red boundaries). Blue lines represent surface water (National Atlas, October 2006).

Topographically, ridges, hills or mountains separate watersheds. Watershed sizes vary depending on where the divide falls. A watershed can be as small as a footprint in the mud or large enough to encompass the entire land area that drains water to the Mississippi and Missouri Rivers and the Gulf of Mexico. Larger watersheds contain many smaller watersheds (USGS, September 2006; USGS, August 2005c).

Geomorphology is the study of surface forms on the earth and the processes that developed those forms. Geologically, geomorphic processes are the primary way that drainage patterns, channel design, floodplains and other watershed features. Erosion, sediment transport and sediment deposition are all geomorphic processes that influence watershed function (FISCRWG, October 2006). No matter how you look at it, watersheds are important. Many things (natural and human-induced) affect streamflow, water quality and water quantity.

1.2.1 WATERSHED FUNCTIONS AND STREAMFLOW

Watersheds and their streamflow vary greatly depending on many factors. Some factors are underlying geology, topography, drainage area, soil characteristics, climate and vegetation. Despite their differences, however, all watersheds should perform the same functions – catch, store and safely release water. These functions allow a watershed to recharge a groundwater aquifer, maintain a normal streamflow and provide clean water for aquatic and terrestrial plants and animals (Palmetto Conservation Foundation and South Carolina DHEC, November 1999; FISCRWG, October 1998).

1.2.2 Understanding a Stream Corridor and How It Influences a Watershed

Stream corridors are complex ecosystems that have significant economic, social, cultural and environmental value. They regulate streamflow, store water, remove harmful materials (i.e., bacteria and some nutrients) from water and provide habitat for aquatic and terrestrial plants and animals. They also function as dynamic crossroads in the landscape where materials (i.e, minerals, nutrients), energy and organisms meet and interact. Much of this movement is dependent on water. The movement of water, materials, energy and organisms within a multidimensional framework forms the physical structure of a stream corridor (FISCRWG, October 1998).

Stream corridors usually consist of three major elements – stream channel, floodplain and transitional upland fringe. Stream channels and floodplains are discussed in previous sections of this chapter. Transitional upland fringes are defined as the "transitional" zone between the floodplain and the surrounding landscape (FISCRWG, October 1998). Changes within the surrounding watershed will impact the physical, chemical and biological processes within the stream corridor.

Stream corridors work within natural ranges to move sediment, control temperature, streamflow and other variables creating a dynamic equilibrium. When changes in a watershed go beyond their natural range, equilibrium is lost and the watershed no longer functions in the same way. Over the years, human activities have contributed to changes in the dynamic equilibrium of stream systems across the nation. Humans often manipulate the stream corridor for a wide variety of purposes including domestic and industrial water supplies, irrigation, transportation, hydropower, waste disposal, mining, flood control, timber management, recreation, aesthetics, and more recently, fish and wildlife habitat. Increases in human population and industrial, commercial and residential development place heavy demands on the country's stream corridors (FISCRWG, October 1998).

1.3 Stream Modification

Natural streams share certain physical characteristics, regardless of their location or geologic condition. Human activities (particularly engineering activities), however, can greatly influence stream hydrology. Physical activities such as the construction of dams, channels and diversions can dramatically impact the geomorphology and the hydrology of a stream corridor.

While most engineered channel modifications concentrate on the conveyance of floodwater, many often neglect sediment transport. A stream channel that has been straightened, or channelized, and enlarged to carry a 50-year storm, for example, will begin to form a smaller channel, point bars, floodplains and meanders as sediment moves from one point to another. Channelized streams can become unstable as they lose their shape and slope through erosion.

Unstable channel conditions ultimately lead to degraded water quality because of excessive sediment loading.

1.3.1 IMPACTS FROM DAMS

Dams can range in size from small temporary structures constructed of stream sediment to large multipurpose structures for hydroelectric power. No matter their size, dams can alter streamflow, impact migratory aquatic species and affect water quality. Dams also disrupt the flow of sediment and natural organic material, and change the composition of vegetative communities and groundwater infiltration throughout the entire stream corridor.

For dams that release water, discharge may vary widely monthly, daily or even hourly in response to water use and purpose. Because suspended sediment and natural organic materials tend to drop out of the water column behind the dam, the amount of nutrients available to downstream organisms is reduced. In the case of hydroelectric dams, discharge can influence the water temperature, depending on where and how the water is released. Changes in discharge volume can have a significant impact on streambank erosion and the subsequent loss of streambank vegetation and aquatic species. Water discharged from dams can also lower oxygen concentrations immediately downstream of the release, potentially impacting fish and aquatic insect communities (FISCRWG, October 1998).

1.3.2 IMPACTS FROM CHANNELIZATION

Like dams, stream channelization or diversions can significantly alter a stream corridor. Channelization can disrupt riffle and pool sequences, increase stream velocity and even elevate flood heights. Instream modifications, such as creating a uniform cross section or placing the stream in a concrete channel or culvert, result in fewer habitats for organisms living in or on the stream's sediments. When sediments, natural organic material and woody debris are lost, biodiversity and watershed functions are reduced (FISCRWG, October 1998).

Several examples of channelized streams can be found in eastern North Carolina in the middle and lower coastal plains and tidewater regions. Channelization began as early as the 1700s in order to improve overland water drainage and provide more land for agricultural production. Consequently, the groundwater table has been lowered. This impacted the hydrology, and wetlands lost the ability to store water, trap sediments and filter pollutants. Channelization also allows more freshwater to enter estuaries and coastal ecosystems, throwing off the delicate balance of a saline coastal environment (WECO, 2003).

1.3.3 INTERBASIN TRANSFERS

Table 1-1 **Interbasin Transfers** Factors that are used to determine whether a certificate should be issued for interbasin transfers.
❑ Necessity, reasonableness and beneficial effects of the transfer; ❑ Detrimental effects on the source and receiving basins, including effects on water supply needs, wastewater assimilation, water quality, fish and wildlife habitat, hydroelectric power generation, navigation and recreation; ❑ Cumulative effect of existing transfers or water uses in the source basin; ❑ Reasonable alternatives to the proposed transfer; and ❑ Any other factors and/or circumstances necessary to evaluate the transfer request.

Throughout North Carolina, many users rely on surface water as their sole source for drinking water. Surface water can also be used for commercial, industrial and agricultural purposes, but often there is not enough water in the right place. If this happens, water can be transferred from one watershed to another via pumps and pipelines.

Water users in North Carolina are required to register surface water transfers with the NC Division of Water Resources (DWR) if they transfer 100,000 gallons per day (GPD) or more. Entities that wish to transfer more than the minimum quantity allowed by the Interbasin Transfer (IBT) law (usually 2.0 MGD), must obtain a certificate from the NC Environmental Management Commission (General Statute 143-215.22I). The river basin boundaries that apply to these requirements are designated on a map entitled
Major River Basins and Subbasins in North Carolina, on file in the Office of the Secretary of State (General Statute 143-215.22G). The boundaries differ slightly from the seventeen major river basins delineated by the NC Division of Water Quality (DWQ).

In determining whether an IBT certificate should be issued, the state must determine that the overall benefits of a transfer outweigh the potential impacts (Table 1-1). The IBT law also requires that an environmental assessment (EA) or environmental impact statement (EIS) be prepared in accordance with the State Environmental Policy Act (SEPA) as supporting documentation for a transfer petition.

1.4 WATER QUALITY AND QUANTITY

Water quality is a term used to describe water's chemical, physical and biological characteristics. The term is usually used to describe water's suitability for a particular purpose (i.e., drinking water, recreation, aquatic life) (USGS, August 2005d). The vulnerability of surface water and groundwater to degradation depends on the interactions and interconnections between surface water and groundwater, the atmosphere, natural landscape features, human activities, and aquatic health (Figure 1-8).

Streamflow affects many issues related to water quality and water quantity – pollutant concentration, water temperature, aquatic habitat and recreational uses. One factor cannot be separated from the other (Table 1-2). Reducing the water quantity of any particular waterbody can negatively impact all of the uses for that waterbody (Richter, 2003).

Population growth increases the pressures on natural ecosystems. Bacteria and microorganisms are being found in many drinking water supplies, and chemical pollutants are detected in many streams and rivers. Their presence endangers humans as well as plant and animal species. Sewage spills have occurred, forcing people to boil water, and stormwater runoff is delivering pesticides, fertilizers and automotive fluids to urban and rural streams (USGS, August 2005d). If water pollution is to be reduced or even eliminated, each individual, each municipality, business and industry and each state should be aware of pollution contributions and take actions to reduce them.

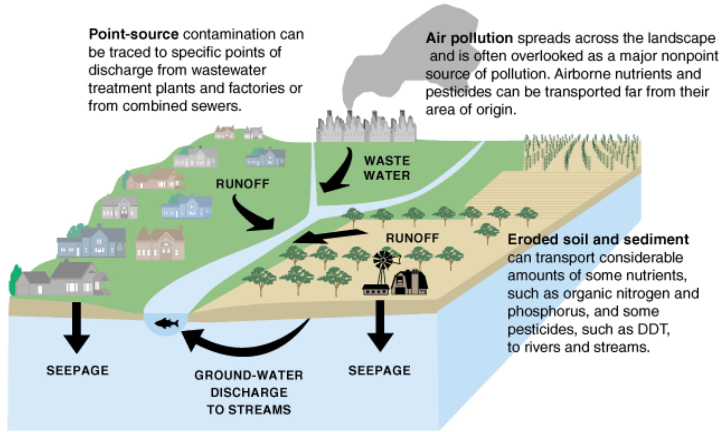

Figure 1-8 Impacts to Water Quality

The vulnerability of surface water and groundwater to degradation depends on the interactions and interconnections between surface water and groundwater, the atmosphere, natural landscape features, human activities, and aquatic health (USGS, August 2005d).

1.4.1 Population Growth and Land Cover Changes Impacts on Watersheds

Population growth results in dramatic impacts on the natural landscape. The most obvious impact is the expansion of urban and suburban areas. New stores, roads and subdivisions are products of growing populations. Not so obvious, however, is the rate at which rural landscapes are converted to developed land. Between 1982 and 1997, the United States population increased by 15 percent. Over the same period, developed land increased by 34 percent – more than double the rate of population growth (USDA-NRCS, 2001; U.S. Census Bureau, 2000). Locally, the trend can be even more pronounced. For example, the urban area of Charleston, South Carolina expanded 250 percent between 1973 and 1994 while its population grew by only 40 percent (Allen and Lu, 2000).

Impervious surfaces are materials that prevent infiltration of water into the soil and include roads, rooftops and parking lots. Impervious surfaces alter the natural hydrology, prevent the infiltration of water into the ground and concentrate the flow of stormwater over the landscape.

Table 1-2 Water Quality and Water Quantity Issues
Four major issues concerning water quality and quantity (Richter, 2003).

Pollutant Concentration Higher flow is important for dilution of pollutants. Water quality standards are often violated during abnormally low flow conditions.	**Recreational Use** Many recreational activities (i.e., whitewater rafting, canoeing) depend on certain levels of flow. Flow also affects swimming and fishing.
Water Temperature More water takes longer to warm; therefore, the amount of water in a stream will ultimately influence how warm the water becomes. Higher flows protect sensitive, coldwater aquatic species from harmful or even lethal water temperatures.	**Aquatic Habitat** A river or stream can support more abundant and diverse aquatic life when flow is higher. Pools, runs and secondary channels are deeper, more varied and more abundant during high flows.

In undeveloped watersheds, stormwater filters down through the soil, replenishing groundwater aquifers. Vegetation holds soil in place, slows the flow of stormwater over land and filters out pollutants by slowing the overland flow of the water and trapping some pollutants in the root system.

When the imperviousness of a watershed increases, the larger volume of stormwater raises the possibility of flooding and reduces the potential for pollutants to settle out. As a result more pollution is delivered to drinking water supplies. Too much paving and hardening of a watershed can reduce infiltration and groundwater levels. This reduction decreases the availability of aquifers, streams and rivers for drinking water supplies (Kauffman and Brant, 2000) (Figure 1-9).

1.4.2 Population Growth and Urbanization Impacts on Aquatic Resources

Urbanization poses one of the greatest threats to aquatic resources. Small towns and communities are usually not considered urban centers, but even small concentrations of urbanization can have significant impacts on local waterways. For example, a one-acre parking lot produces 16 times more runoff than a one-acre meadow (Schueler and Holland, 2000). A wide variety of studies over the past decade converge on a central point: when more than 10 percent of the acreage in a watershed is covered in roads, parking lots, rooftops, and other impervious surfaces, the rivers and streams within the watershed become seriously degraded. Studies show that if urbanized areas cover more than 25 percent of a watershed (Figure 1-10), there is a point where the decline in the health of the ecosystem is irreversible (Beach, 2002; Galli, 1991).

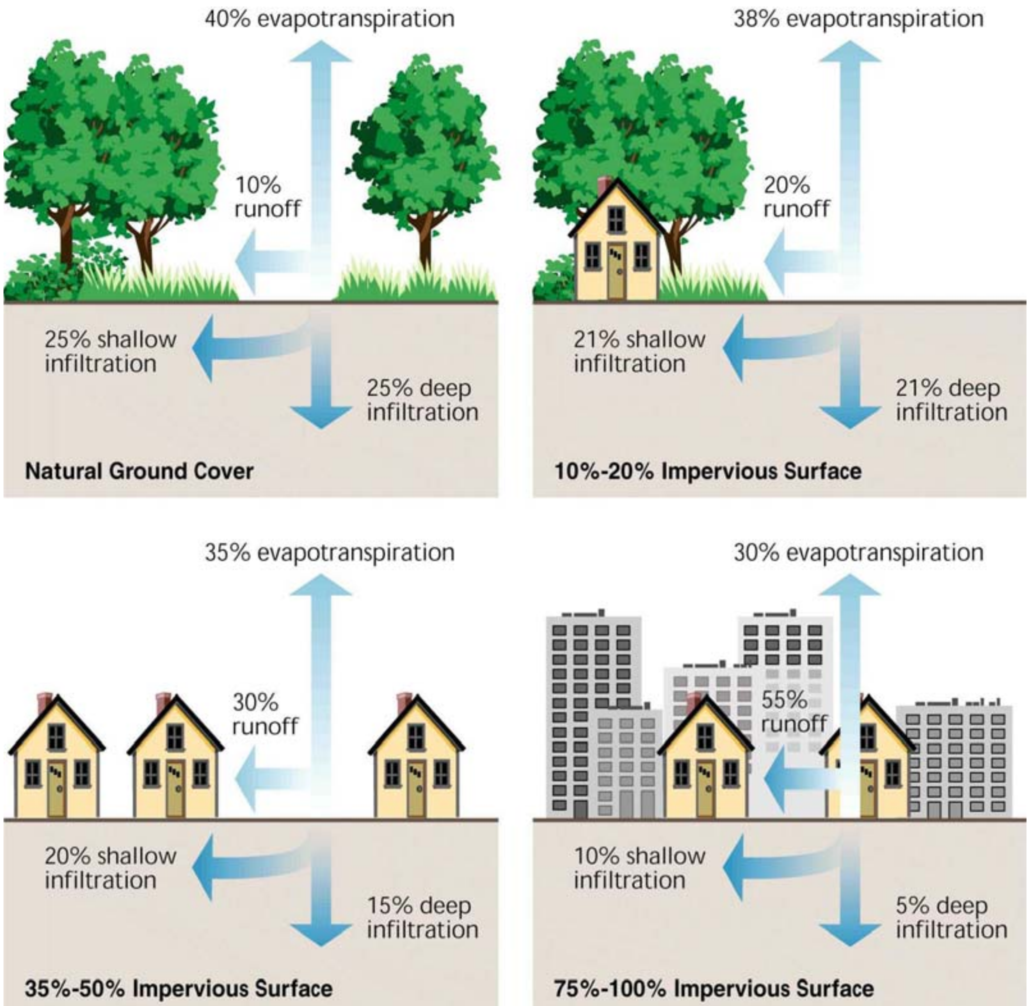

Figure 1-9 Impervious Surfaces and Surface Runoff

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).

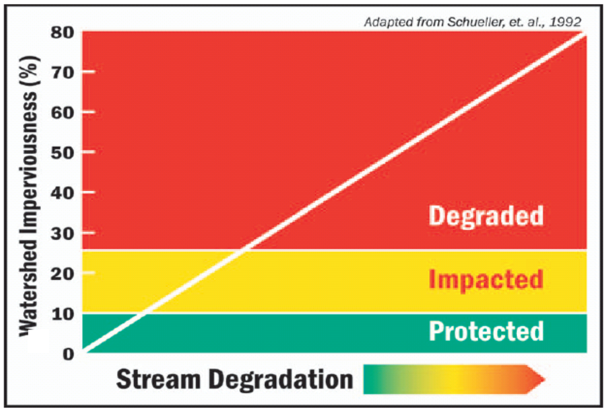

Figure 1-10 Imperviousness and Stream Degradation

Studies show that if urbanized areas cover more than 25 percent of a watershed, there is a point at which there is irreversible decline in the health of the ecosystem (Beach, 2002; Schueller, et *al*., 1992; Galli, 1991).

Greater numbers of homes, stores and businesses require greater quantities of water. They also lead to more discharge and runoff of increased quantities of waste and pollutants into the state's streams, rivers, lakes and groundwater. Thus, just as demand and use increases, some of the potential water supply is also lost (Orr and Stuart, 2000).

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). As watershed vegetation is replaced with impervious surfaces, the ability of the landscape to absorb and diffuse the effects of natural rainfall is diminished.

Urbanization results in increased surface runoff and correspondingly earlier and higher peak streamflows after rainfall. Flooding frequency also increases. These effects are compounded when small streams are channelized (straightened) or piped, and storm sewer systems are installed to increase transport of stormwater downstream. Bank scour from these frequent high flow events tends to enlarge streams and increase suspended sediment. Scouring also destroys the variety of habitat in streams, leading to degradation of aquatic insect populations and the loss of fisheries (EPA, 1999).

1.4.3 Water Quantity and Water Use

Streams and lakes are the most visible part of the water cycle; however, these freshwater supplies represent only about three percent of all the water on Earth. Freshwater lakes, wetlands and swamps account for only 0.3 percent of that total and rivers only hold about 0.006 percent (Figure 1-11) (USGS, August 2005e). In 2000, the United States Geological Survey (USGS) found that 408 billion gallons of water were withdrawn for use in the United States each day. Seventy-nine percent of the withdrawals were from surface water, and the remaining 21 percent was from groundwater aquifers. Eighty-one percent of the water withdraws were freshwater and 19 percent were saline. It is interesting, however, that even though the population in the United States increased by about 33 million

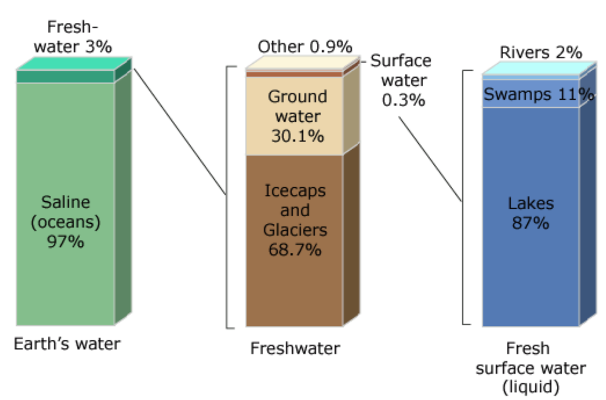

Figure 1-11 Distribution of the Earth's Water

Only a small fraction of the water on the Earth's surface is freshwater. Of that, only 0.3 percent is in the form of surface water (USGS, August 2005e; Gleick, 1996).

individuals between 1990 and 2000, the average use per person decreased from 1,620 gallons per person per day to 1,430 gallons per person per day (Figure 1-12).

Over the years, the percent of the population served by public water suppliers (i.e., water treatment plants, commercial use) has risen from 62 percent in 1950 to 85 percent in 2000. Public water suppliers deliver water to households (domestic), industries, commercial businesses, and other municipal users. Public supply and water used for livestock, aquaculture and mining constituted about 14 percent of the total water use. Self-supplied industrial withdraws were estimated at 5 percent, and withdrawals for irrigation accounted for 34 percent.

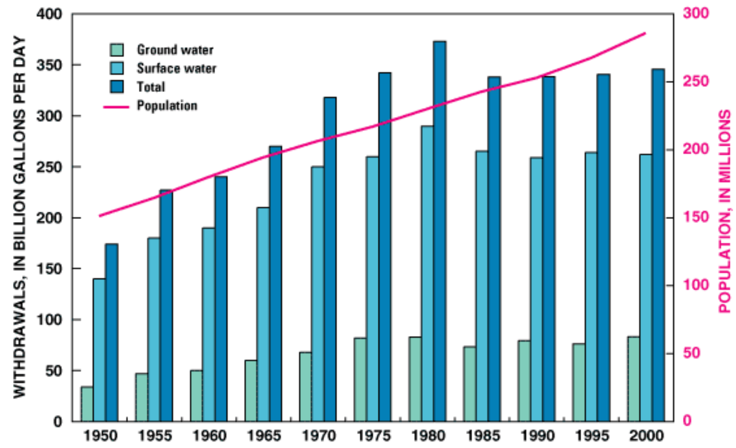

Figure 1-12 Trends in Population and Water Withdrawals

Total withdraws steadily increased from 1950 to 1980 but have varied less than three percent since 1985. In fact, the per capita per person per day actually decreased between 1990 and 2000 despite a population increase (Hudson et *al*., 2004).

By far the largest water withdrawal is associated with thermoelectric power plants. They accounted for 48 percent of the total water withdrawals. Surface water accounted for 99 percent of the total with one-third drawn from saline waters (Hudson et *al*., 2004; Lumin et al., 2005).

Water is essential for everyday use by both plants and animals. It is generally thought of as a renewable resource even though it depends on various parts of the water cycle. The amount of water in streams, lakes, reservoirs, and groundwater is always changing due to inflows and outflows, land use changes and climatic conditions. Over time, engineering and technology has allowed humans the opportunity to live in places where nature doesn’t supply enough water or where water is not available during certain parts of the year. If humans are to continue living in these areas, water will need to be used more efficiently. Additional changes in technology, State and Federal laws, economic factors and an increased awareness of water conservation are necessary if the rivers, lakes, reservoirs and aquifers are to have enough water for future generations.

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CHAPTER 2 – HOW NORTH CAROLINA EVALUATES WATER QUALITY

Basinwide water quality planning is a non-regulatory, watershed-based approach to restoring and protecting the quality of North Carolina's surface waters. The North Carolina Division of Water Quality (DWQ) prepares basinwide water quality plans (basin plans) for each of the seventeen major river basins in the state (Figure 2-1). Even though basin plans are prepared by DWQ, their implementation and the protection of water quality entail the coordinated efforts of many agencies, local governments and stakeholders throughout the state. This chapter provides an overview of the basinwide planning process and how North Carolina evaluates water quality. It defines water quality classifications, identifies water quality monitoring programs and explains how waters are listed on the State Impaired Waters List as required by Section 303(d) of the Clean Water Act.

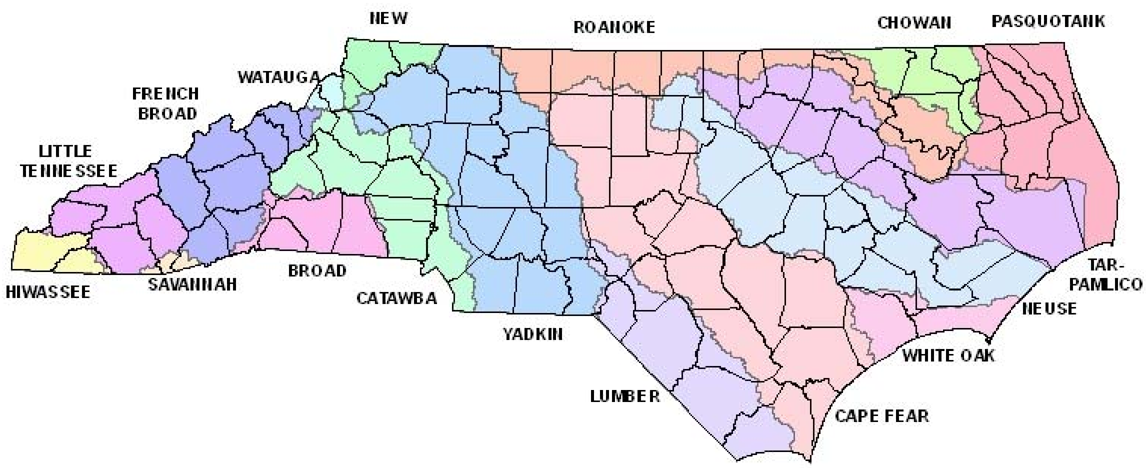

FIGURE 2-1 NORTH CAROLINA'S RIVER BASINS

2.1 BASINWIDE PLANNING PROCESS

The goals of basinwide planning are to identify water quality problems and restore full use of impaired waters; identify and protect high value resource waters; and protect unimpaired waters while allowing for reasonable economic growth. DWQ accomplishes these goals by collaborating with regional and local agencies to develop appropriate management strategies; assuring equitable distribution of waste assimilative capacity; evaluating the cumulative effects of pollution; improving public awareness and involvement; and regulating point and nonpoint sources of pollution where other approaches are unsuccessful. By collaborating with regional and local agencies, DWQ can identify and provide agencies information related to financial and funding opportunities.

Preparation of a basinwide water quality plan is a continuous process that results in a basin plan at least every five years. The process is broken down into three phases (Table 2-1). To assure that basinwide plans are accurately written and effectively implemented, it is important for

Table 2-1 Basinwide Planning Process

Water Quality Data Collection and Identification of Goals and Issues	Data Analysis and Information Collected from State and Local Agencies	Preparation of Draft Basin Plan, Public Review, Approval of Plan, Issue NPDES Permits, and Begin Implementation of Plan
❑ Identify sampling needs ❑ Conduct biological monitoring activities ❑ Conduct special studies and other water quality sampling activities ❑ Coordinate with local stakeholders and other agencies to continue to implement goals within current basinwide plan	❑ Gather and analyze data from sampling activities ❑ Develop use support ratings every two years for the Impaired waters list ❑ Conduct special studies and other water quality sampling activities ❑ Coordinate state and local agencies to establish goals and objectives ❑ Identify and prioritize issues ❑ Develop preliminary pollution control strategies ❑ Coordinate with local stakeholders and other state/local agencies to identify implementations needs	❑ Develop draft basinwide plan based on water quality data, use support ratings, and recommended pollution control strategies ❑ Circulate draft basinwide plan for review and present draft plan for public review ❑ Revise plan (when appropriate) to reflect public comments ❑ Submit plan to Environmental Management Commission for approval ❑ Issue NPDES permits ❑ Coordinate with other agencies and local interest groups to prioritize implementation actions ❑ Conduct special studies and other water quality sampling activities

citizens and local stakeholders to participate in all phases of the planning process. DWQ is continually coordinating with the Soil and Water Conservation Districts (SWCD), council of governments, NC Cooperative Extension Service Centers, the county Natural Resources Conservation Service (NRCS) Centers, and stakeholder groups to develop language and identify water quality concerns throughout the state. Citizens and local communities can participate by contacting their county extension service, local SWCD or the basin planners directly.

Basinwide planning and water quality management benefits water quality by focusing resources on one river basin at a time;

- ❑ Using sound ecological planning and fostering comprehensive permitting strategies on a watershed scale;
- ❑ Ensuring better consistency and equitability by clearly defining the program's long-term goals and approaches regarding permits and water quality improvement strategies;
- ❑ Fostering public participation to increase involvement and awareness about water quality; and
- ❑ Integrating and coordinating programs and agencies to improve implementation of point and nonpoint source pollution reduction strategies.

2.2 North Carolina Surface Water Classifications and Standards

Waters in North Carolina were classified for their "best use" beginning in the early 1950s, with classification and water quality standards for all the state's river basins adopted by 1963. This effort entailed identifying all named waterbodies on USGS 7.5 minute topographic maps; conducting river basin studies to document sources of pollution and appropriate best uses; and formal adoption of standards/classifications through public hearings.

Table 2-2 Primary and Supplemental Surface Water Classifications

Primary Freshwater and Saltwater Classifications	
Class*	**Best Uses**
C and SC	Aquatic life propagation/protection and secondary recreation.
B and SB	Primary recreation and Class C and SC uses.
SA	Suitable for commercial shellfish harvesting and SB and SC uses.
WS	*Water Supply (WS)*: Assigned to watersheds based on land use characteristics. The WS classifications have management strategies to protect the surface water supply. For WS-I through WS-IV, these include limits on point source discharges and local programs to control nonpoint source and stormwater runoff. A WS Critical Area (CA) has more stringent protection measures and is designated within one-half mile from a WS intake or WS reservoir. All WS classifications are suitable for Class C uses.
WS-I	Generally located in natural and undeveloped watersheds.
WS-II	Generally located in predominantly undeveloped watersheds.
WS-III	Generally located in low to moderately developed watersheds.
WS-IV	Generally located in moderately to highly developed watersheds.
WS-V	Generally upstream of and draining to Class WS-IV waters. No categorical restrictions on watershed development or treated wastewater discharges.
Supplemental Classifications	
Class	**Best Uses**
Sw	*Swamp Waters*: Waters that have low velocities and other natural characteristics that are different from adjacent streams (i.e., lower pH, lower levels of dissolved oxygen).
Tr	*Trout Waters*: Provides protection to freshwaters for natural trout propagation and survival of stocked trout.
HQW	*High Quality Waters*: Waters that have excellent water quality, primary nursery areas and other functional nursery areas, WS-I and WS-II or SA waters.
ORW	*Outstanding Resource Waters*: Unique and special waters of exceptional state or national recreational or ecological significance which require special protection.
NSW	*Nutrient Sensitive Waters*: Waters subject to excessive plant growth and requiring limitations on nutrient inputs.
UWL	***Unique Wetland.*** Wetlands of exceptional state or national ecological significance. These wetlands may include wetlands that have been documented to the satisfaction of the Environmental Management Commission (EMC) as habitat essential for the conservation of state or federally listed threatened or endangered species.

* Primary classifications beginning with "S" are assigned to saltwaters.

The water quality standards program in North Carolina has evolved over time and has been modified to be consistent with the federal Clean Water Act and its amendments. Water quality classifications and standards have also been modified to promote additional protection of surface water supply watersheds (WSWS), high quality waters (HQW) and the protection of unique and special pristine waters with outstanding resource values (ORW). Classifications and standards are applied to provide protection of uses from both point and nonpoint source pollution.

2.2.1 STATEWIDE CLASSIFICATIONS AND WATER QUALITY STANDARDS

All surface waters in the state are assigned a *primary* classification that is appropriate to the best use(s) of that water. In addition to primary classifications, surface waters may be assigned a *supplemental* classification. Most supplemental classifications have been developed to provide special protection to sensitive or highly valued resource waters. For example, a mountain stream might have a C Tr classification, where C is the primary classification followed by a Tr (Trout) supplemental classification. Table 2-2 briefly describes the best uses of each classification. A full description is available in the document titled *Classifications and Water Quality Standards Applicable to Surface Waters and Wetlands of North Carolina* (15A NCAC 2B .0200). Information is also available on the DWQ Classifications and Standards Unit website (www.ncwaterquality.org/csu/).

Each primary and supplemental classification is assigned a set of water quality *standards* that establish the level of water quality that must be maintained in the waterbody to support the uses associated with each classification. Some standards, particularly for HQW and ORW waters, outline protective management strategies aimed at controlling point and nonpoint source pollution. The standards for C and SC waters establish the basic protection level for all state surface waters. With the exception of Sw, all other primary and supplemental classifications have more stringent standards than C and SC and require higher levels of protection. Primary classifications beginning with "S" are assigned for saltwaters.

Surface Waters (Class C and SC)

Class C and SC water quality standards are basic standards for water quality applicable to all surface water across the state. Uses include aquatic life propagation and maintenance of biological diversity (i.e, fish and fishing), wildlife, secondary recreation, agriculture and any other usages except for primary recreation or as a source of water supply for drinking, culinary or food processing purposes. Secondary recreation includes wading, boating and other uses involving human body contact with water where such activities take place in an infrequent, unorganized or incidental manner. Rule 15A NCAC 02B .0211 and 15A NCAC 02B .0220 outline standards for freshwater (Class C) and saltwater (Class SC).

Primary Recreation (Class B and SB)

Waters classified as Class B are protected for primary recreation, include frequent and/or organized swimming, and must meet water quality standards for fecal coliform bacteria. Class C and SC uses are also applicable. Sewage and all discharged wastes into Class B waters must be treated to avoid potential impacts to the existing water quality. Primary recreation is also a classified use of Class SA waters. Rule 15A NCAC 02B .0219 and 15A NCAC 02B .0222 outline standards for primary recreation in freshwater (Class B) and saltwater (Class SB).

Shellfish Harvesting (Class SA)

The best uses for Class SA waters are for shellfishing for market purposes and any other usage specified by Class SB and SC. Fecal coliform bacteria in Class SA waters shall meet the current sanitary and bacteriological standards as adopted by the Commission for Health Services. Domestic wastewater discharges are not allowed, and there are provisions for stormwater controls. Rule 15A NCAC 02B 0.221 outlines standards for Class SA waters.

Water Supply Watersheds (Class WS)

The purpose of the Water Supply Watershed (WSWS) Protection Program (http://h2o.enr.state.nc.us/wswp/) is to provide a proactive drinking water supply protection program for local 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 to water supplies.

There are five water supply classifications (WS-I to WS-V) that are defined according to the land use characteristics of the watershed. The WS-I classification carries the greatest protection for water supplies, and no development is allowed in these watersheds. Generally, WS-I lands are publicly owned. WS-V watersheds, however, have the least amount of protection and there are no development restrictions. WS-V watersheds are either former water supply sources or water sources used by industry. WS-I and WS-II classifications are also HQW by definition because requirements for these levels of water supply protection are at least as stringent as those for HQW. Those watersheds classified as WS-II through WS-IV require local governments with jurisdiction within the watersheds to adopt and implement land use ordinances for development that are at least as stringent as the state's minimum requirements. Requirements include a 30-foot vegetated setback on perennial streams in WS-II, WS-III and WS-IV watersheds. Rules 15A NCAC 02B .0212, 15A NCAC 02B .0214, 15A NCAC 02B .0215, 15A NCAC 02B .0216, and 15A NCAC 02B .0218 outline standards for Class WS-I, WS-II, WS-II, WS-IV and WS-V.

High Quality Waters (Class HWQ)

Some of North Carolina's surface waters are relatively unaffected by pollution sources and have water quality higher than the standards that are applied to the majority of the waters of the state. Some waters also provide habitat for sensitive biota such as brook trout, juvenile estuarine fish or rare and endangered aquatic species. These waters may be designated as HQW or ORW.

Criteria for HQW Classification

- Waters rated as Excellent based on DWQ chemical and biological sampling.
- Streams designated as native or special native trout waters by the Wildlife Resources Commission (WRC).
- Waters designated as primary nursery areas or other functional nursery areas by the Division of Marine Fisheries.
- Waters classified by DWQ as WS-I, WS-II or SA.

HQW management strategies are intended to prevent degradation of water quality below present levels from both point and nonpoint sources. The HQW designation requires new wastewater discharge facilities and facilities that are expanding beyond the currently permitted loadings address oxygen-consuming wastes, total suspended solids, disinfection, emergency requirements, volume, nutrients (in nutrient sensitive waters) and toxic substances.

For nonpoint source pollution, development activities which drain to and are within one mile of an HQW and which require a Sedimentation and Erosion Control Plan (http://www.dlr.enr.state.nc.us/pages/sedimentation.html) in accordance with rules established by (1) the NC Sedimentation Control Commission (http://www.dlr.enr.state.nc.us/pages/ncsedcontrolcommission.html) or (2) an approved local erosion and sedimentation control program (http://www.dlr.enr.state.nc.us/pages/sedimentlocalprograms.html) must control runoff. A low-density option requires a 30-foot vegetated buffer between development activities and the stream. A high-density option requires structural stormwater controls (i.e., stormwater infiltration system, wet detention ponds). Rule 15A NCAC 02B .0224 outlines protection measures for Class HQW. North Carolina's Division of Land Resources (DLR) also requires more stringent erosion controls for land-disturbing projects within one mile of and draining to an HQW.

Outstanding Resource Waters (Class ORW)
ORWs have excellent water quality based on biological and chemical sampling and are designated as an outstanding resource. Outstanding resource designations include outstanding fisheries, high level of water-based recreation, National Wild and Scenic River, National Wildlife Refuge, state or national park, and/or special ecological or scientific significance.

The requirements for ORW are more stringent than those for HQW. At a minimum, no new discharges or expansions are permitted, and a 30-foot vegetated buffers or stormwater controls are required for new developments. In some circumstances, the unique characteristics of the waters and resources that need to be protected require a specialized (or customized) ORW management strategy. Special protection measures that apply to North Carolina ORWs are set forth in 15A NCAC 2B .0225.

Outstanding resource values for ORW designation includes one or more of the following:

- An outstanding fisheries resource;
- A high level of water-based recreation;
- A special designation such as National Wild and Scenic River or a National Wildlife Refuge;
- Within a state or national park or forest; or
- A special ecological or scientific significance.

Trout (Class Tr)
Different water quality standards for certain chemical and physical parameters, including dissolved oxygen, temperature and turbidity, have been developed to protect freshwaters for natural trout propagation and survival of stocked trout. These water quality standards result in more restrictive limits for wastewater discharges to trout waters. Even though there are no watershed development restrictions associated with the trout classification, the NC Division of Land Resources (DLR), under the NC Sedimentation and Pollution Control Act (SPCA), has a requirement to protect trout streams from land-disturbing activities. Under General Statue 113A-57(1), "waters that have been classified as trout waters by the NC Environmental Management Commission (EMC) shall have an undisturbed buffer zone 25 feet wide or of sufficient width to confine visible siltation within the twenty-five percent of the buffer zone nearest the land-disturbing activity, whichever is greater." This rule also applies to unnamed tributaries flowing to the affected trout water stream. Further clarification on classifications of unnamed tributaries can be found under 15A NCAC 02B .0301(i)(1). More information regarding land-disturbing activities along designated trout streams can be found on the DLR website (www.dlr.enr.state.nc.us/).

In additions to the DWQ Tr classification, the Wildlife Resources Commission (WRC) administers a state fishery management classification, Designated Public Mountain Trout Waters. It provides for public access to streams for fishing and regulates fishing activities (i.e., season, size limits, creel limits, bait and lure restrictions). Although many of these waters are also classified Tr by DWQ, this is not the same classification.

Nutrient Sensitive Waters (Class NSW)
NSW is a supplemental classification that the NC Environmental Management Commission (EMC) may apply to surface waters that are experiencing or are subject to microscopic (algal) or macroscopic (aquatic weeds) vegetative growth that can impact aquatic communities. Nutrient strategies have been developed to control point and nonpoint source pollution. Nutrient management strategies have been developed for the Neuse and Tar-Pamlico River basins. Management strategies have also been developed for Randleman Lake in the Cape Fear River basin. Rules are outlines in the *Classifications and Water Quality Standards Applicable to Surface Waters and Wetlands of North Carolina* (http://h2o.enr.state.nc.us/admin/rules/documents/rb080104.pdf) (15A NCAC 2B .0200).

2.3 WATER QUALITY MONITORING PROGRAMS

Water quality in North Carolina is assessed using a variety of biological, chemical and physical data. Several different divisions within the NC Department of Environment and Natural Resources (DENR) collect data used for evaluating water quality with the DWQ Environmental Sciences Section (ESS) and the Division of Environmental Health (DEH) Shellfish Sanitation and Recreational Water Quality Section taking the lead roles. Below is a brief introduction to water quality monitoring programs. More specific monitoring information can be found on the ESS website (www.ncwaterquality.org/esb) or on the DEH website (www.deh.enr.state.nc.us/).

2.3.1 BENTHIC MACROINVERTEBRATE MONITORING

Benthic macroinvertebrates are organisms (primarily aquatic insect larvae) that live in and on the bottom substrates of rivers and streams. The use of benthic data has proven to be a reliable monitoring tool because most macroinvertebrates are immobile and sensitive to subtle changes in water quality. Since macroinvertebrates have life cycles of six months to over one year, the effects of short-term pollution (such as a spill) will generally not be overcome until the following generation appears. Benthic communities also respond to, and show the effects of, a wide array of potential pollutant mixtures.

Bioclassification criteria have been developed based on the number of species present and the relative pollution tolerance of each of the species. Commonly referred to as EPT, the number of different species present is dependent upon the pollution intolerant groups of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). The Biotic Index (BI) value is an indication of the overall community tolerance for pollution. The bioclassifications take into consideration the four major ecoregions (mountains, piedmont, coastal plain and swamp) and are used to assess the various impacts of both point and nonpoint source pollution.

Based on the EPT and BI value, mountain, piedmont and coastal plain streams and rivers are given a final bioclassification of Excellent, Good, Good/Fair, Fair or Poor. Slower flow, lower dissolved oxygen, lower pH and (sometimes) complex braided channels and dark-colored waters characterize swamps. They are given a final bioclassification of Natural, Moderate Stress or Severe Stress. In addition to assessing the effects of water pollution, biological information is also used to define high quality and outstanding resource waters (HQW and ORW), support enforcement of water quality standards, and measure improvements associated with management actions. The results of biological investigations are an integral part of the basin plans and North Carolina's basinwide monitoring program.

2.3.2 Fish Community Monitoring

Fish communities are one of the most meaningful indicators of ecological integrity. Fish occupy the upper levels of the aquatic food chain and are directly and indirectly affected by chemical and physical changes in the environment. Water quality conditions that significantly affect lower levels of the food chain (such as benthic macroinvertebrates) will also affect the abundance, species composition and condition of fish populations.

To assess the structure and health of fish communities, DWQ uses the North Carolina Index of Biotic Integrity (NCIBI). The NCIBI uses a cumulative assessment of twelve parameters or metrics including information about species richness and composition, indicator species, trophic function, abundance, condition and reproductive function. Each metric is designed to contribute unique information to the overall assessment. An overall NCIBI is given a final bioclassification of Excellent, Good, Good/Fair, Fair, Poor or Not Rated.

Currently, the NCIBI is applicable only to streams that are wadeable from one shoreline across to the other and for a distance of 600 feet. The NCIBI is only applicable to wadeable streams in the Western and Northern Mountains (French Broad, Hiwassee, Little Tennessee, New and Watauga River basins); the Inner Piedmont, Foothills, and Eastern Mountains (Broad, Catawba, Savannah and Yadkin River basins); and the Outer Piedmont (Cape Fear, Neuse, Roanoke and Tar River basins). Criteria for the NCIBI are continually being refined for greater applicability to wadeable streams in North Carolina.

In addition to assessing the effects of water pollution, biological information is also used to define high quality and outstanding resource waters (HQW and ORW), support enforcement of water quality standards, and measure improvements associated with management actions. The results of biological investigations are an integral part of the basin plans and North Carolina's basinwide monitoring program.

2.3.3 Ambient Monitoring

Statewide, chemical, physical and bacteriological water quality data are collected through the DWQ Ambient Monitoring Program (http://h2o.enr.state.nc.us/esb/ams.html). The program consists of a network of stations established throughout the state to provide site-specific, long-term water quality information on significant rivers, streams and estuaries. Currently, there are 365 ambient monitoring stations across the state.

A basic set of indicators, or parameters, is measured at all ambient monitoring stations. The indicators are primarily selected from those chemicals that have current state water quality standards and can be cost-effectively analyzed. These include water temperature, specific conductance, turbidity, total suspended residue, dissolved oxygen, metals (including arsenic, cadmium, chromium, copper, iron, lead, nickel, zinc, aluminum and mercury), fecal coliform bacteria and weather conditions. Depending on site-specific concerns such as stream classification, discharge types and historical or suspected issues, additional indicators may be included. Examples of these site-specific indicators include salinity, depth, flow, nutrients (including nitrogen and phosphorus), fluoride, sulfate, color, oil and grease and chlorophyll *a*. Metals and residue are sampled quarterly at all stations. All other indicators are sampled monthly.

Although ambient water quality data is not a direct measurement of biological integrity, the chemical and physical data collected can provide an indication of conditions that may be impacting aquatic life. Parameters used to assess water quality for aquatic life include dissolved oxygen, pH, chlorophyll *a* and turbidity. In order for ambient monitoring to be used for water quality assessments, a minimum of ten samples must be collected.

All data collected for water quality assessment through the Ambient Monitoring Program follows established quality assurance procedures. The relative accuracy and precision of laboratory data must be considered as part of any data interpretation or analysis of trends and use support. Absolute certainty in laboratory measurements can never be achieved; however, it is the goal of quality assurance and quality control efforts to quantify an acceptable amount of uncertainty.

DWQ's Chemistry Laboratory (http://h2o.enr.state.nc.us/lab/index.htm) has established rigorous internal quality assurance evaluations to generate the highest quality information in order to apply a statistical level of significance to water quality observations. In addition to quantification limits, lower limits of detection, method detection limits and instrumentation detection limits must be evaluated on a continuing basis to ensure sound data and information. Because each of these detection limits can represent different levels of confidence, water quality evaluations may change from time to time based on improvements to laboratory instruments, analytical methods and quality assurance and quality control applications.

2.3.4 Fish Tissue Monitoring

Throughout North Carolina, heavy metals, pesticides and other complex organic compounds have been documented in freshwater, estuarine and marine fish and shellfish. By analyzing fish tissue, DWQ can determine what chemicals are in the water based on the amount found in the tissue. Results from fish tissue monitoring can also serve as an important indicator of contamination of sediment and surface water. Data for DWQ fish tissue monitoring are also used by the NC Department of Health and Human Services (DHHS) (http://www.ncdhhs.gov/) to issue fish consumption advisories (http://www.epi.state.nc.us/epi/fish/).

2.3.6 AQUATIC TOXICITY MONITORING

Many numeric water quality standards are based on measured effects of individual chemicals, but measurements can only be made on a small percentage of chemicals in production today and many cannot predict the effects of complex chemical mixtures. In order to evaluate the cumulative effects of all constituents in solution, the DWQ Aquatic Toxicology Unit (ATU) conducts acute and/or chronic toxicity tests. Using sensitive aquatic species (usually the fathead minnow or the water flea, *Ceriodaphnia dubia*), aquatic toxicity tests are very efficient and effective at predicting aquatic effects without having to chemically analyze individual chemical constituents. Tests may be conducted on samples of complex wastewater, individual chemical compounds or on actual stream samples. The tests can be sensitive enough to determine not only the lethal dose but also suppression of reproduction or growth of the aquatic organism, effects that may ultimately reduce instream populations. By incorporating whole effluent toxicity (WET) monitoring with "action level" water quality standards, North Carolina has been able to avoid costly and unnecessary regulation of several ubiquitous wastewater constituents.

All permitted dischargers of complex wastewater treatment in the state are required to perform self-monitoring of aquatic toxicity of their wastewater. Also referred to as WET monitoring, there are approximately 580 industrial and municipal facilities required to perform aquatic toxicity tests. The ATU reviews all toxicity data reported by these facilities to verify data quality, track compliance and make enforcement recommendations for non-compliant situations. Where a facility has indicated potential toxicity, the ATU will review and comment on toxicity reduction plans submitted by the facility. All toxicity analyses reported by dischargers must, by water quality regulations, be performed by a state certified biological laboratory.

2.3.7 LAKES ASSESSMENT PROGRAM

Lakes are valued for the multiple benefits they provide to the public, including recreational boating, fishing, drinking water and aesthetic enjoyment. The Lake Assessment Program (http://h2o.enr.state.nc.us/esb/isu.html) seeks to protect these waters through monitoring, pollution prevention and control, restoration and public education activities. Assessments have been made at many publicly accessible lakes, lakes that supply domestic drinking water and lakes (public or private) where water quality problems have been observed. Data are used to determine the trophic state of each lake (a relative measure of nutrient enrichment and productivity) and whether the designated uses of the lake have been threatened or impacted by pollution.

2.3.8 SPECIAL STUDIES – INTENSIVE SURVEY UNIT

Throughout the year, the DWQ Intensive Survey Unit (ISU) (http://h2o.enr.state.nc.us/esb/isu.html) conducts numerous special studies including lake assessments, water quality characterization studies for model support, sediment evaluations for oxygen demand, nutrient flux, chemical contamination and a variety of intensive water quality investigations. ISU collects and interprets a variety of biological, chemical and physical data that are incorporated in the DWQ basinwide planning process. Data collected by ISU is often used in water quality simulation models for the purpose of developing total daily maximum loads

(TMDLs) or wasteload allocations for permitted wastewater dischargers through the National Pollutant Discharge Elimination System (NPDES) Program.

2.3.9 NPDES Discharge Monitoring Coalition Program

The federal government under the Clean Water Act (CWA) established the National Pollutant Discharge Elimination System (NPDES) program to control point source pollution from industrial, municipal and commercial dischargers. The NPDES Permitting and Compliance Programs of DWQ (http://h2o.enr.state.nc.us/NPDES/) are responsible for administering the NPDES Program. Permits issued by DWQ are to protect, maintain and enhance North Carolina's waters by fostering compliance with North Carolina's environmental statutes, rules and regulations.

Many of the NPDES permits issued by the State require instream monitoring in order to determine the effect of the wastewater discharged. DWQ and NPDES permit holders have developed the NPDES Discharge Monitoring Coalition Program (http://h2o.enr.state.nc.us/esb/coalitions.html) in order to utilize the data collected by the permit holders for water quality evaluations. Participating permit holders work in partnership with DWQ to develop a monitoring program. The program is designed to characterize water quality issues basinwide to evaluate coalition interests and other specific issues. Monitoring locations are coordinated with the state's existing ambient and biological monitoring networks. This integrated management of monitoring resources reduces duplication and provides a more complete picture of water quality in a particular watershed. Through this program DWQ facilitates the collection of water quality data at 270 monitoring locations on a monthly basis. The Coalition Program has substantially increased the data resources available to the State for making basinwide water quality management decisions.

All coalition monitoring and reporting requirements are documented in a memorandum of agreement (MOA) between DWQ and the individual permit holders. The MOA only affects requirements for instream monitoring. Permit requirements for effluent monitoring are not altered. Each coalition collects data using a state certified laboratory, and all data are submitted in an electronic format. The use of a single contract laboratory for each coalition produces data that is more comparable and consistent than data collected by multiple facilities. Data collected through the Coalition Program is used to evaluate water quality standards and to document water quality changes. Currently, more than 40,000 records are maintained in the coalition database. There are six active coalitions in four river basins (Neuse, Cape Fear, Tar-Pamlico and Yadkin-Pee Dee River basins) with over 140 permitted facilities participating. The first coalition, the Lower Neuse River Basin Association, began working with DWQ in 1994. The Tar-Pamlico River Basin Association, the most recent to form, will begin monitoring in March 2007.

NPDES Discharge Monitoring Coalitions

- Lower Neuse River Basin Association
- Lower Cape Fear River Program
- Middle Cape Fear River Basin Association
- Upper Cape Fear River Basin Association
- Yadkin Pee-Dee River Basin Association
- Tar-Pamlico River Basin Association

2.3.10 Division of Environmental Health Shellfish Sanitation and Recreational Water Quality Section

The Shellfish Sanitation and Recreational Water Quality Section of the Division of Environmental Health (DEH) (http://www.deh.enr.state.nc.us/shellfish/index.html) is responsible for monitoring and classifying coastal waters as to their suitability for shellfish harvesting for human consumption and coastal recreational swimming. The Shellfish Sanitation Program protects the public from consuming shellfish and crustaceans that could cause illness. Rules and regulations follow national guidelines set forth by the Interstate Shellfish Sanitation Conference (ISSC) and contained within the National Shellfish Sanitation Program (NSSP) *Guide for the Control of Molluscan Shellfish* (http://www.cfsan.fda.gov/~ear/nss3-toc.html). The U.S. Food and Drug Administration (FDA) administer the NSSP.

Classifications of coastal waters for shellfish harvesting in North Carolina are done by means of a Sanitary Survey, which includes a shoreline survey of sources of pollution, a hydrographic and meteorological survey, and a bacteriological survey of shellfish growing waters. Sanitary Surveys are conducted of all potential shellfish growing areas in coastal North Carolina and recommendations for closure are made to the Division of Marine Fisheries (DMF) (http://www.ncfisheries.net/). Waters are sampled regularly and closed if levels of fecal coliform bacteria indicate that harvesting shellfish from these waters could cause a human health risk.

The Recreational Water Quality Program protects the public by monitoring the water quality of coastal recreational waters and notifying the public when bacteriological standards for safe bodily contact are exceeded. The coastal waters monitored include ocean beaches, sounds, bays and estuarine rivers. The program tests 241 ocean and sound-side areas. All ocean beaches and high-use sound-side beaches are tested weekly from April 1 to September 30. Lower-use beaches are tested twice a month. All sites are tested twice a month in October and then monthly from November through March. Coastal waters are sampled for enterococcus bacteria, an indicator organism found in the intestines of warm-blooded animals. While the enterococcus bacterium will not cause illness, its presence is correlated with that of other organisms that can cause illness.

2.3.11 Other Water Quality Data and Research

North Carolina actively solicits "existing and readily available" data and information for each basin as part of the basinwide planning process. Data meeting DWQ quality assurance objectives are used in evaluating water quality. Data and information indicating possible water quality problems are investigated further. Both quantitative and qualitative information are accepted during the solicitation period. High levels of confidence must be present in order for outside

DWQ Data Solicitation Includes:

- Information, letters and photographs regarding the uses of surface waters for boating, drinking water, swimming, aesthetics and fishing.
- Raw data submitted electronically and accompanied by documentation of quality assurance methods used to collect and analyze the samples. Maps showing sampling locations must also be included.
- Summary reports and memos, including distribution statistics and accompanied by documentation of quality assurance methods used to collect and analyze the data.

Contact information must accompany all data and information submitted.

quantitative information to carry the same weight as information collected by DWQ and DEH. This is particularly the case when considering waters for the Impaired Waters List (Section 303(d) of the Clean Water Act).

The way solicited data are used depends on the degree of quality assurance and quality control of sample collection and data analysis (Table 2-3). Level 1 data can be used with the same confidence as DWQ data. Level 2 or Level 3 data may be used to help identify causes of pollution and problem parameters.

Table 2-3 Criteria Levels for Use of Outside Data

Criteria	Level 1	Level 2	Level 3
Monitoring frequency of at least 10 samples for more than a one-year period	Yes	Yes or No	No
Monitoring locations appropriately sited and mapped	Yes	Yes	No
State certified laboratory used for analysis according to 15A NCAC 2B .0103	Yes	Yes or No	No
Quality assurance project plan (QAPP) available describing sample collection and handling	Yes (EPA Guidelines)	Yes or No	No

Level 2 and Level 3 data may also be used to limit the extrapolation of supporting and impaired stream segments or other Level 1 monitoring locations. Where outside data indicates a potential problem, DWQ evaluates the existing DWQ biological and ambient monitoring site locations for appropriate adjustments. All data collected and regularly submitted to DWQ by the NPDES Discharge Monitoring Coalitions are considered Level 1 unless otherwise noted in assessment document or in the basin plans.

2.4 NORTH CAROLINA'S USE SUPPORT CATEGORIES

Under the directive of the federal Clean Water Act (CWA) of 1972, states were required to adopt water quality standards to restore and maintain the chemical, physical and biological integrity of the nation's surface waters. Many states established surface water classifications as a way to manage water quality (Section 2.2). In most cases, the classification is based on the "designated use" or best-intended use for a waterbody. It also became a national policy that each state develop and implement areawide treatment management plans to assure adequate control of point and nonpoint source pollution. In North Carolina, the determination of whether a waterbody is meeting water quality standards for its classification is termed 'use support assessment'.

Designated uses are descriptions of water quality expectations or water quality goals. A designated use is a legally recognized description of a desired use of the waterbody (EPA, October 2005). Examples of designated uses in North Carolina include: supporting the growth and reproduction of aquatic life; swimming; fish consumption; public drinking water supply; and shellfish harvesting. These are uses that the state wants the waterbody to be healthy enough to support. The Clean Water Act requires that waters attain or maintain the level of water quality needed to support one or more of these designated uses.

The designated use must meet numeric and narrative standards as established by each state. Numeric standards are often expressed as minimum and maximum concentrations of pollutants and include specified averages and frequency and/or recurrence periods. Numeric standards are often associated with chemical and physical parameters such as turbidity, dissolved oxygen, bacteria and pH, among others. Narrative standards are associated with biological monitoring and include the bioclassifications. North Carolina assesses both numeric and narrative standards.

DWQ assesses designated uses by applying five use support categories that assess ecosystem and human health risk. These categories are aquatic life, recreation, fish consumption, water supply and shellfish harvesting. The five categories are tied to the state's surface water classifications and standards adopted by the NC Environmental Management Commission (EMC) (Table 2-4). Water quality standards established by the EMC protect for ecosystem and/or human health depending on the classification. Below is a brief description of each of the five use support categories used to assess water quality in North Carolina and how decisions are currently made for each designated use.

2.4.1 Aquatic Life

Biological community data and water chemistry data are used to make assessments in the aquatic life category. Benthic macroinvertebrate (aquatic insects) and fish samples are the best way to assess the biological integrity of most waterbodies. Insect and fish communities are evaluated once every five years unless a special study is conducted by DWQ's Environmental Sciences Section (ESS). A special study may be conducted to evaluate biological communities for stream reclassifications, potential restoration projects, or to identify potential stream impacts. Chemical parameters that are used to assess aquatic life include dissolved oxygen, pH, chlorophyll *a* and turbidity, just to name a few. Chemical parameters are collected by DWQ on a monthly basis at 365 ambient monitoring stations across the state.

2.4.2 Recreation

Water quality standards for fecal coliform and enterococci bacteria are used to make assessments in the recreation category. These bacteria do not pose an immediate threat to humans or animals; however, they may indicate the potential presence of other disease-causing organisms that may threaten human health. For the coastal areas and beaches, the NC Division of Environmental Health (DEH) Recreational Monitoring (RECMON) Program is responsible for posting swimming advisories where enterococci bacteria are detected above water quality standards.

2.4.3 Fish Consumption

Statewide and site-specific fish consumption advisories issued by the DHHS (http://www.epi.state.nc.us/epi/fish/) form the basis of assessments in the fish consumption category. This category is based on the human health approach and assesses whether humans can safely consume fish from a particular waterbody.

Table 2-4 Primary Classifications and Use Support Categories

	Ecosystem Approach	Human Health Approach			
Primary Classification	**Aquatic Life**	**Fish Consumption**	**Recreation**	**Water Supply**	**Shellfish Harvesting**
C	X	X	X	n/a	n/a
SC	X	X	X	n/a	n/a
B	X	X	X	n/a	n/a
SB	X	X	X	n/a	n/a
SA	X	X	X	n/a	X
WS I – WS IV	X	X	X	X	n/a

2.4.4 Water Supply

Drinking water standards are established by the Division of Environmental Health (DEH) and apply to water that is treated by drinking water facilities. Each year DEH regional water treatment consultants provide DWQ with reports that indicate whether a surface water supply (raw water) had to be closed or switched due to water quality problems. Reports include the frequency and duration of the closure or switch and a description of the water quality concern. This information is then used to assess use support in the water supply category.

2.4.5 Shellfish Harvesting

Shellfish growing areas defined and evaluated by the DEH (http://www.deh.enr.state.nc.us/shellfish/index.html) are used to make assessments for shellfish harvesting. DEH defines and evaluates growing areas by surveying the existing land use, determining rainfall amounts in a watershed, and sampling water and shellfish for fecal coliform bacteria. The fecal coliform bacteria standard for human consumption of shellfish must be met for a growing area to be approved for shellfish harvesting.

2.5 Data Interpretation and Water Quality Assessments

In North Carolina, criteria are established for each of the use support categories to define the minimum pollutant limits, goals, conditions or other requirements necessary for a waterbody to maintain or attain its designated use(s). Waters are supporting their designated use if the criteria for the use support category are met. Waters are impaired if the criteria are not met. Waters with inconclusive data are not rated, and waters where no information is available are no data (Table 2-5). Water quality assessments are used to develop the State's Integrated Report and Impaired Waters List (Section 305(b) and 303(d) of the Clean Water Act) for the federal Environmental Protection Agency (EPA). Water quality assessments and use support ratings also identify waters to be targeted for special studies related to TMDLs and aid other agencies and watershed groups in identifying watersheds for restoration or protection activities.

Many types of data and information are used to determine if the water quality standards, biological aquatic life criteria, and the designated uses of the water are attained. Data from all of the water quality monitoring programs are used in determining use support ratings including data collected for benthic macroinvertebrates and fish communities, chemical/physical parameters (ambient monitoring), fish consumption advisories from DHHS, swimming advisories and shellfish surveys from DEH. Data also includes information collected from other organizations (i.e., universities, coalitions and volunteer monitoring programs) that have an approved Quality Assurance Project Plan (QAPP) (http://h2o.enr.state.nc.us/esb/qa_000.html) with DWQ. Organizations without a QAPP can still submit data and information to assist DWQ in the development of basinwide water quality plans.

When interpreting data and other descriptive and qualitative information, it is important to understand the associated limitations and degree of uncertainty. Although use support methods have been established and are used for analyzing data and information and determining use support ratings, best professional judgment is also used. Use support ratings are intended to provide an assessment of water quality using a five-year data window, describe how well surface waters support their designated use, and document potential stressors contributing to water quality degradation and the sources of those contributions.

Assessment methods continue to improve over time. The information and technology used to make use support decisions continue to become more accurate and comprehensive as scientific methodology changes, data becomes more readily available, and EPA guidance changes.

2.5.1 ASSESSMENT UNIT NUMBERS (AU#)

DWQ identifies waters by index numbers and assessment unit numbers (AU#). The AU# is used to track defined stream segments or waterbodies in the water quality assessment database, for the 303(d) Impaired Waters List, and in various tables in basin plans and other water quality documents. The AU# is a subset of the DWQ index number (classification identification number). A letter attached to the end of the AU indicates that the AU is smaller than the DWQ index segment. No letter indicates that the AU and the DWQ index segment are the same.

2.5.2 BASIS OF ASSESSMENT – MONITORED V. EVALUATED

Assessments are made on an overall basis of either monitored (M) or evaluated (E), depending on the level of available information. A monitored rating is based on the most recent data and is site-specific; therefore, monitored ratings are treated with more confidence than an evaluated rating. Evaluated ratings are used when there are no site-specific data.

2.5.3 MULTIPLE MONITORING SITES

There are assessment units with more than one type of monitoring data. When the data from multiple biological data types are gathered, each data type is assessed independently. Biological monitoring is typically assessed independent of ambient monitoring data and either may be used to assign a use support rating for an assessment unit. Monitored data are always used over evaluated information; however, evaluated information can be used to lengthen or shorten monitored assessment units and to assign use support ratings on an evaluated basis to non-monitored assessment units.

2.5.4 ASSESSMENT METHODOLOGIES – FRESHWATER V. SALTWATER

Both freshwater and saltwater water quality assessments require data analyses of biological data, chemical/physical data and other descriptive and qualitative information in order to determine use support. Unlike freshwater, however, saltwater or estuarine waters also include shellfish growing areas. The Division of Environmental Health (DEH) delineates shellfish growing areas and classifies them based on their suitability for shellfish harvesting and includes Class SA, SB and SC waters. DEH samples growing areas regularly and reevaluates the areas by conducting shellfish sanitation shoreline surveys every three years to determine if the classification is still applicable. Classifications are based on bacteria levels, locations of pollution sources and the availability of shellfish resources (Section 2.4.5).

Freshwater and saltwater are assigned use support ratings of supporting, impaired, not rated or no data depending the classification, data analyses and other quantitative and qualitative information. Table 2-5 provides an overview of water quality assessments associated with freshwater streams and Table 2-6 provides an overview of water quality assessments associated with saltwater or estuarine waters based on DEH growing area classifications.

Table 2-5 Data Interpretation and Water Quality Assessments (Freshwater Streams)

Benthic Macroinvertebrate and/or Fish Community Bioclassification	Ambient Monitoring Criteria	Water Quality Assessments (Use Support Rating)
Excellent Good Good/Fair Natural (Sw)[1] Moderate Stress (Sw)[1] Not Impaired[2]	Numerical Standard exceeded in ≤10 percent of samples	Supporting
Fair Poor Severe Stress (Sw)[1]	Numerical Standards exceeded in ≥ 10 percent of samples	Impaired
Not Rated	Less than 10 samples collected OR Standard exceeded for dissolved oxygen and pH in swamp streams	Not Rated

Table 2-6 Data Interpretation and Water Quality Assessments (Saltwater or Estuarine Waters)

DEH Classification	DEH Growing Area Description/Criteria	Water Quality Assessment (Use Support Rating)
Approved (APP)	Sanitary Survey indicate the area is in compliance.	Supporting
Conditionally Approved-Open (CAO)	Sanitary Survey indicates an area can meet approved area criteria for a reasonable period of time, and the pollutant event is known and predictable and can be managed by a plan. These areas tend to be open more frequently than close.	Impaired
Conditionally Approved-Closed (CAC)	Sanitary Survey indicates an area can meet approved area criteria for a reasonable period of time, and the pollutant event is known and predictable and can be managed by a plan. These areas tend to be closed more frequently than open.	Impaired
Restricted (RES)	Sanitary Survey indicates limited degree of pollution, and the area is not contaminated to the extent that consumption of shellfish could be hazardous after controlled depuration or relaying.	Impaired
Prohibited (PRO)	No Sanitary Survey; point source discharges; marinas; data do not meet criteria for Approved, Conditionally Approved or Restricted Classification.	Impaired

1 Swamp (Sw) streams for benthic macroinvertebrate sampling are defined as streams in the coastal plain that have no visible flow for part of the year but flow during the February to early March benthic monitoring period.
2 This designation may be used for flowing waters that are too small to assign a bioclassification (less than a three square mile drainage area) but have a Good/Fair or higher bioclassification using the benthic macroinvertebrate standard qualitative and EPT criteria.
3 Swamp (Sw) streams for benthic macroinvertebrate sampling are defined as streams in the coastal plain that have no visible flow for part of the year but flow during the February to early March benthic monitoring period.
4 This designation may be used for flowing waters that are too small to assign a bioclassification (less than a three square mile drainage area) but have a Good/Fair or higher bioclassification using the benthic macroinvertebrate standard qualitative and EPT criteria.

2.6 INTRODUCTION TO NORTH CAROLINA'S IMPAIRED WATERS LIST

The *North Carolina Water Quality Assessment and Impaired Waters List* is an integrated report that includes both the 305(b) and 303(d) reports. The *305(b) Report* is compiled to meet the Section 305(b) reporting requirement of the federal Clean Water Act (CWA). The 305(b) portion of the integrated report presents how well waters support designated uses (e.g., swimming, aquatic life support, water supply), as well as likely stressors (e.g., sediment, nutrients) and potential sources of impairment. The *303(d) List* is a comprehensive accounting of all Impaired waters and is derived from the 305(b) Report. North Carolina refers to the Impaired Waters List as the *Integrated Report* because it fulfills both the 305(b) and 303(d) requirements.

Section 303(d) of the CWA enacted in 1972 required States, Territories and authorized Tribes to 1) identify and establish a priority ranking for waters for which technology-based effluent limitations are not stringent enough to attain and maintain water quality standards, 2) establish total maximum daily loads (TMDLs) for the pollutants causing impairment in those waters, and 3) develop and submit the list of Impaired waters and TMDLs biennially by April 1st of every even numbered year to the US Environmental Protection Agency (EPA). EPA is required to approve or disapprove the state-developed 303(d) list within 30 days. For each segment Impaired by a pollutant and identified in the 303(d) list, a TMDL must be developed. TMDLs are not required for waters Impaired by pollution. Here, pollution is defined by the EPA as, "man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of the water," and is related to water control structures.

2.6.1 CONTENTS OF THE INTEGRATED REPORT

The Integrated Report includes descriptions of monitoring programs, the use support methodology, and the Impaired waters list. New guidance from EPA places all waterbody assessment units into one unique assessment category (EPA, 2001b). Although EPA specifies five unique assessment categories, North Carolina elects to use seven categories. Each category is described in detail below:

Category 1: Attaining the water quality standard and no use is threatened. This category consists of those waterbody assessment units where all applicable use support categories are rated "Supporting". Data and information are available to support a determination that the water quality standards are attained and no use is threatened. Future monitoring data will be used to determine if the water quality standard continues to be attained.

Category 2: Attaining some of the designated uses; no use is threatened; and insufficient or no data and information are available to determine if the remaining uses are attained or threatened. This category consists of those waterbody assessment units where at least one of the applicable use support categories are rated "Supporting" and the other use support categories are rated "Not Rated" or "No Data". Also included in this category are waters where at least one of the applicable use support categories, except Fish Consumption, are rated "Supporting"; the remaining applicable use support categories, except Fish Consumption, are rated "Not Rated"; and the Fish Consumption category is rated "Impaired-Evaluated". Data and information are available to support a determination that some, but not all, uses are attained. Attainment status of the remaining uses is unknown because there are insufficient or no data or information. Future monitoring data will be used to determine if the uses previously found to be in attainment remain in attainment, and to determine the attainment status of those uses for which data and information were previously insufficient to make a determination.

Category 3: Insufficient or no data and information to determine if any designated use is attained. This category consists of those waterbody assessment units where all applicable use support categories, except Fish Consumption, are rated "Not Rated", and the Fish Consumption category is rated "Impaired-Evaluated". Measured data or information to support an attainment determination for any use are not available. Supplementary data and information, or future monitoring, will be required to assess the attainment status.

Category 4: Impaired or threatened for one or more designated uses but does not require the development of a TMDL. This category contains three distinct sub-categories:

Category 4a: TMDL has been completed. This category consists of those waterbody assessment units for which EPA has approved or established a TMDL and water quality standards have not yet been achieved. Monitoring data will be considered before moving an assessment unit from Category 4a to Categories 1 or 2.

Category 4b: Other pollution control requirements are reasonably expected to result in the attainment of the water quality standard in the near future. This category consists of those waterbody assessment units for which TMDLs will not be attempted because other required regulatory controls (e.g., NPDES permit limits, Stormwater Program rules, etc.) are expected to attain water quality standards within a reasonable amount of time. Future monitoring will be used to verify that the water quality standard is attained as expected.

Category 4c: Impairment is not caused by a pollutant. This category consists of assessment units that are Impaired by pollution, not by a pollutant. EPA defines pollution as "The man-made or man-induced alteration of the chemical, physical, biological and radiological integrity of the water." EPA staff have verbally stated that this category is intended to be used for impairments related to water control structures (i.e., dams). Future monitoring will be used to confirm that there continues to be an absence of pollutant-caused impairment and to support water quality management actions necessary to address the cause(s) of the impairment.

Category 5: Impaired for one or more designated uses by a pollutant(s) and requires a TMDL. This category consists of those waterbody assessment units that are Impaired by a pollutant and the proper technical conditions exist to develop TMDLs. As defined by the EPA, the term pollutant means "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into the water". When more than one pollutant is associated with the impairment of a single waterbody assessment unit in this category, the assessment unit will remain in Category 5 until TMDLs for all listed pollutants have been completed and approved by the EPA.

Category 6: Impaired based on biological data. This category consists of waterbody assessment units historically referred to as "Biologically Impaired" waterbodies; these assessment units have no identified cause(s) of impairment although aquatic life impacts have been documented. The waterbody assessment unit will remain in Category 6 until TMDLs have been completed and approved by the EPA.

Category 7: Impaired, but the proper technical conditions do not yet exist to develop a TMDL. As described in the Federal Register, "proper technical conditions" refer to the availability of the analytical methods, modeling techniques and data base necessary to develop a technically defensible TMDL. These elements will vary in their level of sophistication depending on the nature of the pollutant and characteristics of the segment in question" (43 FR 60662, December 28, 1978). These are assessment units that would otherwise be in Category 5 of the integrated list. As previously noted, EPA has recognized that in some specific situations the data, analyses or models are not available to establish a TMDL. North Carolina seeks EPA technical guidance in developing technically defensible TMDLs for these waters. Open water and ocean hydrology fecal coliform Impaired shellfishing waters are included in this category.

For this integrated list, Categories 1 and 2 are considered fully supporting any assessed uses. This portion of the integrated list is extensive (thousands of segments); thus, a printed copy is not provided. A table of waters on Categories 1 through 3 is available for downloading on the DWQ website (http://h2o.enr.state.nc.us/tmdl/General_303d.htm). Categories 5, 6 and 7 constitute the 2004 North Carolina 303(d) List for the State of North Carolina.

2.6.2 How North Carolina Proposes Delisting Waters

In general, waters will move from Categories 5, 6 or 7 when data show that uses are fully supported or when a TMDL has been approved by EPA. In some cases, mistakes have been discovered in the original listing decision and the mistakes are being corrected. Waters appearing on the previously approved Impaired waters list will be moved to Categories 1, 2, 3 or 4 under the following circumstances:

- An updated 305(b) use support rating of Supporting, as described in the basinwide management plans.
- Applicable water quality standards are being met (i.e., no longer Impaired for a given pollutant) as described in either basinwide management plans or in technical memoranda.
- The basis for putting the water on the list is determined to be invalid (i.e., was mistakenly identified as Impaired in accordance with 40 CFR 130.7(b)(6)(iv) and/or National Clarifying Guidance for State and Territory 1998 Section 303(d) Listing Decisions. Robert Wayland, III, Director. Office of Wetlands, Oceans and Watersheds. Aug 27, 1997).
- A water quality variance has been issued for a specific standard (e.g., chloride).
- Removal of fish consumption advisories or modification of fish eating advice.
- Typographic listing mistakes (i.e., the wrong water was identified).
- EPA has approved a TMDL.

2.7 Introduction to TMDLs

A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the state had designated. The calculation must also account for seasonal variation and critical conditions in water quality.

A TMDL includes a water quality assessment that provides the scientific foundation for an implementation plan that outlines the steps necessary to reduce pollutant loads to restore and maintain standards and aquatic life. For more information on TMDLs and the 303(d) listing process, visit the TMDL website at http://h2o.enr.state.nc.us/tmdl/.

Point source implementation plans are included in TMDLs. Thus, any point source discharging to Impaired waters will receive a discharge allocation within the TMDL. In some cases, the allocation may be equal to existing permit limits and therefore not require further action by the wastewater permittee. In other cases, the allocation may require a reduction in loading.

Nonpoint source implementation plans are not included in TMDLs, nor are they required by federal law. Nonpoint source implementation plans can be developed by DWQ, other agencies within DENR, COGs or local government offices.

EPA has provided guidance regarding TMDLs and NPDES stormwater permits. As a result, selected NPDES stormwater permits may contain additional language when subject to a TMDL. Per EPA, MS4s identified in TMDLs as contributors to impairment may be required to develop a management plan that includes additional monitoring and BMP installation associated with pollutants of concern.

2.7.1 SCHEDULING TMDLS

Category 5 waters, those for which a TMDL is needed, are at many different stages on the path to an approved TMDL. Some require additional data collection to adequately define the problem in TMDL terms. Some require more outreach to increase stakeholder involvement. Others need to have a technical strategy budgeted, funded and scheduled. Some are ready for EPA submittal.

North Carolina has prioritized TMDL development for waters Impaired due to bacteria or turbidity. The approach of prioritizing TMDL development based on pollutant has been successfully used in other states. Limited resources are used more effectively with a focus on a particular pollutant. Waters Impaired by other pollutants (i.e., not bacteria) are not excluded from the schedule. However, the majority of waters prioritized for the next few years are associated with bacterial contamination. Compliance with TMDL development schedules provided in the Integrated Report depends upon DWQ and EPA resources.

North Carolina uses biological data to place the majority of waterbody assessment units on the 303(d) list. Additional consideration and data collection are necessary if the establishment of a TMDL for waters on Category 6 is to be expected. It is important to understand that the identification of waters in Category 6 does not mean that they are low priority waters. The assessment of these waters is a high priority for the State of North Carolina. However, it may take significant resources and time to determine the environmental stressors and potentially a cause of impairment. Assigning waters to Category 6 is a declaration of the need for more data and time to adequately define the problems and whether pollution, pollutants or a combination affects waters.

According to EPA guidance (EPA 2004), prioritization of waterbody assessment units for TMDLs need not be reflected in a "high, medium or low" manner. Instead, prioritization can be reflected in the TMDL development schedule. Generally, North Carolina attempts to develop

TMDLs within 10 years of the original pollutant listing. Other information for each assessment unit is also utilized to determine the priority in the TMDL development schedule. This information includes the following:

- Year listed. Assessment units that have been on the 303(d) list for the longest period of time will receive priority for TMDL development and/or stressor studies.
- Reason for listing. (Applicable to Category 5 AUs only) AUs with an impairment due to a standard violation will be prioritized based on which standard was violated. Standard violations due to bacteria or turbidity currently receive priority for TMDL development.
- Classification. AUs classified for primary recreation (Class B), water supply (Class WS-I through WS-V), trout (Tr), high quality waters (HQW), and outstanding resource waters (ORW) will continue to receive a higher priority for TMDL development and/or stressor studies.
- Basinwide Planning Schedule. (Applicable to Category 6 AUs only). The basinwide schedule is utilized to establish priority for stressor studies.

2.7.2 REVISING TMDLS

Current federal regulations do not specify when TMDLs should be revised. However, there are several circumstances under which it would seem prudent to revisit existing TMDLs. The TMDL analysis of targets and allocations is based upon the existing water quality standards, hydrology, water quality data (chemical and biological), and existing, active NPDES wastewater discharges. Conditions related to any of these factors could be used to justify a TMDL revision. Specific conditions that the Division will consider prior to revising an existing, approved TMDL include the following:

- A TMDL has been fully implemented and the water quality standards continue to be violated. If a TMDL has been implemented and water quality data indicate no improvement or a decline in overall water quality, the basis for the TMDL reduction or the allocation may need to be revised;
- A change of a water quality standard (e.g., fecal coliform to Echerichia coli). The Division will prioritize review of existing TMDLs and data to determine if a revision to TMDLs will be required;
- The addition or removal of hydraulic structures to a waterbody (e.g., dams). Substantial changes to waterbody hydrology and hydraulics have the potential to change many aspects of target setting, including the water quality standard upon which the TMDL was developed, the water quality data, and the water quality modeling;
- Incorrect assumptions were used to derive the TMDL allocations. This would include errors in calculations and omission of a permitted discharge.

Should a TMDL be revised due to needed changes in TMDL targets, the entire TMDL would be revised. This includes the TMDL target, source assessment, and load and wasteload allocations. However, the Division may elect to revise only specific portions of the TMDL. For example, changes may be justifiable to the load and wasteload allocation portions of a TMDL due to incorrect calculations or inequities. In these cases, revisions to the TMDL allocations would not necessarily include a revision of TMDL targets.

CHAPTER 3 – WATER QUALITY STRESSORS

Human activities can negatively impact surface water quality, even when the activity is far removed from the waterbody. The many types of pollution generated by human activities may seem insignificant when viewed separately, but when taken as a whole, can be very stressful to aquatic ecosystems. Water quality stressors are identified when impacts have been noted to biological (benthic and fish) communities and/or water quality standards have been violated. Stressors apply to one or more use support categories (i.e., aquatic life, recreation, shellfish harvesting, fish consumption, water supply) and may be identified for impaired as well as supporting waters. This chapter provides an overview of how stressors are identified in a watershed, defines commonly identified stressors and reviews the water quality standards that can be listed as potential water quality stressors.

3.1 IDENTIFICATION OF STRESSORS

Identifying stressors is challenging because direct measurements of the stressor may be difficult or prohibitively expensive. DWQ staff use field observations from sample sites, special studies and data collected from ambient monitoring stations to identify potential water quality stressors. Information from other natural resource agencies and concerned citizens are also used. It is important to identify stressors and potential sources of those stressors so that water quality programs can target resources to address water quality problems.

Cumulative Effects

While any one activity may not have a dramatic effect on water quality, the cumulative effect of land use activities in a watershed can have a severe and long-lasting impact.

Most stressors to the biological community are complex groupings of many different stressors that individually may not degrade water quality or aquatic habitat but together can severely impact aquatic life. Sources of stressors (Chapter 4) are most often associated with land use in a watershed as well as the quality and quantity of any treated wastewater that may be entering a stream. During naturally severe conditions, such as droughts or floods, any individual stressor or group of stressors may have more severe impacts to aquatic life than during normal climatic conditions.

3.2 HABITAT DEGRADATION (AQUATIC LIFE)

Good instream habitat is necessary for aquatic life to survive and reproduce. A notable reduction in habitat diversity or a negative change in habitat often leads to significant changes to an aquatic ecosystem. The term habitat degradation includes sedimentation, streambank erosion, channelization, lack of riparian vegetation, loss of pools and/or riffles, loss of organic (woody and leaf) habitat and streambed scour. The stressors to benthic and fish communities can be caused by many different land use activities and less often by discharges of treated wastewater. Many of the stressors discussed below are either directly caused by, or are a symptom of, altered watershed hydrology. The altered hydrology increases both sources of stressors and delivery of the stressors to the receiving waters.

Streams that typically show signs of habitat degradation are in watersheds that have a large amount of land-disturbing activities (i.e., construction, mining, timber harvest, agricultural land use). Habitat degradation is also evident in watersheds that have large impervious surface areas. A watershed in which the stream has been channelized, or most of the riparian vegetation has been removed, will also exhibit habitat degradation, and streams that receive a discharge quantity that is much greater than the natural flow in the stream may also show signs of degradation.

Examples of Best Management Practices (BMPs)

Agriculture

- No till or conservation tillage practices
- Strip cropping and contour farming
- Leaving natural buffer areas around small streams and rivers

Construction

- Using phased grading/seeding plans
- Limiting time of exposure
- Planting temporary ground cover
- Using sediment basins and traps

Forestry

- Controlling runoff from logging roads
- Replanting vegetation on disturbed areas
- Leaving natural buffer areas around small streams and rivers

Quantifying the amount of habitat degradation is very difficult in most cases because extensive technical and monetary resources are needed. DWQ and other agencies (i.e., SWCD, NRCS, town and county governments) are starting to address this issue; however, local efforts are needed to prevent further instream degradation. Local efforts are also needed to restore streams that have been impaired by activities that cause habitat degradation. As point source dischargers become less common sources of water quality impairment, nonpoint sources that pollute water and cause habitat degradation must be addressed if we are to improve water quality.

3.2.1 Sedimentation

Sedimentation is a natural process that is important to the maintenance of diverse aquatic habitats. It is the process by which soil particles washed off of the landscape and streambanks are deposited in the stream channel. Streams naturally tend toward a state of equilibrium between erosion and deposition of sediments. As streams meander through their floodplains, the outside of the stream cuts into the streambanks eroding it away, while the inside of the stream deposits sediments to create sand bars further downstream. The natural process of erosion and deposition can be disrupted by human activities such as dams, dredging, agriculture, urban development or logging. Construction projects or logging in the upper reaches of a watershed may worsen erosion or sediment deposition on property further downstream. If streams are straightened or moved without taking into consideration water's natural energy, erosion and sediment deposition rates can increase. This can result in the loss of valuable agricultural land, damage to roads or structures, destruction of productive wetlands and the addition of sediments and nutrients to waterways that can degrade surface water quality and biodiversity.

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 and streams decreases their storage volume and increases the frequency of floods (NCDLR, 1998). Suspended sediment also increases the cost of treating municipal drinking water.

Streambank erosion and land-disturbing activities are sources of sedimentation. Streambank erosion is often caused by high stormwater flows immediately following rainfall events or snowmelts. Watersheds with large amounts of impervious surface transport water to streams more rapidly and at higher volumes than in watersheds with more vegetative cover. In many urban areas, stormwater is delivered directly to the stream by a stormwater sewer system. This high volume and concentrated flow of water after rain events undercuts streambanks often causing streambanks to collapse. This leads to large amounts of sediment being deposited into the stream. Many urban streams are adversely impacted by sediment overloading from the watershed as well as from the streambanks. Minimizing impervious surface area and reducing the amount of stormwater outlets releasing stormwater directly to the stream can often prevent substantial amounts of erosion.

Land-disturbing activities such as the construction of roads and buildings, crop production, livestock grazing and timber harvesting can accelerate erosion rates by causing more soil than usual to be detached and moved by water. In most land-disturbing activities, sedimentation can be controlled through the use of appropriate best management practices (BMPs). BMPs that minimize the amount of acreage and length of time that the soil is exposed during land-disturbing activities can greatly reduce the amount of soil erosion. More information on land-disturbing activities and BMPs can be found in Chapter 8.

Livestock grazing with unlimited access to the stream channel and banks can also cause severe streambank erosion resulting in sedimentation and degraded water quality. Although they often make up a small percentage of grazing areas by surface area, riparian zones (vegetated stream corridors) are particularly attractive to cattle that prefer the cooler environment and lush vegetation found beside rivers and streams. This concentration of livestock can result in increased sedimentation of streams due to "hoof shear", trampling of bank vegetation and entrenchment by the destabilized stream. Despite livestock's preference for frequent water access, farm veterinarians have reported that cows are healthier when stream access is limited (EPA, 1999). More information on livestock exclusion and other agricultural practices can be found in Chapter 6.

3.2.2 Loss of Riparian Vegetation

Removing trees, shrubs and other vegetation to plant grass or place rock (also known as riprap) along a streambank often degrades water quality. Removing riparian vegetation eliminates habitat for aquatic organisms, which are a food source for many fish species. Rocks lining a streambank absorb the sun's heat, which then raises the water's temperature. Many fish require cooler water temperatures as well as the higher levels of dissolved oxygen that cool water provides. Trees, shrubs and other native vegetation cool the water by shading it. Straightening a stream, clearing streambank vegetation and lining the streambanks with grass or rock severely impact the habitat that aquatic insects and fish need to survive. The loss of riparian vegetation is most commonly associated with land-disturbing activities including urban development, forestry, agriculture and pasture grazing.

Establishing, conserving and managing streamside vegetation (riparian buffer) is one of the most economical and efficient BMPs. Forested buffers, in particular, provide a variety of benefits including filtering runoff and taking up nutrients, moderating water temperature, preventing erosion and loss of land, providing flood control, moderating streamflow and providing food and habitat for both aquatic and terrestrial wildlife (NCDENR-DWQ, 2004). DWQ developed a brochure explaining the benefits of riparian vegetation along the stream corridor. A free copy of the brochure *Buffers for Clean Water* can be found on the DWQ Web site (www.ncwaterquality.org/Wateryouknow.htm).

3.2.3 Loss of Instream Organic Microhabitats

Organic microhabitat (i.e., leafpacks, sticks and large wood) and edge habitat (i.e., root banks and undercut banks) play very important roles in a stream ecosystem. Organic matter in the form of leaves, sticks and other materials serve as the base of the food web for small streams. Additionally, these microhabitats serve as special niches for different species of aquatic insects, providing food and/or habitat. For example, many stoneflies are found almost exclusively in leafpacks and on small sticks. Some beetle species prefer edge habitat, such as undercut banks. If these microhabitat types are not present, there is no place for these specialized macroinvertebrates to live and feed. The absence of these microhabitats in some streams is directly related to the absence of riparian vegetation. Organic microhabitats are critical to headwater streams, the health of which is linked to the health of the entire downstream watershed.

3.2.4 Channelization

Channelization refers to the physical alteration of naturally occurring streams and rivers. Typical modifications are described in the text box. Channelization can control floods, reduce erosion, increase usable land area, improve transportation and drain an area more efficiently; however, downstream streambanks are unstable and the damage caused by flooding often increases substantially (McGarvey, 1996).

Direct or immediate biological effects of channelization include injury and mortality of aquatic insects, fish, shellfish/mussels and other wildlife populations as well as habitat loss. Indirect biological effects include changes in the aquatic insect, fish and wildlife community structures, favoring species that are more tolerant of or better adapted to the altered environment (McGarvey, 1996).

Typical Channel Modifications

- Removal of any obstructions, natural or artificial, that inhibit a stream's capacity to convey water (clearing and snagging).
- Widening, deepening or straightening of the channel to maximize conveyance of water.
- Lining the bed or banks with rock or other resistant materials.

Restoration or recovery of channelized streams may occur through processes, both natural and artificially induced. In general, streams that have not been excessively stressed by the channelization process can be expected to return to their original forms. However, streams that have been extensively altered may establish a new, artificial equilibrium (especially when the channelized streambed has been hardened). In such cases, the stream may enter a vicious cycle of erosion and continuous entrenchment. Once the benefits of a channelized stream are outweighed by the costs, both in money and environmental integrity, channel restoration efforts are likely to be taken (McGarvey, 1996).

Channelization of streams within the continental United States is extensive and promises to become even more so as urban development continues. Overall estimates of lost or altered riparian habitats within the United States are as high as 70 percent. Unfortunately, the dynamic nature of stream ecosystems makes it difficult (if not impossible) to quantitatively predict the effects of channelization (McGarvey, 1996).

3.2.5 IMPOUNDMENTS

The consensus among river ecologists is that impoundments, or dams, are the single greatest cause of the decline of river ecosystems (World Commission on Dams, 2000). By design, dams alter the natural flow regime, and with it virtually every aspect of a river ecosystem, including water quality, sediment transport and deposition, fish migration and reproduction, riparian and floodplain habitat and all of organisms that rely on those habitats (Raphals, 2001). Dams also require ongoing maintenance. For example, reservoirs in sediment-laden streams lose storage capacity as silt accumulates in the reservoir.

The location of dams can lead to the loss of habitat resulting from the inundation of wetlands, riparian areas and farmlands upstream of the impounded waterway. Dams trap sediment and other pollutants and change the water quality. Water quality changes include: reduced sediment transport, decreased dissolved oxygen, altered temperature regimes and increased levels of some pollutants, such as hydrogen sulfide, nutrients and manganese.

Once streams are impounded, water demand dictates the artificial regulation and control of streamflow. The new flow rates and volume often do not reproduce natural conditions. Water released from impoundments often has lower levels of dissolved oxygen, high turbidity and/or different temperatures that can impact downstream aquatic organisms. Not only can reservoir water temperatures and oxygen content differ significantly from expected seasonal temperatures, but critical minimum flows needed for riparian areas may not be maintained. Decreased flow in coastal areas can also increase saltwater intrusion and impact estuary productivity (EPA, 1999). These effects are the result of both large and small impoundments.

In 2003, the Tennessee Department of Environment and Conservation (TDEC), Division of Water Pollution Control was awarded a grant to perform a probabilistic monitoring study of 75 streams below small impoundments. The study measured effects of the impoundments on aquatic life, nutrients, dissolved oxygen, pH, iron, manganese, habitat, flow and periphyton (aquatic plant) growth. Benthic macroinvertebrate communities were adversely affected in most of the downstream sites that were sampled. Of the 75 sample sites below impoundments, only four passed biological criteria guidelines or were comparable to first order references in the seasons they were sampled. Biologists also saw a shift in the type of dominant organisms. Organisms shifted from pollution intolerant species to more tolerant taxa indicating a loss of biological diversity and integrity.

Sediment deposition was identified as a significant habitat problem in nearly 80 percent of the downstream sites that were sampled. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many aquatic organisms. Other frequently documented habitat problems included embedded substrate, unstable streambanks, no sinuosity and disconnected, or disrupted, streambank vegetation. The study also concluded that impoundments can significantly alter streamflow, decrease dissolved oxygen levels, change the concentration of metals and nutrients, increase water temperature and increase total suspended solids (TSS) downstream (Arnwine et *al*., 2006).

3.3 Water Quality Specific Parameter as Stressors

Water quality standards are usually direct measurements of water quality parameters from ambient water quality monitoring stations. The water quality standards are designed to protect designated uses (i.e., aquatic life, recreation, shellfish harvesting, fish consumption, water supply). As with habitat degradation, altered watershed hydrology greatly increases the sources of these stressors as well as delivery of the stressors to the receiving waters. Many of the water quality standards discussed in the following section can be found in *Classification and Water Quality Standards Applicable to Surface Waters and Wetlands in North Carolina* (15A NCAC 02B .0200) (DWQ, August 2004).

3.3.1 Bacteria – Recreation

Throughout the nation, water quality standards for bacteria are based on human health for recreation and shellfish harvesting and consumption (15A NCAC 2B .0200). North Carolina evaluates waters for the support of primary recreational activities such as swimming, water-skiing, skin diving and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis. Waters of the state designated for these uses are classified as Class B, SB and SA. North Carolina also evaluates waters used for secondary recreation activities such as wading, boating and other uses not involving human body contact with water where such activities take place on an infrequent, unorganized or incidental basis. These waters are classified as Class C, SC and WS.

DWQ conducts monthly ambient water quality monitoring in many freshwater streams and rivers. The monitoring includes sampling for fecal coliform bacteria. The fecal coliform standard for freshwater is 200 colonies per 100milliliters (ml) of water based on at least five consecutive samples taken during a 30-day period, not to exceed 400 colonies per 100ml in more than 20 percent of the samples during that the same period (15A NCAC 2B .0219). The 200 colonies per 100ml standard is intended to ensure that waters are safe enough for water contact through primary recreation. Class B waters are impaired in the recreation category if the water quality standard for fecal coliform bacteria is exceeded. Fecal coliform bacteria are identified as the stressor to these waters. Class C and WS waters are not rated if the geometric mean exceeds 400 colonies per 100 ml.

For coastal beaches, sounds and estuaries, the DEH monitors bacteria levels through their Recreational Water Quality Monitoring Program (http://www.deh.enr.state.nc.us/shellfish/Water_Monitoring/RWQweb/home.htm (RECMON). Water quality objectives and criteria have been established for enterococci bacteria. DEH has established Tier I, II and III swimming areas/beaches based on their recreational usage. Swimming advisory signs are posted and press releases issued for Tier I swimming areas or beaches (swimming areas used daily) when a minimum of five samples, equally spaced over 30 days, exceed a geometric mean of 35 enterococci per 100 ml or when a single sample exceeds 500 enterococci per 100 ml. The public is notified only by press release, without an advisory sign, when a single sample exceeds 104 enterococci per 100 ml and is less than 500 enterococci per 100 ml. If a second sample exceeds 104 enterococci per 100 ml, an advisory is posted and the public will be notified by press release. An advisory will also be issued when at least two of three samples from a monitoring site exceed 104 enterococci per 100 ml. For an advisory to be rescinded, the station must have two consecutive samples below 35 enterococci per 100 ml.

In a case where a station under advisory is subject to triplicate sampling, two of the three samples must be under the single-sample maximum of 104 enterococci per 100 ml. If two of the three samples are above the single-sample maximum of 104 enterococci per 100 ml, an advisory will be put into place. The advisory will be rescinded when two of the three re-samples are under the single-sample level, as long as the running geometric mean of 35 enterococci per 100 ml has not been exceeded.

Beaches that violate the single-sample maximum criteria are re-sampled at the time of the public notification and/or sign posting, depending on the level of the exceedence. If the re-sample is satisfactory, the advisory may be lifted as early as 24 hours from the time of the initial advisory notification or posting. If the re-sample is unsatisfactory, but the geometric mean is not exceeded, the sign remains posted. If the re-sampling causes the exceedence of the geometric mean, then the geometric mean criteria apply.

The timeframe for posting swimming advisory signs at Tier I beaches, based on the enterococci geometric mean, runs from the beginning of May through the end of September. Weekly sampling of Tier I beaches is from April to October. During April and October, advisories at all Tier I monitoring sites are based on the single-sample maximum for Tier II beaches/swimming areas (276 enterococci per 100 ml.). More information about fecal coliform and enterococci bacteria can be found in Chapter 10.

3.3.2 BACTERIA – SHELLFISH HARVESTING

The Shellfish Sanitation Section (http://www.deh.enr.state.nc.us/shellfish/index.html) of DEH is responsible for monitoring and classifying coastal waters as to their suitability for shellfish harvesting for human consumption and the inspection and certification of shellfish and crustacean processing plants. Classifications of coastal waters for shellfish harvesting are done by means of a Sanitary Survey. The survey includes a shoreline survey, a hydrographic survey and a bacteriological survey of growing waters. The surveys are conducted of all potential shellfish growing areas in coastal North Carolina and recommendations are made to the DMF of which areas should be closed for shellfish harvesting. Based on the results of the survey, waters are classified into one of five categories: Approved (APP), Conditionally-Approved Open (CAO), Conditionally-Approved Closed (CAC), Prohibited (PRO) and Restricted (RES). DWQ evaluated water quality based on the recommendations provided by DEH. More information on bacteria in shellfish waters can be found in Chapter 10.

3.3.3 CHLOROPHYLL

Chlorophyll *a*, a constituent of most algae, is a widely used indicator of algal biomass. North Carolina has a chlorophyll *a* standard of 40µg/1 (micrograms per liter) for lakes, reservoirs and slow moving waters not designated as trout waters and a 15µg/1 standard for trout waters. Total dissolved gas levels in excess of 110 percent of saturation are also a violation of standards.

3.3.4 DISSOLVED OXYGEN

Dissolved Oxygen (DO) can be produced by turbulent actions, such as waves, rapids and waterfalls that mix air into the water. High levels are found mostly in cool swift moving waters, and low levels are found in warm slow moving waters. In slow moving waters such as reservoirs or estuaries, depth is also a factor. Wind action and plants can cause these waters to have a higher dissolved oxygen concentration near the surface and decline to as low as zero at the bottom. Waters are impaired for aquatic life when greater than 10 percent of samples collected exceed the state DO standard. A minimum of 10 samples is required. The DO water quality standard for Class C waters is not less than a daily average of 5.0 mg/l (milligrams per liter of water) with a minimum instantaneous value of not less than 4 mg/l. Swamp waters (supplemental Class Sw) may have lower values if the low DO level is caused by natural conditions. Trout waters (supplement Class Tr) should not have less then 6.0 mg/L DO.

3.3.5 PH

pH is a measure of hydrogen ion concentration that is used to express whether a solution is acidic or alkaline (basic). Lower values can have chronic effects on the community structure of macroinvertebrates, fish and phytoplankton. The water quality standard for pH in surface freshwaters is 6.0 to 9.0. Swamp waters (supplement Class Sw) may have a pH as low as 4.3 if it is the result of natural conditions.

3.3.6 TEMPERATURE

All aquatic species require specific temperature ranges in order to be healthy and reproduce. For example, trout prefer temperatures below 20° C (68° F) and cannot survive in the warm reservoirs of the piedmont and coastal plain where temperatures can exceed 30° C (86 degrees F). An aquatic species becomes stressed when water temperatures exceed their preferred temperature range, and stressed fish are more susceptible to injury and disease. Water quality standards state that discharge from permitted facilities should not exceed the natural temperature of the water by more than 2.8° C (5.04° F). Waters should never exceed 29° C (84.2° F) for the mountain and upper piedmont area or 32° C (89.6° F) for the lower piedmont and coastal plain areas. The discharge of heated liquids to trout water temperatures should not increase the natural water temperature by more than 0.5° C (0.9° F), and in no case, exceed 20°C (68° F).

Excursions do not constitute water quality impairment, but they do suggest that precautions should be taken to ensure stream temperature is not elevated by human activities. Human activities most likely to contribute to temperature increases in North Carolina include removal of shade trees along streambanks and construction of private dams and ponds. In both cases, more sunlight reaches the stream causing an increase in water temperature. Impervious surface cover also has the potential to increase water temperature. Rain that falls onto impervious surfaces absorbs heat, and the heated stormwater is transferred to nearby streams.

3.3.7 TURBIDITY

Turbidity can influence water clarity, plant and animal growth and drinking water treatment processes. It is often a measure of suspended solids within the water column and is influenced by existing land uses including agriculture, land-disturbing activities and urban stormwater runoff. The water quality standard for receiving waters are not to exceed 50 Nephelometric Turbidity Units (NTU). If the stream has the supplement classification of trout, the receiving water must not exceed 10 NTU. For lakes and reservoirs not designated trout, the turbidity should not exceed 25 NTU. If turbidity exceeds these levels due to natural background conditions, the existing turbidity level cannot be increased. Waters are impaired for aquatic life when greater than 10 percent of samples collected exceed the state turbidity standard.

3.4 TOXIC SUBSTANCES

Rule 15A NCAC 02B .0202(64) defines a toxic substance as "any substance or combination of substances ... which after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, has the potential to cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions or suppression in reproduction or growth) or physical deformities in such organisms or their offspring." Toxic substances frequently encountered in water quality management include chlorine, ammonia, organics (hydrocarbons and pesticides), heavy metals and pH. Because these substances are toxic to different organisms at different levels, their effects can be immediately evident or may manifest only after long-term exposure or accumulation in living tissue.

3.4.1 PH

pH is a measure of hydrogen ion concentration. pH levels that are too high (alkaline) or too low (acidic) can impact the availability of many chemical constituents in the water column including metals, nutrients and oxygen. Metals, for example, become more soluble when pH decreases. Metals that are bound to soil particles can detach, making them more readily available to aquatic organisms. In their detached form, metals are often more harmful and even toxic to the aquatic community. Increases in pH, however, cause metals to precipitate out of the water column. While low pH may not be toxic to aquatic organisms, the metals and the chronic effects associated with those metals can have chronic effects on the community structure.

Changes in the pH of surface waters occur primarily through point source discharges. Changes can also occur during accidental spills, acid deposition (i.e., rain, snow) and algal blooms.

3.4.2 METALS

Some metals can have a negative impact upon both human and aquatic life. Some organic metals (i.e., methylmercury) can build up (bioaccumulate) in the fatty tissue of fish by uptake through the food chain, making them potentially unsafe for human consumption. For aquatic organisms, metals in surface waters can have chronic, sublethal effect and effect neurological and respiratory systems. A variety of water quality characteristics including dissolved and particulate organic carbon, pH and hardness affect the availability of metals and their subsequent impacts upon aquatic life (Bergman and Dorward-King, 1997). Metals can enter surface waters through industrial and wastewater point source dischargers and atmospheric deposition.

North Carolina has adopted numerical water quality standards (maximum permissible levels) for several metals including arsenic, cadmium, chlorine, chromium, cyanide, mercury, nickel and selenium. Action levels, however, are established for metals that do not bioaccumulate in the environment. These metals include copper, iron and zinc. These metals vary in toxicity because of their chemical form, solubility, stream characteristics and/or associated waste characteristics. Limits are not usually assigned to metals that have action level standards unless (1) monitoring indicates that the parameter may be causing toxicity or (2) federal guidelines exist for a given discharger for an action level substance. For those metals not assigned a given numeric standard or action level, a water quality-based limit may be assigned if data indicates the presence of a substance for which there is a federal criterion.

MERCURY

The presence and accumulation of mercury in North Carolina's aquatic environment are similar to contamination observed throughout the country. Mercury has a complex life in the environment, moving from the atmosphere to soil, to surface water and eventually, to biological organisms. Mercury circulates in the environment as a result of natural and human (anthropogenic) activities. A dominant pathway for mercury in the environment is through the atmosphere. Mercury emitted from industrial and municipal stacks into the ambient air can circulate around the globe. At any point, mercury may then be deposited onto land and water. Once in the water, mercury can accumulate in fish tissue and humans. Mercury is also commonly found in wastewater; however, mercury in wastewater is typically not at levels that could be solely responsible for elevated fish levels

Fish is part of a healthy diet and an excellent source of protein and other essential nutrients; however, nearly all fish and shellfish contain trace levels of mercury. The risks from mercury in fish depend on the amount of fish eaten and the levels of mercury in the fish. In March 2003, the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) issued a joint consumer advisory for mercury in fish and shellfish. The advice is for women who might become pregnant, women who are pregnant, nursing mothers and young children. Aside from being issued jointly by two federal agencies, this advisory is important because it emphasizes positive benefits of eating fish and gives examples of commonly eaten fish that are low in mercury. In the past, the FDA (www.cfsan.fda.gov/seafood1.html) issued an advisory on consumption of commercially caught fish, while the EPA (www.epa.gov/waterscience/fish/) issued advice on recreationally caught fish.

In North Carolina, the Department of Health and Human Services (NCDHHS) issues fish consumption advisories for those fish species and areas at risk for contaminants. NCDHHS notifies people to either limit consumption or avoid eating certain kinds of fish. While most freshwater fish in North Carolina contain very low levels of mercury and are safe to eat, several species have been found to have higher levels (bowfin, catfish, chain pickerel and largemouth bass). For more information and detailed listing of site-specific advisories, visit the NCDHHS Web site www.schs.state.nc.us/epi/fish/current.html.

3.4.3 CHLORINE

Chlorine is a greenish-yellow gas that dissolves easily in water. Because chlorine is an excellent disinfectant, it is commonly added to drinking water supplies to kill bacteria. Chlorine is also used as a disinfectant in wastewater treatment plants and swimming pools and as a bleaching agent in textile factories and paper mills. It is an important ingredient in many laundry bleaches. Even in very small amounts, free chlorine (chlorine gas dissolved in water) is toxic to fish and aquatic organisms. Chlorine becomes more toxic as pH decreases or when it is combined with other toxic substances such as cyanides, phenols or ammonia. Because chlorine reacts quickly with other substances in water (and forms combined chlorine) or dissipates as a gas into the atmosphere, effects are relatively short-lived compared to most other highly poisonous substances. Free chlorine (Cl^-) can also combine with organic material to form compounds called trihalomethanes (THMs). In high concentrations, some THMs are carcinogenic (cancer causing). Unlike free chlorine, THMs are persistent and can pose a threat to human health for many generations.

North Carolina has adopted a freshwater standard for trout waters of 17 μg/l (micrograms per liter) for total residual chlorine. For all other waters, an action level of 17 μg/l for total residual chlorine is applied to protect against toxicity. A total residual chlorine limit is assigned based on the freshwater action level standard of 17 μg/l or a maximum concentration of 28 μg/l for protection against acute effects in the mixing zone. Federal guidelines for residual chlorine of 8 μg/l for chronic effects and 13 μg/l for acute effects are used in saltwaters. New and expanding discharges are encouraged provide dechlorination or alternate wastewater disinfection treatment to avoid discharging chlorine into surface waters of the state.

3.4.4 AMMONIA

Ammonia (NH_3) is a compound of nitrogen and hydrogen. It is a gas at room temperature and is toxic and corrosive to some materials. It has a characteristic pungent odor and is one of the most common industrial and household chemical cleaners.

Ammonia is an important source of nitrogen for many living systems. Nitrogen is essential for the synthesis of amino acids, which are the building blocks for proteins. In humans and animals, ammonia is created through normal amino acid metabolism. It is toxic in high concentrations;

however, our livers convert ammonia to urea through a series of reactions known as the urea cycle. Urea is much less toxic and is a major component of urine. Many plants rely on ammonia and nitrogenous wastes that are incorporated into the soil through the decaying process. Others, such as nitrogen-fixing legumes, however, rely on symbiotic relationships with certain types of bacteria that can covert atmospheric nitrogen to ammonia (Wikipedia, December 2006).

Because ammonia is rich in nitrogen, it also makes an excellent fertilizer. Ammonium salts are a major source of nitrogen for fertilizers. Nitrogen not used by plants can enter streams, rivers and reservoirs during storm events and increase the potential for eutrophication. Even in very low concentrations, ammonia is toxic to aquatic organisms. When levels reach 0.06 mg/l, fish can suffer gill damage. When levels reach 0.2 mg/l, sensitive fish (like trout) begin to die. As levels near 2.0 mg/l, even ammonia-tolerant fish (like carp) begin to die. Ammonia levels greater than approximately 0.1 mg/l usually indicate polluted waters. The danger ammonia poses for fish is dependent upon on water temperature, pH and dissolved oxygen and carbon dioxide concentrations. Ammonia is more toxic to fish and aquatic life when the water column contains very little dissolved oxygen and/or carbon dioxide.

Point source dischargers are the primary sources of ammonia in surface waters. Decaying organic matter and bacterial decomposition of animal waste can also contribute to increased ammonia levels in surface water.

DWQ addresses ammonia toxicity through an interim set of instream criteria of 1.0 mg/l in the summer (April to October) and 1.8 mg/l in the winter (November to March). Current limits are no less than 2.0 mg/l in summer and 4.0 mg/l in winter, unless dissolved oxygen problems or modeling analysis dictate stricter limits. These interim criteria are under review, and the state may adopt a standard in the future.

3.5 Other Water Quality Stressors

3.5.1 Nutrients

Nutrients refer to phosphorus (P) and nitrogen (N), which are common components of fertilizers, animal and human waste, vegetation, aquaculture and some industrial processes. Nutrients in surface waters come from both point and nonpoint sources including agriculture and urban runoff, wastewater treatment plants, forestry activities and atmospheric deposition. While nutrients are beneficial to aquatic life in small amounts, excessive levels can stimulate algal blooms and plant growth, depleting dissolved oxygen in the water column. More information on nutrients and management strategies to control eutrophication can be found in Chapter 11.

3.5.2 Total Suspended Solids (TSS)

TSS are solids (i.e., sediment, decaying plant and animal material, industrial waste, sewage) that can be filtered out of the water column. High TSS can block light from reaching submerged aquatic vegetation, which slows down the rate of photosynthesis and reduces the amount of dissolved oxygen in the water column. If light is completely blocked from bottom dwelling plants, the plants will stop producing oxygen and die. As plants decompose, bacteria will use up even more oxygen from the water, ultimately leading to fish kills.

High TSS can also increase surface water temperature and decreases water clarity. Surface water temperature increases because the suspended particles absorb heat from sunlight. Because warmer waters hold less dissolved oxygen, dissolved oxygen levels tend to fall even further. The decrease in water clarity caused by TSS can affect the ability of fish to see and catch food. Suspended sediment can also clog fish gills, reduce growth rates, decrease resistance to disease and prevent egg and larval development. When suspended solids settle to the bottom of a waterbody, they can smother fish eggs, as well as suffocate newly hatched insect larvae. Settling sediments can fill in spaces between rocks, reducing habitat availability (Mitchell and Stapp, 1992).

3.5.3 Color

Color is generally associated with industrial wastewater, municipal plants that receive industrial wastes from textile manufacturers that dye fabrics and pulp and paper mills. Color can affect the aesthetic quality of a waterbody and interfere with sunlight penetration. Submerged aquatic vegetation needs light for photosynthesis. If color blocks out light, photosynthesis will be reduced, thus reducing the production of oxygen needed for the survival of aquatic life. If light levels get too low, photosynthesis may stop altogether, causing algae to die. In addition, fish may not be able to see in waters polluted with color, making it difficult to find food. Color is usually not a toxicological problem. There is no current data showing that colored effluent poses any threats to human health or that it is the sole source of aquatic life impacts.

According to state regulations, colored effluent is allowed in "only such amounts as will not render the waters injurious to public health, secondary recreation, or to aquatic life and the wildlife or adversely affect the palatability of fish, aesthetic quality or impair the waters for any designated uses" (15A NCAC 02B .0211(3)(a)). The state has considered developing a numeric standard for color, but there are many challenges in doing so. Some of these challenges include knowing what the appropriate analytical approach is, assigning the appropriate numeric standard is and determining if a different standard should be used for different regions in the state to reflect variations in natural (background) water color. The practical application of this regulation must also take into account the various ways in which color is perceived. No narrative definition of color impairment can be specified by a simple set of criteria because color is perceived differently under varying conditions. The advantage of a narrative standard is that it is flexible. The disadvantages are that it is subjective and difficult to enforce.

All dischargers with colored waste are required to conduct toxicity testing on the effluent to assure that the discharge will not adversely impact the aquatic organisms in the receiving stream. DWQ believes that the most effective and equitable means of addressing color is to rely on the narrative aesthetic standard as well as on citizen complaints.

3.6 WHOLE EFFLUENT TOXICITY

Whole effluent toxicity (WET) testing is required on a quarterly basis for major dischargers (>1 MGD) permitted through the National Pollutant Discharge Elimination Program (NPDES). Dischargers that contain complex (industrial) wastewater are also required to conduct WET testing. A WET test shows whether the effluent from a treatment plant is toxic, but it does not identify the specific cause of toxicity. Where a facility has indicated potential toxicity, toxicity reduction plans are reviewed by DWQ to evaluate compliance with permit limits. Other testing, or monitoring, that can be done to detect aquatic toxicity problems include fish tissue analyses, chemical water quality sampling and assessment of fish community and bottom-dwelling organisms such as aquatic insect larvae. More information on WET testing can be found in Chapter 2.

3.6.1 PERMIT LIMITS

Many of the toxic substances reviewed in the chapter are identified and controlled through the (NPDES) permitting process. Facilities are inspected and compliance reports are reviewed by DWQ to ensure that permitted facilities are meeting permit limits and not impacting water quality. Permit limits for specific toxicants are based on the volume of the discharge and the flow conditions of the receiving waters. Methods for determining permit limits are established by the federal Environmental Protection Agency (EPA). The limits consider the maximum predicted effluent concentration and the amount of variation in effluent monitoring data. If the point source (permitted facility) is not meeting its permit limits, it can be identified as a water quality stressor. More information on the NPDES permitting process can be found in Chapter 9.

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CHAPTER 4 – SOURCES OF WATER QUALITY STRESSORS

When evaluating water quality stressors, DWQ evaluates and identifies the source of the stressor as specifically as possible depending on the amount of information available for that particular watershed. Sources are most often associated with the predominant land use where the altered hydrology is able to easily deliver the water quality stressor to the waterbody. Construction, stormwater outfalls, agriculture and impervious surface are just a few of the sources that can be identified in any given watershed. This chapter provides an overview of point and nonpoint sources of pollution, identifies sources of nonpoint source (NPS) pollution and describes several state and federal programs that focus on reducing the impacts of pollution.

4.1 POINT SOURCES

Point source (PS) pollution refers to pollution that enters surface waters through a pipe, ditch or other discrete, well-defined discharge. The most common point source pollutants are oxygen-consuming wastes, nutrients and toxic substances including chlorine, ammonia and metals.

Figure 4-1 Example of Point Source Pollution (Encarta Encyclopedia Online)

Point source pollution applies primarily to wastewater and stormwater discharges from municipal (city and county) and industrial wastewater treatment plants and small domestic wastewater treatment systems that serve schools, commercial properties, residential subdivisions and individual homes. There are several federal and state regulations in place to control point sources. These include wastewater and stormwater permits issued through the National Pollutant Discharge Elimination System (NPDES) Program.

4.1.1 PERMITTED WASTEWATER ACTIVITIES

The Clean Water Act of 1972 initiated strict control of wastewater discharges and assigned enforcement responsibility to the Environmental Protection Agency (EPA). The EPA created the National Pollutant Discharge Elimination System (NPDES) to track and control point sources of pollution. The primary method of control is the issuance of discharge permits with limitations on wastewater flow and constituents. The EPA delegated permitting authority to the State of North Carolina in 1975. All wastewater discharges to surface waters in the State of North Carolina must receive a permit to control water pollution.

DWQ's NPDES Permitting and Compliance Program is responsible for administering NPDES for the state. The NPDES Permitting and Compliance Program must determine the quality and quantity of treated wastewater that can be discharged into a receiving stream. An NPDES permit will specify an acceptable level of a pollutant in a discharge (i.e., bacteria, nitrate, ammonia, pH, biochemical oxygen demand, total suspended solids, etc.) in order to protect water quality. Conservative methods are used to calculate the acceptable level, based on the assimilative capacity and designated uses of the receiving stream. The permittee may choose which technologies to use to achieve the level specified in the permit. NPDES permits ensure that both North Carolina's mandatory standards for clean water and federal minimum requirements are met. As a delegated state, North Carolina has the authority to establish state water quality standards more stringent than the federal standards established by EPA. More information about wastewater treatment can be found in Chapter 9.

4.1.2 Permitted Stormwater Activities

The goal of DWQ's stormater discharger permitting regulations and programs is to prevent pollution from entering the waters of the sate via stormwater runoff. These programs try to accomplish this goal by controlling the source(s) of pollution and include the federal NPDES Phase I and Phase II rules and regulations, state stormwater requirements and requirements associated with the Water Supply Watershed Program. Below is a brief description of each of the stormwater programs. More information about stormwater management can be found in Chapter 5.

NPDES Phase I Stormwater Program: Phase I of the NPDES stormwater program started as an amendment to the Clean Water Act in 1990. Phase I requires NPDES permit coverage to address stormwater runoff from medium and large stormwater sewer systems serving populations of 100,000 or more. 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.

NPDES Phase II Stormwater Program: Phase II of the NPDES stormwater program was signed into law in December 1999. EPA delegated Phase II implementation to each state, and DWQ, under the direction of the Environmental Management Commission (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. However, in early 2004, the Rules Review Commission (RRC) objected the proposed Phase II stormwater rules for failure to comply with the Administrative Procedures Act and lack of statutory authority. As a result, the legislature approved Session Law 2006-246, Senate Bill 1566 in 2006. It includes provisions for projects that cumulatively disturb one acre or more of land in Phase II municipalities and counties and 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.

Phase II builds upon the existing Phase I program by requiring smaller communities (population < 100,000) and public entities that own and operate a municipal separate storm sewer system (MS4) to apply and obtain an NPDES permit for stormwater discharges. Local governments permitted under Phase II are required to develop and implement a comprehensive stormwater management program that includes six minimum measures. These measures include public education, public involvement, illicit discharge detection and elimination, pollution prevention and post-construction stormwater management.

North Carolina's State Stormwater Management Program: The State Stormwater Management Program was established in the late 1980s under the authority of the EMC and North Carolina General Statute 143-214.7. The program affects development activities that require either an Erosion and Sediment Control Plan (for disturbances of one or more acres) or a Coastal Area Management Act (CAMA) major permit within one of the 20 coastal counties and/or development draining to Outstanding Resource Waters (ORW) or High Quality Waters (HQW). The program requires new developments to protect ORW and HQW waters by maintaining low-density development, restricting impervious surfaces, maintaining vegetative buffers and transporting runoff through vegetated conveyances.

Water Supply Watershed Stormwater Rules: The purpose of the Water Supply Watershed Protection Program is to provide a proactive drinking water supply protection program for local 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.

4.1.3 PERMITTED ANIMAL OPERATIONS

Facilities with more than 2,500 swine, 1,000 slaughter and feeder cattle, 700 mature dairy cows or 30,000 laying hens or broilers which discharge or propose to discharge waste to surface waters are required to obtain an NPDES general or individual permit. Facilities with fewer numbers of animals that discharge or propose to discharge waste to surface waters are also required to obtain an NPDES permit under new guidance by the EMC. The permit must comply with both state and federal requirements and reflect effluent limitations based on technological capability, water quality standards and more stringent state requirements.

General permits are issued to facilities that involve the same or substantially similar operations, have similar discharge characteristics, require the same effluent limitations or operating conditions and require the same or similar monitoring. The basis for the animal waste NPDES general permits can be found in the North Carolina General Statutes 143-215.1 (http://www.ncleg.net/EnactedLegislation/Statutes/HTML/BySection/Chapter_143/GS_143-215.1.html) and 143-215.10C (http://www.ncga.state.nc.us/EnactedLegislation/Statutes/HTML/BySection/Chapter_143/GS_143-215.10C.html). Under new guidance by the EMC, the general permits now incorporate federal requirements and include additional operational, monitoring and reporting requirements.

Individual permits may be required if the facility is a significant contributor of pollutants to waters of the state; conditions of the permitted facility have changed, altering the constituents or characteristics of the wastewater; noncompliance with the general permit or with DWQ rules; and/or technology or practices to control or abate applicable pollutants changed. Individual permits may also be issued if it has been determined that there is the potential for direct discharge of wastewater, sludge or residuals to waters of the state. Factors considered when making this determination include: chronic flooding (100-year floodplain), staging areas located in or near a wetland and land application adjacent to a waterbody with special emphasis on ORW, shellfish waters, critical habitats, water supply watersheds, wild and scenic rivers and waters listed as impaired for nutrients or other pollutants found in animal wastes.

Both permits become effective on July 1, 2007 and will be applicable for five years. Each facility will be covered under an animal waste permit by issuance of a certificate of coverage (COC). More information on NPDES permits can be found on the DWQ Aquifer Protection Section, Animal Feeding Operations Unit (AFOU) Web site (http://h2o.enr.state.nc.us/aps/afou/afou_home.htm).

4.2 Nonpoint Sources

Nonpoint source (NPS) pollution refers to runoff that enters surface waters through stormwater, snowmelt or atmospheric deposition (i.e., acid rain). The majority of water quality problems in North Carolina are the result of NPS pollution.

There are many types of land use activities that contribute to nonpoint source pollution. Land development, construction, forestry operations, mining operations, crop production, animal feeding lots, failing septic systems, landfills, roads and parking lots all contribute to NPS pollution (Table 4-1).

Nonpoint Sources of Pollution

- Construction activities
- Roads, parking lots and rooftops
- Turf and lawn maintenance
- Agriculture
- Failing septic systems and straight pipes
- Timber harvesting
- Hydrologic modifications

Sediment and nutrients are major pollution-causing substances associated with NPS pollution. Others include fecal coliform bacteria, heavy metals, oil and grease and any other substance that may be washed off the ground or removed from the atmosphere and carried into surface waters. Unlike point source pollution, however, NPS pollution is diffuse in nature and occurs intermittently, depending on rainfall, snowmelt and topography. Sediment and nutrients are most often associated with nonpoint source pollution. Given these characteristics, it is difficult and resource intensive to quantify nonpoint contributions to water quality degradation in a given watershed.

4.2.1 Agricultural Operations

When performed without protective best management practices (BMPs), agricultural activities that may cause water quality impacts include confined animal facilities, grazing, plowing, stream access, pesticide spraying, irrigation, fertilizing, planting and harvesting. The major agricultural NPS pollutants that result from these activities are sediment, nutrients, pathogens, pesticide and salts. Without proper BMPs in place, agricultural activities can also damage aquatic habitat and stream channels. More information about agricultural activities can be found in Chapter 6.

4.2.2 CONSTRUCTION ACTIVITIES

Construction activities that entail excavation, grading or filling, such as road construction or land clearing for development, can produce significant sedimentation if not properly controlled. Sedimentation from developing urban areas can be a major source of pollution due to the cumulative number of acres disturbed within a watershed. While construction activities are

typically a temporary pollution source, their impacts upon water quality can be severe and long lasting. More information about construction, or land-disturbing, activities can be found in Chapter 8.

Table 4-1 Activities, Sources and Solutions Associated with Nonpoint Source Pollution

ACTIVITIES	POLLUTION SOURCE	SOLUTION
Land clearing or plowing	Erosion Sedimentation	Contour plowing Terracing Conservation tillage Grassed waterways Vegetated buffer between fields and streams
Pesticides and fertilizers (including chemical fertilizers and animal wastes)	Nutrients Pesticides	Integrated crop and pest management Soil testing
Construction of drainage ditches on poorly drained soils	Enhanced runoff	Maintaining natural stream channels Vegetated buffers
Concentrated animal feed lot operations and dairy farms	Oxygen-consuming wastes Fecal coliform bacteria Sediment Nutrients	Fencing cattle and dairy cows from streams Non-discharging animal waste lagoons Vegetated buffers

4.2.3 GOLF COURSES

Golf courses may impact water quality in three ways. First, erosion can occur during construction activities. Second, intensive turf management practices often rely heavily on the use of fertilizers and chemical pesticides. Stormwater runoff then carries these pollutants to nearby streams, impacting aquatic life and habitat. Third, golf courses impact water quality when stream channels are altered or cleared of vegetation during construction and site maintenance.

4.2.4 MINING ACTIVITIES

Mining operations, if not properly conducted, can produce stream sedimentation. The North Carolina Mining Act of 1971 applies to all persons or firms involved in any activity or process that disturbs or removes surface soil for the purpose of removing minerals or other solid matter. The Act also applies to activities that prepare, wash, clean or in any way treat minerals or other solid materials in order to make them suitable for commercial, industrial or construction use. While mining operations range from large quarries to small borrow pits, the NC Mining Act applies only to those operations that impact one acre or more.

4.2.5 ON-SITE WASTEWATER TREATMENT (SEPTIC SYSTEMS)

More than 52 percent of all housing units in North Carolina are served by on-site wastewater (septic) systems. Most on-site wastewater treatment systems are conventional septic systems that consist of a tank, a distribution box and a series of subsurface absorption lines with perforated pipes laid in a gravel bed. The septic system provides a natural method of treatment and disposal of household wastes for homes that are not part of a municipal sewage treatment system. Septic systems can be a safe and effective method for treating domestic wastewater as long as they are sized, sited and properly maintained. Advanced on-site wastewater systems utilize pre-treatment methods such as filters and aerobic treatment and use improved distribution systems such as pressure dosing on sensitive sites.

Problems Associated with Malfunctioning Septic Systems include:

Polluted Groundwater
Septic system pollutants include bacteria, nutrients, toxic substances and oxygen-consuming wastes. Nearby wells can become contaminated by these pollutants.

Polluted Surface Water
Groundwater can carry pollutants into surface waters where they can harm aquatic ecosystems. Septic tanks can also leak into surface waters through, or over, the soil.

Human Health Risks
Malfunctioning septic systems can endanger human health by contaminating nearby wells, drinking water supplies and fishing and swimming areas.

In a septic system, household wastewater is separated into solids, liquids and gases by bacteria and sedimentation in a two-chambered septic. The gases exit the system through the plumbing roof vent while the solids float to the surface or settle to the bottom of the first chamber of the tank. The liquid passes through the center of the chamber wall and receives additional sedimentation and bacterialogical treatment in the second chamber before passing through a filter at the outlet end of the tank. The treated liquid, or effluent, is then distributed throughout the drainfield through a series of shallow subsurface pipes. Final treatment of the effluent occurs as the soil absorbs and filters the liquid, and microbes break down the remaining waste into harmless organic material.

If the tank and/or drainfield are improperly located, poorly constructed or not maintained, nearby wells and surface waters may become contaminated. In some cases, wastewater illegally discharges from homes directly to streams or the land surface through what is known as a "straight pipe". Straight pipes can carry black water, grey water or both. Black water refers to raw sewage from toilets being discharged directly from homes into streams or the ground. Grey water refers to the water that is used for washing dishes, bathing and laundry. It has a cloudy appearance and often contains bacteria, nutrients, soaps, oils and greases. Straight piping and failing septic systems are considered illegal wastewater discharges. More information about on-site wastewater management can be found in Chapter 9.

4.2.6 SOLID WASTE DISPOSAL

Solid waste includes household trash, commercial or industrial wastes, refuse or demolition waste and infectious or hazardous wastes. The improper disposal of these wastes can serve as a primary source for a wide array of pollutants. The two major water quality concerns associated with modern solid waste facilities are: leachate control and stabilization of the soils used to cover many disposal facilities. When properly designed, constructed and operated, facilities should have no significant impact to water quality.

4.2.7 TIMBER HARVESTING

Undisturbed forested areas are an ideal land cover for water quality protection because they stabilize soils and produce balanced loading of organic matter to waterways. Forested stream buffers also filter impurities in stormwater runoff from adjoining, nonforested areas. Inappropriate forest management practices, however, can have significant impacts upon water quality. Some adverse effects that can result from poorly managed forestry operations include unstable soils, increased sedimentation and loss of riparian vegetation and canopy. Forestry BMPs that minimize sediment loss and runoff must be implemented during timber harvest. More information about forestry activities can be found in Chapter 7.

4.2.8 URBAN LANDSCAPES

Natural streams with forested watersheds and vegetated riparian zones experience little overland runoff - most rainfall percolates through the soil and enters the groundwater. Therefore, natural streamflow is primarily the result of groundwater inputs. In urban areas, however, natural vegetation is replaced with paved surfaces (impervious surfaces) and streamside vegetation is often removed. Managed or manicured lawns also reduce the ability of the watershed to filter pollutants before they enter a stream. In other words, urbanization increases the amount - and decreases the quality - of stormwater runoff.

Studies have demonstrated that water quality begins to decline when only 10 to 15 percent of a watershed is covered by impervious surfaces such as roads, rooftops and parking lots (Schueler, 1994), and recent work at North Carolina State University (NCSU) suggests that impacts to aquatic life can occur at any level of disturbance (Gilliam et *al*., 2005). While it is widely known that urban streams are often polluted, there are still a number of issues that need to be addressed, such as the specific aspects of urbanization that cause degradation, the extent to which urbanization alone is responsible for degradation and how to change human habits and reduce the amount of pollutants that cause the degradation (Mulholland and Lenat, 1992).

There is also abundant information on the effects of urban runoff on aquatic communities. Studies show that stream organisms are affected not only by water quality, but also by the character of the physical habitat such as flow regime (Eagleson et *al*., 1990; Lenat et *al*., 1979). Structures used to control flooding in urban areas often impact stream characteristics and flow. Structures that prevent flooding often route water directly to streams. This is especially true in urban landscapes where large amounts of impervious surfaces promote overland flow at the expense of groundwater recharge. These structures also cause streamflows to rapidly increase after rainfall events, which can lead to bottom scour - the physical movement of bedload - and the disruption of stream biology and habitat.

One of the long-term results of increased overland flow is an accentuated summer low flow, due primarily to a reduction in groundwater storage. Many streams in developed areas even stop flowing during summer months, severely limiting the diversity of aquatic fauna. Because most fish and macroinvertebrates in streams require flowing water, they may be adversely affected by either extreme high or low flows. Urban development may affect streamflow by increasing flow variability and/or by altering base flow.

Due to the chronic introduction of pollutants found in urban stormwater, along with an increase in both the velocity and flow of urban stormwater into streams, attention to stormwater control in urban areas is critical. Without proper BMPs, urban development can alter the hydrology of a watershed and significantly increase the rate and flow of stormwater runoff. This often results in downstream flooding, streambank erosion and severely degraded habitats.

4.2.9 MARINAS

Marinas, both freshwater and saltwater, can pose a great risk to water quality. A large source of pollution from commercial and recreational boaters is sewage, along with litter and gasoline spills. Each can cause any number of problems with wastewater carrying many different bacteria or viruses that impact human health. Bacteria also impact shellfish harvesting areas and recreational beaches. Oxygen that fish and other aquatic life depend on can be depleted during waste decomposition. In coastal areas, many marinas are located in relatively shallow waters away from large waves. This often makes the water stagnant and can have devastating effects on the oxygen levels aquatic organisms depend on.

Sewage is also high in nutrients (i.e., nitrogen and phosphorus). Algal blooms (fast-growing floating algae) block light from other plants growing on the bottom substrate. Once the algae have used all of the nutrients, they begin to die. The decaying process for algae also depletes oxygen from the water compounding any existing problems the waterbody may be having with oxygen levels.

Many boat owners add chlorine and formaldehyde to their wastewater holding tanks to control odor or to disinfect, which if released, can be toxic to aquatic life. Most of these chemical additives are now biodegradable; however, if the wrong amount or the wrong type is added, it can be toxic to aquatic life.

4.2.10 STORMWATER OUTFALLS

Stormwater outfalls are pipes that carry untreated stormwater runoff to the nearest waterbody. As the runoff travels downslope, it picks up many different pollutants and carries them into a stormwater inlet. The pipes divert the unfiltered runoff away from roads and parking lots and carry the runoff to streams, rivers and estuaries. This untreated stormwater contains pollutants such as oils and other liquids from vehicles, roadside litter, sediment, bacteria and many other contaminates that can be toxic to aquatic life and may be harmful to humans. Stormwater outfalls can lead to severe habitat degradation.

4.3 CONTROLLING NONPOINT SOURCE POLLUTION

There are two commonly used approaches to address NPS pollution - prevention (nonstructural) and engineered (structural) BMPs. Examples of pollution prevention measures include minimizing built-upon areas, protecting of sensitive areas, optimum site planning, use of natural drainage systems rather than curb and gutter, nutrient management strageties, public/farmer education, storm drain stenciling and hazardous waste collection sites.

Engineered BMPs generally work by capturing, retaining and treating runoff before it leaves an area. Some commonly used BMP types include stormwater wetlands, wet detention ponds, water control structures, bioretention areas and infiltration basins. Higher levels of pollutant removal can often be achieved through a combination of different control systems. The primary advantage of engineered controls is that they are able to treat runoff from high-density developments.

The current nonpoint source management trend involves a comprehensive "systems approach" that incorporates an integrated system of preventive and control practices to accomplish NPS pollution reduction goals. This approach emphasizes site planning, natural area protection and cost-effective engineered controls for high-density areas. Several preventive and engineered BMPs are identified throughout this document.

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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

<u>Phase I</u> – 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.

<u>Phase II</u> – 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.

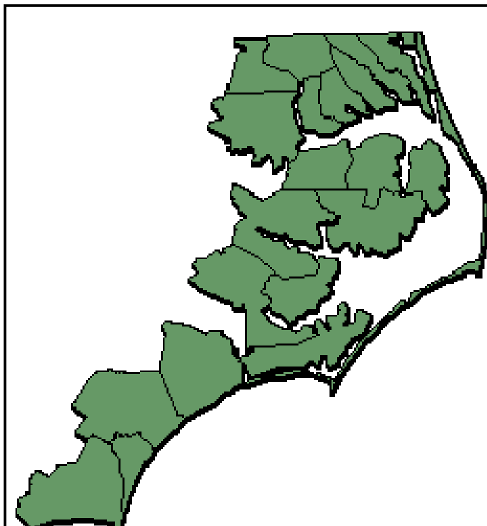

Figure 5-1 Twenty Coastal Counties
Source: http://dcm2.enr.state.nc.us/

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.

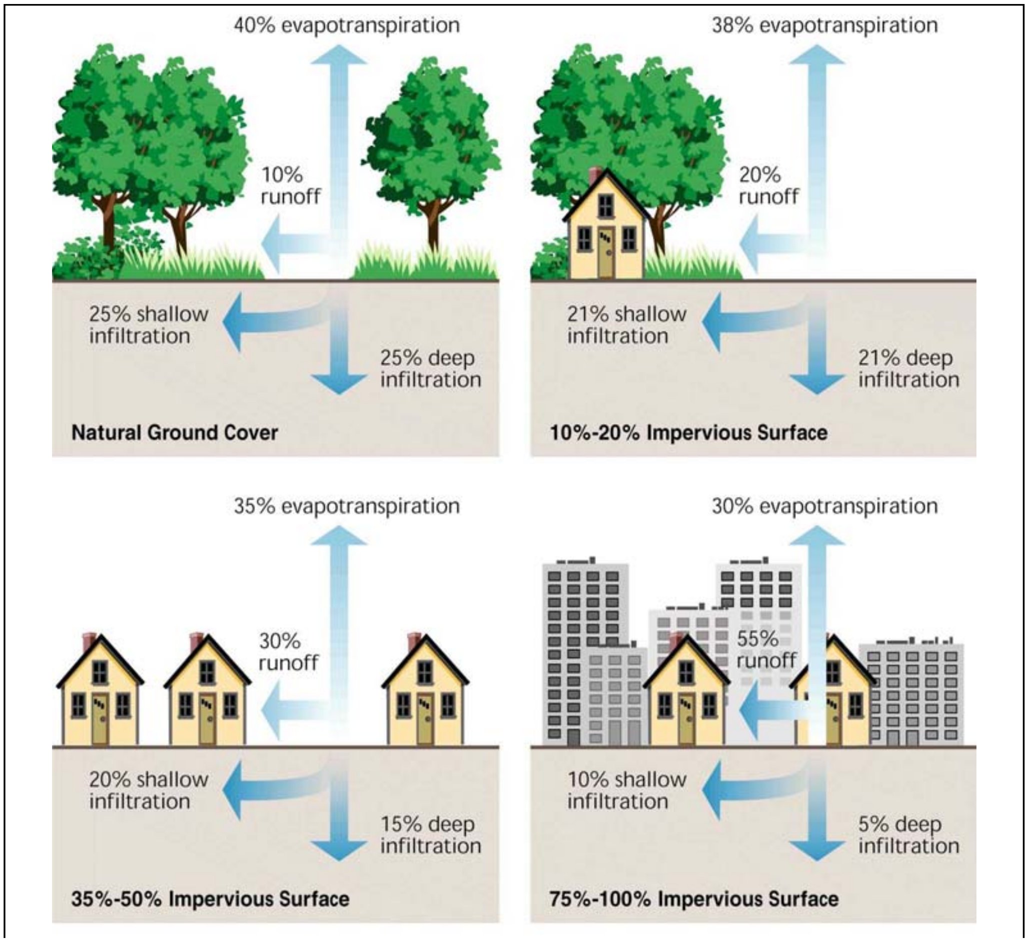

Figure 5-2 Impervious Surfaces and Surface Runoff

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 Storage Tanks)
Infiltration Devices	Vehicle-Use Reduction	Roadway Cleaning
Manufactured BMP Systems	Storm Drain Stenciling	
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/).

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CHAPTER 6 - AGRICULTURE AND WATER QUALITY IMPACTS

Confined animal operations, grazing, plowing, stream access, pesticide spraying, fertilizing, planting and harvesting are all agricultural activities that may impact water quality. The major agricultural nonpoint source pollutants that result from these activities are sediment, nutrients, pathogens (i.e., bacteria), pesticide and salts. Agricultural activities can also damage habitat and stream channels.

This chapter includes an overview of how agricultural activities can impact water quality, a summary of key legislative rules that effect animal operations throughout the state of North Carolina, how several federal and state agencies play an active role in protecting water quality, and how conservation and best management practices (BMPs) can protect water quality.

6.1 AGRICULTURAL LAND USE ACROSS THE NATION

Land use is dynamic, with annual shifts in and out of different uses. Examining net change in land use reveals general trends, but masks the real extent of land use change over time. In agriculture there are frequent shifts in the use of land among cropland, pastureland, rangeland and forestland. Each time land use changes, it may affect erosion potential, contiguity of habitat, or hydrologic features of the landscape.

Cropland, pastureland, rangeland and forestland comprise the majority of the nation's land resources. Consequently, the condition of these lands directly and indirectly influences the environment (NRCS, May 2006).

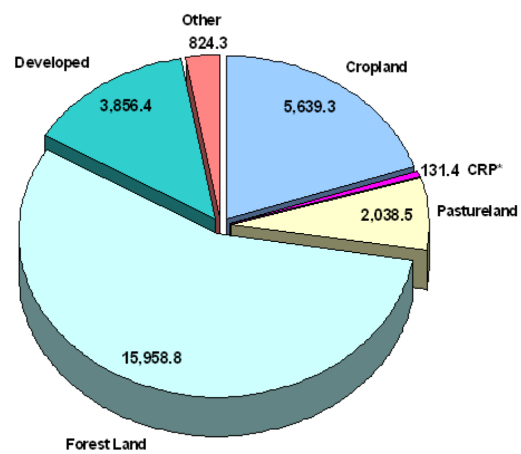

Figure 6-1 Land Use in North Carolina

There are 28,448.7 million acres of nonfederal, rural land in the State of North Carolina. Over 56 percent is in forestland and 27 percent is in cropland or pastureland (USDA NRCS, 1997. Revised December 2000).

* Conservation Reserve Program (CRP)

The National Resources Inventory (NRI) is a statistical survey of natural resource conditions and trends on nonfederal land in the United States -- nonfederal land includes privately owned lands, tribal and trust lands, and lands controlled by State and local governments. The NRI provides nationally consistent statistical data on how these lands are used and on changes in land use patterns for the period 1982 - 2003. To assess conservation issues on nonfederal rural lands, this land use information must be analyzed in conjunction with other NRI data elements. Land uses of particular interest are those involving the production of agricultural and timber products that are the foundation of our Nation's agricultural economy.

Nationwide, the key findings from the NRI include:

- The contiguous 48 states cover 1.9 billion acres. About 71 percent of this area is in nonfederal, rural land use – nearly 1.4 billion acres.
- Non-Federal rural lands are predominantly forestland (406 million acres), rangeland (405 million acres) and cropland (368 million acres).
- The Nation's cropland acreage declined from 420 million acres in 1982 to 368 million acres in 2003, a decrease of 12 percent (approximately 2 million acres lost per year). The net decline between 1997 and 2003 was 8 million acres, or about two percent (approximately 1 million acres lost per year).
- Between 1982 and 2003, nonfederal acreage devoted to grazing uses – rangeland, pastureland and grazed forestland – declined from 611 million acres to 576 million acres, a decrease of 5 percent (approximately 1.5 million acres per year) (NRCS, May 2006).

In North Carolina, there are 28,448.7 million acres in nonfederal, rural land use – 56 percent forestland, 20 percent cropland, 14 percent developed and 7 percent pasture (Figure 6-1). More information about the NRI can be found on the NRCS Web site (www.nrcs.usda.gov/technical/NRI/).

6.2 Impacts to Water Quality

6.2.1 Habitat Degradation

Instream habitat degradation is identified as a notable reduction in habitat diversity or a negative change in habitat. Habitat degradation includes sedimentation, streambank erosion, channelization, lack of riparian vegetation, loss of pools and/or riffles, loss of organic (woody and leaf) habitat, and streambed scour. These stressors to aquatic insect and fish communities can be caused by many different land use activities and less often by discharges of treated wastewater. Refer to Chapter 3 for more information.

Good instream habitat is necessary for aquatic life to survive and reproduce. Streams that typically show signs of habitat degradation are in watersheds that have a large amount of land-disturbing activities (i.e., construction, mining, timber harvest, agricultural activities) or a large percentage of impervious surfaces. A watershed in which most of the riparian vegetation has been removed from streams or channelization (straightening) has occurred also exhibits instream habitat degradation.

6.2.2 Streambank Erosion and Sedimentation

Livestock grazing with unlimited access to the stream channel and banks can also cause severe streambank erosion resulting in sedimentation and degraded water quality. Although they often make up a small percentage of grazing areas by surface area, riparian zones (vegetated stream corridors) are particularly attractive to cattle that prefer the cooler environment and lush vegetation found beside rivers and streams. This concentration of livestock can result in increased sedimentation of streams due to "hoof shear", trampling of bank vegetation, and entrenchment by the destabilized stream. Despite livestock's preference for frequent water access, farm veterinarians have reported that cows are healthier when stream access is limited (EPA, 1999).

6.2.3 LOSS OF RIPARIAN VEGETATION

Removing trees, shrubs and other vegetation to plant grass or place rock (also known as riprap) along the bank of a river or stream degrades water quality. Removing riparian vegetation eliminates habitat for aquatic macroinvertebrates that are food for trout and other fish. Rocks lining a streambank absorb the sun's heat and warm the water. Some fish require cooler water temperatures as well as the higher levels of dissolved oxygen cooler water provides. Trees, shrubs and other native vegetation cool the water by shading it. Straightening a stream, clearing streambank vegetation, and lining the streambanks with grass or rock severely impact the habitat that aquatic insects and fish need to survive.

Establishing, conserving and managing streamside vegetation (riparian buffer) is one of the most economical and efficient BMPs. Forested buffers in particular provide a variety of benefits including filtering runoff and taking up nutrients, moderating water temperature, preventing erosion and loss of land, providing flood control and helping to moderate streamflow, and providing food and habitat for both aquatic and terrestrial wildlife (NCDENR-DWQ, 2004).

6.2.4 CHANNELIZATION OR CHANNEL MODIFICATIONS

In the middle and lower coastal plains and tidewater regions of eastern North Carolina, channelization began as early as the 1700s in order to improve overland water drainage and provide more land for agricultural production. Channelization refers to the physical alteration of naturally occurring streams and riverbeds in the name of flood control, reduced erosion, increased usable land area, greater navigability and more efficient drainage. However, increased flooding, streambank erosion and channel instability often occur in downstream areas after channelization has occurred. Direct or immediate biological effects of channelization include injury and mortality of aquatic insects, fish, shellfish/mussels and other wildlife populations, as well as habitat loss. Indirect biological effects include changes in the aquatic insect, fish and wildlife community structures, favoring species that are more tolerant of or better adapted to the altered habitat (McGarvey, 1996).

Typical Channel Modifications

- ❑ Remove any obstructions, natural or artificial, that inhibit a stream's capacity to convey water (also referred to as clearing and snagging).
- ❑ Widening, deepening or straightening the channel to maximize water movement away from the land surface.
- ❑ Lining the stream channel or streambanks with rock or other resistant material.

6.2.5 NUTRIENTS

Nutrients refer to the elements phosphorus and nitrogen, both of which are common components of fertilizers, animal and human wastes, vegetation, aquaculture and some industrial processes. Both point and nonpoint sources contribute to the phosphorus and nitrogen levels in surface water. Sources include agricultural and urban runoff, wastewater treatment plants, forestry activities and atmospheric deposition. Nutrients in nonpoint source runoff come mostly from fertilizer and animal wastes. Nutrients in point source discharges typically come from human waste, food residues, cleaning agents and industrial processes.

Nutrients are beneficial to aquatic life in small amounts, but excessive nutrient concentrations can stimulate algal blooms and plant growth in ponds, lakes, reservoirs and estuaries. Through respiration and decomposition, algal blooms can deplete the water column of dissolved oxygen and contribute to serious water quality problems. In addition, algal blooms are aesthetically undesirable, cause an unbalanced food web, impair recreational uses of surface waters, impede commercial fishing and pose problems for water treatment systems.

Nutrient sensitive water (NSW) is a supplemental water classification applied to waters that are experiencing, or are subject to, excessive growths of microscopic or macroscopic vegetation. The NC Environmental Management Commission (EMC) defines excessive vegetation growth as growth, which can substantially impair the use of a waterbody as determined by the classification applied to that waterbody.

NSW may include any or all waters within a river basin that the EMC deems necessary to effectively control excessive growths of aquatic vegetation. For the purposes of this classification, "nutrients" refers to phosphorus and nitrogen, although other nutrients or chemicals may be specified if it is determined that they are essential to the growth of aquatic vegetation.

No increase in nutrients over background levels is allowed within NSW waters unless it can be shown that: (1) the increase is the result of natural variations; (2) the increase will not endanger human health, safety or welfare; and (3) preventing the increase would cause a serious economic hardship without equal or greater public benefits. In North Carolina, Nutrient Management Strategies have been implemented in the Tar-Pamlico and Neuse River basins. The Chowan River basin, the New River watershed in the White Oak River basin and the Jordan Lake watershed in the Cape Fear River basin are also designated NSW. BMPs must be implemented to prevent nutrient impacts to surface water quality.

6.2.6 BACTERIA

Fecal coliform bacteria live in the digestive tract of warm-blooded animals. They are excreted in the solid waste of humans and other mammals. In themselves, fecal coliform do not pose a danger to people or animals. Where fecal coliform are present, however, disease-causing bacteria may also be present and water that is polluted by animal and/or human waste can harbor other pathogens that may threaten human health.

Under favorable conditions, fecal coliform bacteria can survive in bottom sediments for an extended period of time (Howell et *al*., 1996; Sherer et *al*., 1992; Schillinger and Gannon, 1985). Therefore, bacterial levels measured in the water column can reflect both recent inputs as well as the resuspension of older inputs.

Improperly designed or managed animal waste operations are a potential source of fecal coliform bacteria in many sections of the state. Livestock in streams and stormwater runoff from pasturelands are also potential sources for fecal coliform bacteria. Limiting direct, easy access to streams can dramatically reduce impacts from bacteria, and there are several rules and regulations that facilities must follow when dealing with animal waste issues.

6.3 Rules and Regulations

There are approximately 18,800 concentrated animal feeding operations (CAFOs) in the United States. They can contribute up to 60 percent of all manure generated by operations that confine animals. Poorly managed CAFOs may threaten water quality and public health by releasing pollutants into the environment through spills, overflows and runoff (EPA, June 2006). Several federal and state rules and regulations are in place to prevent CAFOs from impacting water quality.

6.3.1 Federal Regulations

The federal Clean Water Act created the National Pollution Discharge Elimination System (NPDES) Program "to protect and improve water quality by regulating point source dischargers." The Act defines a CAFO as a point source; therefore, general and/or individual permits are required under the NPDES Program. National Effluent Limitation Guidelines were also established. In February 2003, EPA issued a revised rule that included requirements to address the land application of manure from CAFOs. It required all large and medium CAFOs that discharge manure, litter or process wastewater to the nation's waters apply for an NPDES permit. The rules became effective in April 2003. Authorized NPDES states were required to modify their programs by February 2005 and develop state technical standards. The final 2003 rule can be found on the EPA Web site (http://cfpub.epa.gov/npdes/afo/cafofinalrule.cfm?program_id=7).

EPA recently proposed to revise the NPDES permitting requirements and effluent limitations for CAFOs. The proposal would revise several aspects of the current regulations governing CAFOs.

- EPA proposes to require only the owners and operators of those CAFOs that discharge or propose to discharge to apply for a NPDES permit. Those CAFOs that land apply manure, litter or processed wastewater would not be required to obtain an NPDES permit if the only discharge from those facilities is agricultural stormwater.
- EPA proposes to require greater public participation in the issuance of an NPDES permit by requiring CAFOs seeking coverage under a permit to submit a facility-specific nutrient management plan (NMP) with their permit application or notice of intent. Permitting authorities are also required to incorporate terms of the NMP into the permits as enforceable elements.
- EPA proposes to authorize permit writers, upon request by a CAFO, to establish best management, zero discharge effluent limitations when the facility demonstrates that it has designed an open containment system that will comply with the no discharge requirements.

The proposed rule modification was the result of decisions by the Second Circuit Court of Appeals decision in *Waterkeeper Alliance et al. v. EPA*. The changes further the statutory goal of restoring and maintaining the nation's water quality and effectively ensuring that CAFOs properly manage on-site waste and manure (http://cfpub.epa.gov/npdes/afo/aforule.cfm).

6.3.2 North Carolina Water Quality Regulations

Over the years, key legislative bills were introduced and approved to regulate CAFOs in the State of North Carolina. Original rules for animal waste management systems were set forth under 15A NCAC 02H .0200 (http://h2o.enr.state.nc.us/admin/rules/2H.0200.pdf) – Waste Not Discharged to Surface Waters. These rules identified the requirements and procedures for the application and issuance of permits for animal waste management systems. Subchapter 02H .0200 also sets forth requirements and procedures for other non-discharge systems including wastewater collection systems, wastewater residuals and other non-discharge systems including wastewater irrigation, reclaimed water utilization, groundwater remediation and soil remediation projects.

In May 2006, the Environmental Management Commission (EMC) adopted Title 15A Subchapter 02T (http://h2o.enr.state.nc.us/admin/rules/documents/2Tbook_000.pdf). The subchapter replaced 15A NCAC 02H .0200 and Rules 15A NCAC 02H .0122 – Concentrated Animal Feeding Operations – and 15A NCAC 02H .0123 – Requirements: Evaluating Feedlot Permit Applications. The rules reflect current policy and provide routine consideration of an applicant's compliance status. Section .1300 of Subchapter 02T applies to all persons proposing to construct, modify, expand or operate an animal waste management system. Animal waste is defined as livestock or poultry excreta or mixture of excreta with feed, litter, bedding or other material generated at a feedlot. Animal waste management systems are defined as a combination of structural and nonstructural practices that collect, treat, store or apply animal waste to the land. An animal waste management plan is defined as a plan to properly collect, store, treat or apply animal waste to the land in an environmentally safe manner developed in accordance with the General Statute §143-215.10C (www.ncleg.net/EnactedLegislation/Statutes/HTML/BySection/Chapter_143/GS_143-215.10C.html).

6.3.3 Permits Issued by DWQ

In 2003, there were 2,461 registered animal operations required to obtain a permit from DWQ (Figure 6-2). DWQ has issued state non-discharge permits for swine, cattle, dairy and poultry operations since 1997. Non-discharge permits are issued to those animal operations that land-apply treated effluent. Instead of discharging treated wastewater to the nearest waterbody, it is discharged to a spray irrigation system, rapid infiltration basin or trickling system. Rapid infiltration systems are designed to have a much more intense and higher rate of land application compared to spray irrigation. Most rapid infiltration systems are located in the sandy regions of the state where soils can handle an increased application volume.

Trickling systems, which are typically used for lower effluent volumes are located statewide. Animal waste management plans must meet standards adopted by the USDA NRCS or the Soil and Water Conservation Commission (SWCC) and adhere to all applicable state statutes and rules at the time of development and design. The practices must provide water quality protection and should not be applied above agronomic rates (15A NCAC 02T .1304).

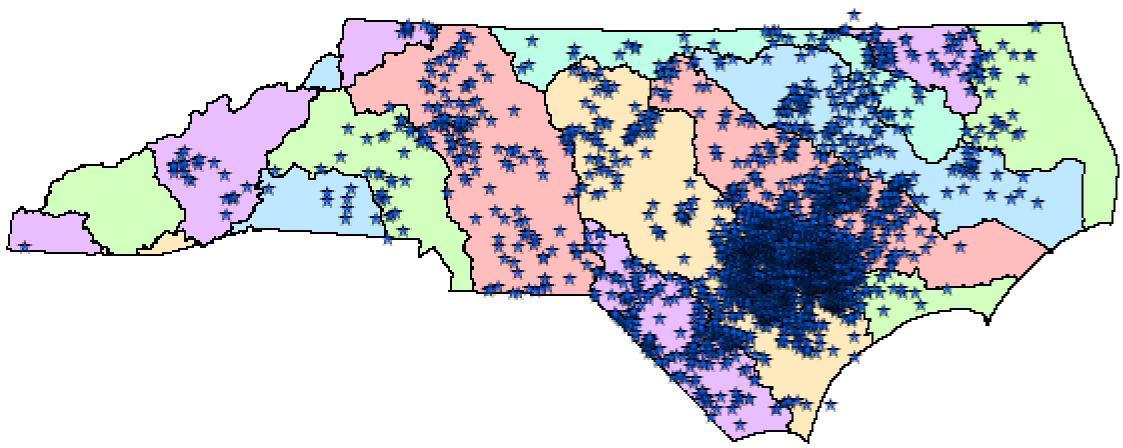

Figure 6-2   Registered Animal Operations in the State of North Carolina (2003)

Facilities with more than 2,500 swine, 1,000 slaughter and feeder cattle, 700 mature dairy cows or 30,000 laying hens or broilers which discharge or propose to discharge waste to surface waters are required to obtain an NPDES general or individual permit. Facilities with fewer numbers of animals that discharge or propose to discharge waste to surface waters are also required to obtain an NPDES permit under new guidance by the EMC. The permit must comply with both state and federal requirements and reflect effluent limitations based on technological capability, water quality standards and more stringent state requirements.

General permits are issued to facilities that involve the same or substantially similar operations, have similar discharge characteristics, require the same effluent limitations or operating conditions, and require the same or similar monitoring. The basis for the animal waste NPDES general permits can be found in the North Carolina General Statutes 143-215.1 (http://www.ncleg.net/EnactedLegislation/Statutes/HTML/BySection/Chapter_143/GS_143-215.1.html) and143-215.10C (http://www.ncga.state.nc.us/EnactedLegislation/Statutes/HTML/BySection/Chapter_143/GS_143-215.10C.html). Under new guidance by the EMC, the general permits now incorporate federal requirements and includes additional operational, monitoring and reporting requirements.

Individual permits may be required if the facility is a significant contributor of pollutants to waters of the state; conditions of the permitted facility have changed, altering the constituents or characteristics of the wastewater; noncompliance with the general permit or with DWQ rules; and/or technology or practices to control or abate applicable pollutants changed. Individual permits may also be issued if it has been determined that there is the potential for direct discharge of wastewater, sludge or residuals to waters of the state. Factors considered when making this determination include: chronic flooding (100-year floodplain); staging areas located in or near a wetland; and land application adjacent to water of the state, with special emphasis on

Outstanding Resource Waters, shellfish waters, critical habitats, water supply watersheds, wild and scenic rivers and waters listed as impaired for nutrients or other pollutants found in animal wastes. Both permits become effective on July 1, 2007 and will be applicable for five years. Each facility will be covered under an animal waste permit by issuance of a certificate of coverage (COC). More information on NPDES permits can be found on the DWQ Aquifer Protection Section, Animal Feeding Operations Unit (AFOU) Web site (http://h2o.enr.state.nc.us/aps/afou/afou_home.htm).

6.3.4 Operator Training and Certification

The Technical Assistance and Certification Unit (http://h2o.enr.state.nc.us/tacu/index.html) of the DWQ Office of Personnel, Training and Information Management (PTIM) Section (http://h2o.enr.state.nc.us/PTIMHome.htm) is responsible for administering the training and certification program for operators of animal waste management systems. The purpose of the program is to reduce nonpoint source pollution associated with the operation of animal waste management systems. Senate Bill 974 §143-215.74C-E (http://www.ncga.state.nc.us/Sessions/1995/Bills/Senate/HTML/S974v7.html) specifically notes that animal operations with 250 or more swine are required to designate an Operator or Charge who is responsible for the operation of the animal waste management system. Rule 15A NCAC 08F .0203 identifies additional animal operations required to obtain permits and/or designate operator responsibilities.

Working with representatives from the animal agriculture industry, environmental groups, North Carolina Department of Agriculture & Consumer Service (NCDA&CS), NRCS, NC Division of Soil and Water Conservation (DSWC), NC Cooperative Extension Service and DWQ, an instruction manual and exam questions were developed for the training and certification program. Individuals who wish to become certified animal waste management system operators must attend a minimum of ten training hours and demonstrate competence in the operation of animal waste management systems by passing an examination. More information about training and certification can be found on the PTIM Web site (http://h2o.enr.state.nc.us/tacu/aniwaste.html). To date, approximately 2,500 animal operations statewide are required to designate a Certified Operator.

6.3.5 North Carolina Pesticide Law of 1971

The North Carolina Pesticide Law of 1971, G.S. 143-434, Article 52 (http://www.ncga.state.nc.us/EnactedLegislation/Statutes/HTML/ByArticle/Chapter_143/Article_52.html) (§143-434 through §143-470.1), establishes programs of pesticide management and control under the authority of the North Carolina Pesticide Board. The purpose of the Law is to protect the health, safety and welfare of the people of this State, and to promote a more secure, healthy and safe environment for all people of the state. This is accomplished by regulation in the public interest of the use, application, sale, disposal and registration of pesticides. The law also requires the registration of pesticide products in the state, the licensing and certification of commercial and private applicators and pest control consultants, the proper handling, transportation, storage and disposal of pesticides, and the licensing of dealers selling restricted use pesticides.

Under the NC Department of Agriculture & Consumer Services (NCDA&CS) Division of Structural Pest Control and Pesticides, the Pesticide Section is responsible for enforcement on the 1971 Pesticide Law through inspections and investigations. All commercial storage facilities and pesticide applicators that store restricted-use pesticides must have an approved pre-fire plan and an annual inspection by a local fire department and/or emergency services office. In addition, each commercial storage facility and pesticide applicator storing at least 10,000 pounds of restricted-use pesticides at any one time must have a board-approved contingency plan that describes the actions facility personnel will take in the event of fires, explosions, spills or any other sudden release of pesticides or pesticide contaminated materials to air, soil or surface water.

The NCDA&CS Pesticide Section has also been involved in a groundwater-monitoring program to determine the impact of pesticides on this valuable resource. The section has been conducting private domestic drinking water well surveys in order to protect human health and to find additional locations to study by installing new monitoring wells. Data will be used in the development of Pesticide Management Plans for the protection of groundwater resources as required by the USEPA. More information can be found on the NCDA&CS Pesticide Section Web site (http://www.ncagr.com/str-pest/pesticides/).

6.4 Reducing Agricultural Impacts to Water Quality – Best Management Practices and Funding Opportunities

To address agricultural impacts to water quality, the State of North Carolina encourages voluntary participation in the protection of land and water resources through the installation and implementation of best management practices (BMPs) and conserving working lands. This approach is supported by financial incentives, technical and educational assistance, research and regulatory programs at the federal and state level.

6.4.1 USDA NRCS Environmental Quality Improvement Program (EQIP)

The Environmental Quality Incentives Program (EQIP) is a voluntary program that provides assistance to farmers and ranchers who face threats to soil, water, air and other related natural resources on their land. Through EQIP, NRCS provides assistance to agricultural producers in a manner that will promote agricultural production and environmental quality as compatible goals, optimize environmental benefits and help farmers and ranchers meet federal, state, tribal and local environmental requirements. The 2002 Farm Bill reauthorized national EQIP funding at $6.16 billion over the six-year period of FY 2002 through FY 2007. Program priorities are as follows:

- Reduction of nonpoint source pollution including nutrients, sediment, pesticides and excess salinity in impaired watersheds consistent with total maximum daily loads (TMDLs) where available; reduction of groundwater contamination; and reduction of point source pollution including contamination from CAFOs.

North Carolina EQIP Funding 2000-2005

2000:	$1.1 Million
2001:	$3.5 Million
2002:	$7.1 Million
2003:	$10.0 Million
2004:	$13.2 Million
2005:	$14.3 Million

- Conservation of ground and surface water resources.
- Reduction of emissions including particulate matter, nitrogen oxides (NOx), volatile organic compounds and ozone precursors and depleters that contribute to air quality impairment violations of National Ambient Air Quality Standards.
- Reduction in soil erosion and sedimentation.
- Promotion of at-risk species habitat conservation.

EQIP offers contracts with a minimum term that ends one year after the implementation of the last scheduled practice and a maximum term of ten years. These contracts provide incentive payments and cost-shares to implement conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. EQIP activities are carried out according to an environmental quality incentives program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or practices to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan.

EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. However, limited resource producers and beginning farmers and ranchers may be eligible for cost-shares up to 90 percent. Farmers and ranchers may elect to use a certified third-party provider for technical assistance. An individual or entity may not receive, directly or indirectly, cost-share or incentive payments that, in the aggregate, exceed $450,000 for all EQIP contracts entered during the term of the Farm Bill. More information about EQIP can be found on the NRCS Web site (www.nc.nrcs.usda.gov/programs/EQIP/index.html).

6.4.2 Conservation Reserve Program (CRP)

The Conservation Reserve Program (CRP) is a voluntary program for agricultural landowners. Through CRP, a farmer can receive annual rental payments and cost-share assistance to establish long-term, resource-conserving covers on eligible farmland. The Commodity Credit Corporation (CCC) makes annual rental payments based on the agriculture rental value of the land, and it provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices. Participants enroll in CRP contracts for 10 to 15 years.

CRP protects millions of acres of American topsoil from erosion and is designed to safeguard the Nation's natural resources. By reducing water runoff and sedimentation, CRP protects groundwater and helps improve the condition of lakes, rivers, ponds and streams. Acreage enrolled in the CRP is planted to resource-conserving vegetative covers, making the program a major contributor to increased wildlife populations in many parts of the country.

The USDA Farm Service Agency (FSA) administers CRP. Technical support functions are provided by NRCS, USDA's Cooperative State Research, Education and Extension Services, state forestry agencies, local SWCDs and private sector providers of technical assistance.

Monthly reports by the USDA show that as of September 2006, there are 137,600 acres of farmland and 5,824 farms in North Carolina enrolled in CRP. More information on CRP can be found on the USDA FSA Web site (www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp) or on the NRCS Programs Web site (www.nrcs.usda.gov/programs/crp/).

6.4.3 Conservation Reserve Enhancement Program (CREP)

The Conservation Reserve Enhancement Program (CREP) is a voluntary land retirement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat and safeguard ground and surface water. The program is a partnership among producers including tribal, state and federal governments and in some cases, private groups. CREP is an offshoot of the country's largest private-lands environmental improvement program - the Conservation Reserve Program (CRP). Like CRP, USDA's Farm Service Agency (FSA) administers CREP. By combining CRP resources with state, tribal, and private programs, CREP provides farmers and ranchers with a sound financial package for conserving and enhancing the natural resources of farms.

Enrollment in a state is limited to specific geographic areas and practices. A specific CREP project begins when a state, Indian tribe, local government or local nongovernmental entity identifies an agriculture-related environmental issue of state or national significance. The involved parties and FSA then develop a project proposal to address particular environmental issues and goals. CREP is a cost-effective way to address rural environmental problems and meet regulatory requirements. It also provides a viable option to supplement farm income. Other benefits include:

- CREP is convenient for producers because it is based on the familiar, highly successful CRP model. Land must be owned or leased for at least one year prior to enrollment to be eligible, and must be physically and legally capable of being cropped in a normal manner.
- Land must also meet cropping history and other eligibility requirements. Enrollment can be on a continuous basis, permitting farmers and ranchers to join the program at any time rather than waiting for specific sign-up periods. CREP supports increased conservation practices such as filter strips and forested buffers. These conservation practices help protect streams, lakes, and rivers from sedimentation and agricultural runoff.
- CREP also helps landowners develop and restore wetlands through the planting of appropriate groundcover. Restoring water regimes helps protect national treasures like the Chesapeake Bay, Mammoth Cave, and the Florida Everglades. By maintaining clear goals and requiring annual monitoring, CREP helps participants measure progress and ensure success.
- CREP addresses high-priority conservation issues of both local and national significance, such as impacts to water supplies, loss of critical habitat for threatened and endangered wildlife species, soil erosion, and reduced habitat for fish populations such as salmon. CREP is a community-based, results-oriented effort centered around local participation and leadership.

In North Carolina, CREP is a joint effort of the DSWC (http://www.enr.state.nc.us/DSWC/index.html), the NC Clean Water Management Trust Fund (http://www.cwmtf.net/) (CWMTF), the Ecosystem Enhancement Program (EEP) (http://www.nceep.net/), and USDA FSA (http://www.fsa.usda.gov/FSA/webapp?area=home&subject=landing&topic=landing). Like the NC Agricultural Cost Share Program (NCACSP) (Section 6.4.4), it is a voluntary program that seeks to protect lands along waterbodies that are currently in agricultural production. Objectives for CREP in North Carolina include: installing 100,000 acres of forested riparian buffers (http://www.soil.ncsu.edu/publications/BMPs/buffers.html), grassed filter strips and wetlands; reducing the impacts of sediment and nutrients within the targeted areas; and providing substantial ecological benefits for many wildlife species that are declining in part as a result of habitat loss. Program funding will combine the CRP funding with State funding from the CWMTF, NCACSP (http://www.enr.state.nc.us/DSWC/pages/agcostshareprogram.html) and the NC EEP.

Under CREP, landowners can voluntarily enroll eligible land in 10-year, 15-year, 30-year or permanent contracts. The state will pay additional bonuses to landowners that enroll land in 30-year or permanent agreements. Cost sharing will be available for installation of forested riparian buffers, grassed filter strips, wetlands restoration practices, water control structures, livestock exclusion, and remote livestock watering in order to increase the efficiency of enrolled practices. Interested landowners should contact their local DSWC or USDA Farm Service Agency Office (http://www.fsa.usda.gov/edso). More information about CREP can be found on the DSWC Web site (http://www.enr.state.nc.us/DSWC/pages/crep.html) and on the USDA FSA Web site (http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=cep).

6.4.4 NC Agricultural Cost Share Program (NCACSP)

The NC Agricultural Cost Share Program (NCACSP) was established in 1983 to help reduce agricultural nonpoint runoff into the state's waters. The program helps owners and renters of established agricultural operations improve their on-farm management by using BMPs and include vegetative, structural or management systems that can improve the efficiency of farming operations while reducing the potential for surface and groundwater pollution. The Division of Soil and Water Conservation (DSWC) implements the NCACSP. The BMPs are divided into five main purposes or categories:

- *Erosion Reduction/Nutrient Loss Reduction in Fields*
  Erosion/nutrient management measures include planned systems for reducing soil erosion and nutrient runoff from cropland into streams. Practices include: critical area planting, cropland conversion, water diversion, long-term no-till, pastureland conversion, sod-based rotation, stripcropping, terraces and Christmas tree conservation cover.
- *Sediment/Nutrient Delivery Reduction from Fields*
  Sediment/nutrient management measures include planned systems that prevent sediment and nutrient runoff from fields into streams. Practices include: field borders, filter strips, grassed waterways, nutrient management strategies, riparian buffers, water control structures, streambank stabilization and road repair/stabilization.

- *Stream Protection from Animals*
  Stream protection management measures are planned systems for protecting streams and streambanks. Such measures eliminate livestock access to streams by providing an alternate watering source away from the stream itself. Other benefits include: reduced soil erosion, sedimentation, pathogen contamination and pollution from dissolved, particulate and sediment-attached substances. Practices include: heavy use area protection, livestock exclusion (i.e., fencing), spring development, stream crossings, trough or watering tanks, wells and livestock feeding areas.
- *Animal Waste Management*
  A waste management system is a planned system in which all necessary components are installed for managed liquid and solid waste to prevent or minimize degradation of soil and water resources. Practices include: animal waste lagoon closures, constructed wetlands, controlled livestock lounging area, dry manure stacks, heavy use area protection, insect and odor control, stormwater management, waste storage ponds/lagoons, compost and waste application system.
- *Agricultural Chemical (Agrichemical) Pollution Prevention*
  Agrichemical pollution prevention measures involve a planned system to prevent chemical runoff to streams. Practices include: agrichemical handling facilities and fertigation/ chemigation back flow prevention systems.

The NCACSP is a voluntary program that reimburses farmers up to 75 percent of the cost of installing an approved BMP. The remaining 25 percent is paid by the landowner or through in-kind contributions. The cost share funds are paid to the farmer once the planned BMP is completed, inspected and certified. The BMP must be installed according to NCACSP standards.

Cost Share allocation and funding decisions by District Boards are based on their written strategy plans. After receiving their allocation, District Boards review applications from landowners for Cost Share funding and decide who will be funded for BMP installation. The written strategy plans are used to prioritize the BMPs in terms of effectiveness for water quality protection. District Boards are encouraged to place the highest priority on the most cost effective water quality protection measures.

Since the first cost share contracts were issued in 1984, there have been approximately 45,241 contracts approved for installing BMPs through the end of the 2005 program year. It has been estimated that an average of 7.2 million tons of soil have been saved annually during the life of the program. Additional accomplishments include (1984-2005):

- Converted 117,143 acres of cropland to trees or grass.
- Installed 4,829,540 feet of fence to exclude livestock from streams.
- Constructed 3,870 waste management structures to properly store and dispose of animal waste.
- Installed 15,426 acres of grassed waterways and field borders to prevent sediment and nutrient delivery to streams, lakes and estuaries.

In 2004-2005 fiscal year, NCACSP received $7.3 million in state appropriations. The $7.3 million include $2.1 million for technical assistance funding. The program cost shared 123 full and part-time technical positions to plan, design and install agricultural BMPs to improve water quality. NCASCP is currently budgeted for $7.3 million in non-reverting, recurring funds. More information about the NCACSP and BMPs eligible for cost sharing can be found on the DSWC Web site (http://www.enr.state.nc.us/DSWC/pages/agcostshareprogram.html).

6.4.5 WORKING LANDS AND CONSERVATION BENEFITS

Working Lands are used for agriculture, forestry or other natural resource industries. Well-managed working lands provide important non-market goods and services. For example, farms, ranches and forestlands provide food and cover for wildlife, help control flooding, protect wetlands and watersheds and maintain air quality. They can absorb and filter wastewater, runoff and provide groundwater recharge.

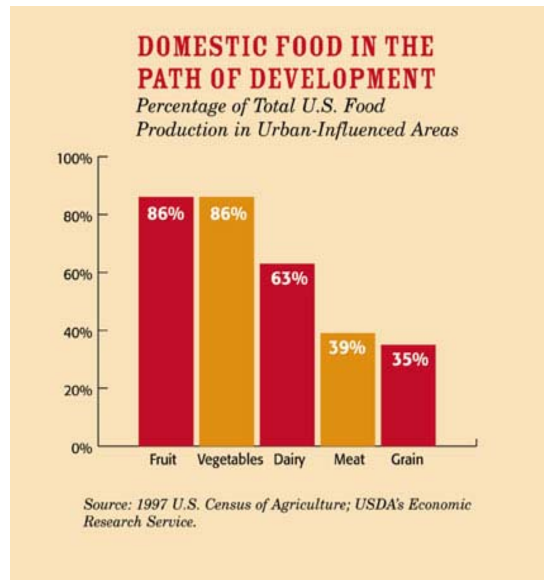

Figure 6-3 Crop Production on Urban-Influenced Areas

Rapid urbanization is forcing the conversion of working lands to developed land at an astonishing rate in North Carolina. From 1992 to 1997, over 170,000 acres of agricultural land was converted to developed land. That was the 12th highest rate in the nation. The figures for Prime Farmland, the best land for growing crops, are even more disturbing. North Carolina is losing prime farmland at the fourth fastest rate in the nation (USDA, 2001). The 1997 U.S. Census of Agriculture shows that a large percentage of cropland is in urban-influenced areas, making them prime targets for development (Figure 6-3). It is well established that developed land negatively impacts water quality; therefore, preserving North Carolina's working lands should be a priority (Figure 6-4).

The value of specific working lands can be calculated for any watershed by performing a Cost of Community Services (COCS) study. COCS studies are a case study approach used to determine a community's public service costs versus revenues based on current land use. Their particular niche is to evaluate the overall contribution of agricultural and other open lands on equal ground with residential, commercial and industrial development.

As of January 2002, 83 COCS studies conducted in 19 states found that tax and other revenues collected from farm, ranch and forest landowners more than covered the public service costs these lands incur. COCS studies show that on average, residential development generates significant tax revenue but requires costly public services that typically are subsidized by revenues from commercial and industrial land uses. The special contribution of COCS studies is that they show that farm, ranch, and forestlands are important commercial land uses that help balance community budgets. Working lands are not just vacant land waiting to be developed (Freedgood et *al*., 2002).

A recent analysis of the fiscal impact of different land uses in Macon County, North Carolina demonstrates the cost-saving benefits to the county of maintaining farmland and open space. Using county budget data and tax data from fiscal year 2000, the study indicates that typical residential and commercial properties cost the county budget by demanding more in tax-supported services than they contribute in property tax revenues. Such services include schools, roads, water and sewer lines, fire and police protection and social and administrative services. On the other hand, the typical farmland/open-space parcel contributed more property tax to the county budget than it demanded in expenditures for county services. Analyzing a scenario of a 30-acre parcel of farmland/open-space, the study estimated that the county budget would gain $290 if the land remained as farmland, but would lose a net $532 if converted to ten 3-acre lots with houses on them (Jones and Kask, 2001).

The opportunities for private landowners to protect working lands are growing. North Carolina cities and counties have now begun to use the new set of farmland protection tools authorized by the General Assembly in 2005 through Session Law 2005-390. Along with an expanded definition of agriculture and a revamped Agricultural Development and Farmland Preservation Trust Fund, this legislation authorized a new category for localities to promote the stability of their agricultural sectors. Counties and municipalities now have the authority to create an Enhanced Voluntary Agricultural District (EVAD) option, which offers an increased set of incentives for landowners to restrict development over a ten-year period. Polk County in the

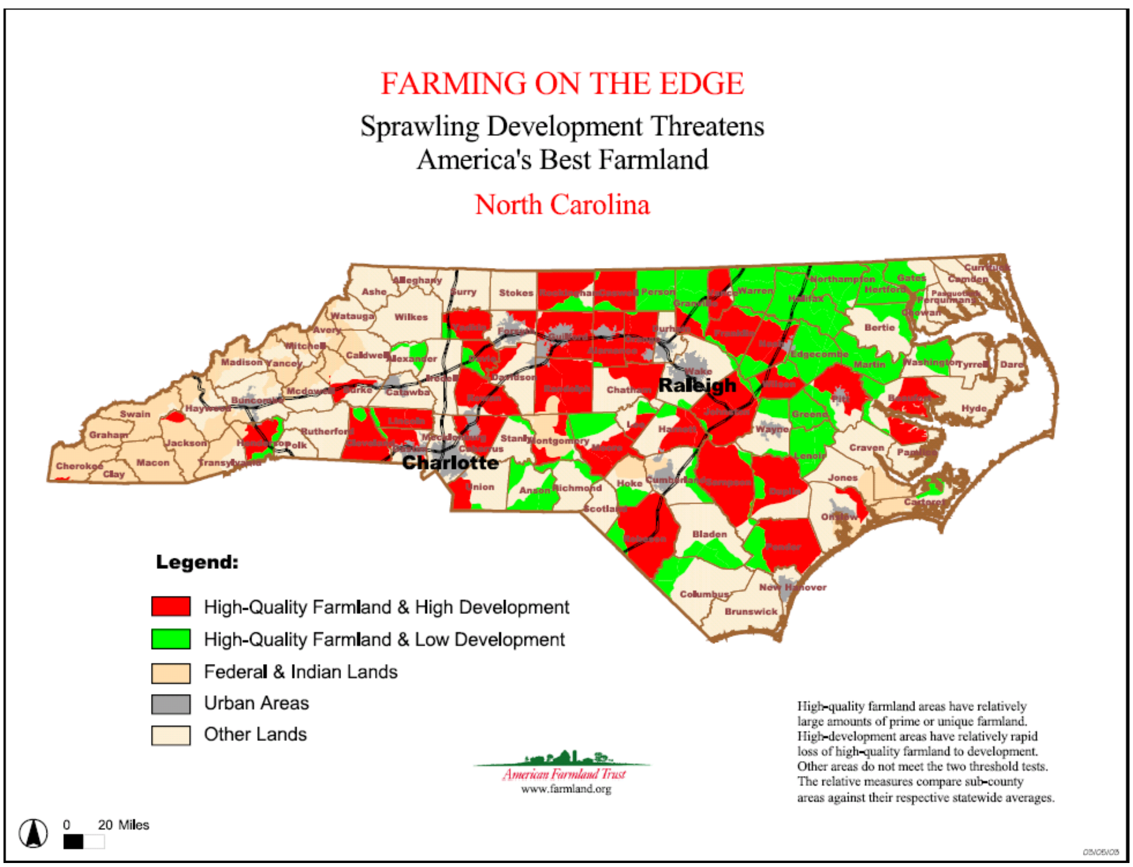

Figure 6-4 North Carolina's High Quality Farmland and High Development Areas

mountains and Wentworth in the Piedmont are amongst the first jurisdictions in the state to utilize this new tool, with the recent adoption of local EVAD ordinances. Landowners interested in working land protection should contact their local land trust, NRCS field representative or SWCD. The Farmland Information Center is also an excellent online resource (www.farmlandinfo.org/). Local government officials interested in the value of working land conservation should visit the Land Trust Alliance's Economic Benefits of Open Space Protection Web site (www.lta.org/resources/economic_benefits.htm).

6.4.6 NRCS WETLANDS RESERVE PROGRAM (WRP)

The Wetlands Reserve Program (WRP) is a voluntary program offering landowners the opportunity to protect, restore and enhance wetlands on their property. It was established by the 1990 Farm Bill with the goal to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. The USDA NRCS provides technical and financial support to help landowners with their wetland restoration efforts and offers landowners an opportunity to establish long-term conservation and wildlife practices and protection.

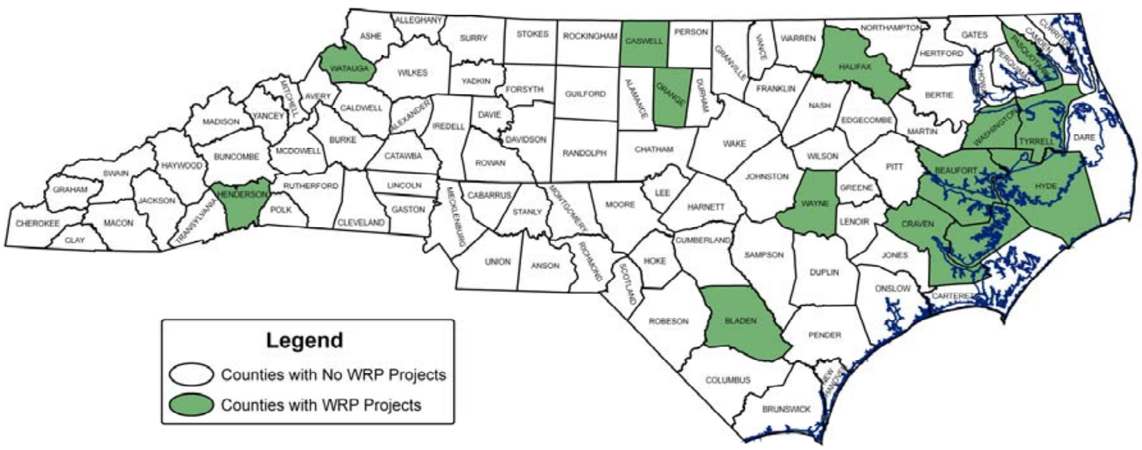

Figure 6-5 Wetland Reserve Programs in North Carolina

The program has become a popular, cost-effective and ecologically successful voluntary, incentive-based wetlands restoration and conservation program. WRP provides incentives to farmers and ranchers to stop cultivating areas that were once wetlands and make them wetlands again. WRP met the acreage limit established prior to the 2002 Farm Bill. Consequently, Congress raised the program's total acreage enrollment limit to 2,275,000 acres. This action enables WRP to continue to be a viable option for the nation's private landowners who want to restore wetlands through 2007. As of fiscal year 2004, 8,396 projects have been enrolled on 1,633,398 acres. Landowner interest in the program remains strong. NRCS anticipates enrolling 154,500 acres in fiscal year 2005.

Landowners have three program participation options: (1) short-term 10-year restoration cost-share agreements, (2) mid-term 30-year conservation easements or (3) permanent easements. NRCS provides financial assistance in the form of easement payments, restoration cost-share assistance and technical assistance for restoration and wetland management.

Enrolled lands are mostly marginal, high-risk, flood prone restorable agricultural wetlands. All states and Puerto Rico have active WRP projects. The top 10 states in terms of enrollment are Louisiana, Arkansas, Mississippi, California, Florida, Missouri, Iowa, Texas, Minnesota and Oklahoma. Nationally, the full average project cost per acre is approximately $1,470. In FY 2004 the average project size was approximately 188 acres.

Landowners participating in WRP continue to control access, have use of non-developed recreational activities, such as hunting and fishing, and maintain the right to lease the recreational uses of their land for financial gain. At any time during the contract period, landowners may request NRCS approval of other uses that are compatible with wetland and wildlife conservation objectives of the program. WRP funds and subsequent lease revenue provide financial relief to landowners and reduce future disaster assistance needs.

As of FY 2003, 28,773 acres have been enrolled in the WRP in North Carolina (Figure 6-5). More information on WRP can be found on the NRCS Programs Web site (www.nrcs.usda.gov/programs/wrp/).

6.4.7 SOIL TESTING AND WASTE ANALYSIS

The Agronomic Division, Plant/Waste/Solution Section of the NCDA&SC provides analytical and advisory services to protect soil and water resources and improve agricultural productivity and efficiency. Soil testing and waste analyses are the basic tools needed to responsibly apply waste and other nutrient-bearing materials on agricultural land while protecting the State's natural resources.

Soil testing determines fertility status and nutrient requirements. A waste analysis indicates usability of by-products as nutrient sources and predicts nutrient availability. Plant analysis determines nutritional status of growing crops and the effectiveness of fertilizer programs in meeting crop requirements. Solution analysis indicates quality of surface and groundwater supplies and usability in agricultural production.

Agronomic Division services can be effective in solving crop production problems and ensuring optimum yield, quality and efficiency. They are also critical in monitoring soil and water resources and environmental stewardship. Division field advisory services provide a staff of agronomists for site-specific implementation of recommendations and assistance in crop production and waste utilization. More information on soil, waste and solution analysis can be found on the Agronomic Division Web site (http://www.ncagr.com/agronomi/pwshome.htm).

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CHAPTER 7 – FORESTRY AND WATER QUALITY IMPACTS

Forests are an ideal land use for water quality protection because they stabilize soil and filter stormwater runoff from adjoining, non-forested areas. In order to sustain a forest's ability to protect water quality, some degree of management is often required. Timber harvesting is part of the forest renewal cycle and is usually the most intensive forest management activity that requires special attention to assure water quality is protected. Inappropriate management practices can impact water quality by destabilizing streambanks, reducing riparian vegetation and removing tree canopies. Any one of these impacts can alter the interface of the aquatic and terrestrial ecosystem, influence downstream flooding and change watershed functions.

Sedimentation is the most common water pollution agent that may result from forestry activities. Potential sources of sedimentation include stream crossings, forest roads, skid trails and log decks. As a result, the majority of regulations and erosion control recommendations pertaining to forestry focus on these four main areas. This chapter explores forestry in North Carolina. It includes information on forestland ownership, resources and management. It also includes information related to best management practices (BMPs) and forestry operations. More information on any of the topics in this chapter can be found on the NCDENR Division of Forest Resources Web site (www.dfr.state.nc.us).

7.1 FORESTRY REGULATIONS IN NORTH CAROLINA

Forestry activities in North Carolina are regulated through a series of state and federal rules, laws and regulatory guidance documents. Ongoing forestry, or silviculture, activities should not be confused with land-clearing activities that are undertaken for construction, development, real estate or highway projects. These types of non-forestry activities must have all applicable federal, state and local permits with engineered erosion and sedimentation control plans and stormwater discharge permits. In addition, land-clearing for agriculture or horticulture can include pastures, Christmas tree farms or winery vineyards, none of which are considered forestry silviculture activities.

Major water quality regulations that can directly affect forestry are provided below. All forestry activities must also remain in compliance with state and federal surface water quality standards, including standards for wetland waters.

- Catawba River Basin: Protection and Maintenance of Existing Riparian Buffers 15A NCAC 02B .0243.
- Discharges Not Requiring Permits: 33 Code of Federal Regulations (CFR) 323.4.
- Forest Practices Guidelines (FPGs) Related to Water Quality: 15A NCAC 01I .0100 - .0209.
- Neuse River Basin Nutrient Sensitive Waters Management Strategy: Protection and Maintenance of Existing Riparian Buffers: 15A NCAC 02B .0233.
- North Carolina Coastal Area Management Act (CAMA): GS 113A-103(5)(b).
- North Carolina Dredge & Fill Law: GS 113-229.
- North Carolina Sedimentation Pollution Control Act (SPCA): GS 113A, Article 4.
- Obstructing streams a misdemeanor: GS 77-13.

- Obstructions in streams and drainage ditches: GS 77-14.
- Randleman Lake Water Supply Watershed Protection and Maintenance of Riparian Areas: 15A NCAC 02B .0250.
- Tar-Pamlico River Basin Nutrient Sensitive Waters Management Strategy: Protection and Maintenance of Existing Riparian Buffers: 15A NCAC 02B .0259.

7.1.1 History of the Forest Practices Guidelines (FPGs) Related to Water Quality

The North Carolina Sedimentation Pollution Control Act (SPCA) (G.S. Ch.113A Art.4) was passed in 1973. Its purpose is to prevent sediment from reaching streams by requiring the installation and maintenance of adequate sediment control measures during site-disturbing activities. The initial law provided a blanket exemption for agriculture and forestry. In 1974, a Forest Practices Act study committee concluded that forestry was not a major contributor of sediment and recommended that voluntary BMPs be developed and used during forestry activities. These generic BMPs were summarized in the publication *Forest Practices Guidelines Related to Water Quality*, referred to as the FPGs.

The FPGs were followed voluntarily until the end of 1989 when they became required. Following an amendment to the SPCA, FPG regulations became effective January 1, 1990. The amendment maintains that forestry operations in North Carolina are subject to regulation under the SPCA but may be exempted if those operations comply with the FPG performance standards defined within Rule 15A NCAC 01I .0100 - .0209.   Today, the FPGs are the regulatory foundation upon which all forestry operations are evaluated regarding water quality protection.

7.1.2 Monitoring FPG Compliance

The NC Division of Forest Resources (NCDFR) is delegated the authority to monitor and evaluate forestry operations for compliance with the FPGs as well as other water quality laws and/or rules. In addition, the NCDFR works to resolve identified FPG compliance questions brought to its attention through citizen complaints. Violations of the FPG performance standards that cannot be resolved by NCDFR are referred to the appropriate state environmental agency for possible enforcement action (Table 7-1)

In addition to state regulations, NCDFR also monitors the implementation of federal rules or guidance relating to water quality and forestry operations in wetlands. These include:

- Clean Water Act Section 404 silviculture exemption.
- Fifteen mandatory practices related to road construction in wetlands
- Six mandatory practices related to mechanical site preparation activities for the establishment of pine plantations in wetlands of the southeastern US.
- Information Regarding Compliance with the Federal Clean Water Act Section 404(f)(1) Provisions for the Construction of Forest Roads within Wetlands, in North Carolina.

Table 7-1 FPG Inspections and Compliance (1995 to 2006)

State Fiscal Year	Total FPG Site Inspections	Notices of FPG Non-Compliance	Percent of Sites in Compliance with FPGs
1995-96	3,318	192	94%
1996-97	3,779	197	95%
1997-98	3,782	175	95%
1998-99	3,904	176	95%
1999-00	3,662	209	94%
2000-01	4,700	274	94%
2001-02	4,287	205	95%
2002-03	3,609	215	94%
2003-04	4,129	249	94%
2004-05	4,241	229	95%
2005-06	3,903	181	95%
Totals	**43,314**	**2,302**	**95%**

7.1.3 FPGs vs. BMPs in North Carolina

North Carolina is one of only a few southern states in which regulatory standards exist for how forestry activities are expected to protect water quality. FPGs are codified in the NC Administrative Code; therefore, they are required by law. BMPs, on the other hand, are practical recommendations that can be implemented to help comply with the stated goals of the FPG standards.

Structuring the FPGs in this manner allows for flexibility and best professional judgment of the individuals responsible for the forestry activity. For example, 15A NCAC 01I .0201(a) states:

> *A streamside management zone (SMZ) shall be established and maintained along the margins of intermittent and perennial streams and perennial waterbodies. The SMZ shall be of sufficient width to confine within the SMZ visible sediment resulting from accelerated erosion.*

Note that FPG .0201 does not specify exactly how wide the SMZ must be since each site location and circumstance is different depending upon the type of soil, slope of land, intensity of activity and other factors. In this case, the BMP related to SMZ widths is to establish a SMZ that is 50 feet wide along each side of the stream or waterbody, with provisions for adjusting this width depending upon the site-specific conditions.

7.2 FORESTRY BEST MANAGEMENT PRACTICES (BMPS)

In North Carolina, forestry BMPs are effective, economical and practical treatments, methods or practices that can be implemented to help protect or maintain water quality. NCDFR strongly recommends implementing applicable BMPs when forestry activities occur. It is also important to realize that even good BMPs may not always result in FPG compliance. Just using a BMP does not automatically result in FPG compliance. Think of BMPs as the tools in the toolbox. Examples of forestry BMPs include:

- Use temporary portable bridgemats for stream or ditch crossings instead of culverts or fords.
- Avoid de-limbing logs or felling trees into the SMZ.
- Retain a representative mix of tree species, size and spacing when harvesting in the SMZ.
- Minimize the number and slope angle of skid trails and roads.
- Set trails and roads along the land contour, avoiding alignment straight downslope.
- Avoid operating on a site during saturated soil conditions.

From 2003 to 2006, the first-ever revision to the *North Carolina Forestry BMP Manual* was undertaken. The revision was led by the statutory-defined forestry Technical Advisory Committee (TAC). This comprehensive revision to the BMP manual includes significantly expanded recommendations on many topics, including pre-harvest planning, stream crossings, wetland activities and site stabilization. The new manual should be available by early 2007 and will be accessible via the NCDFR Web site www.dfr.state.nc.us.

7.2.1 BMP IMPLEMENTATION SURVEYS

Beginning in 2000, NCDFR conducted a comprehensive statewide BMP Implementation Survey of active harvest sites in order to determine the degree to which loggers are using BMPs and assess the relative value of each BMP in accomplishing its intended goal. This detailed survey adheres to protocols set forth jointly by the Southern Group of State Foresters and the USDA-Forest Service's Southern Region. Round 1 of this survey ran from 2000 to 2003 and included 565 harvest sites. The average statewide BMP implementation rate was 82 percent. The areas of concern most commonly found in the survey were stream crossings, skid trails and site stabilization. The final report is available in the Water Section of the NCDFR Web site (www.dfr.state.nc.us). Round 2 of this survey began in May 2006 and will evaluate 200 additional harvest sites.

7.2.2 WATERSHED STUDY – EVALUATING RIPARIAN BUFFERS

In cooperation with the USDA-Forest Service's Southern Global Change Program, NCDFR will begin collecting data by early 2007 as part of a five-year paired watershed study in the piedmont of North Carolina. This long-term monitoring project will evaluate the effectiveness of the Neuse/Tar-Pamlico riparian buffer protection rules as they apply to forestry operations. Additional cooperators include the NCSU Department of Forestry & Environmental Resources (www.cnr.ncsu.edu/for/) and the NC Department of Agriculture & Consumer Services (NCDA&CS) Research Stations Division (www.ncagr.com/research/index.htm).

7.2.3 BRIDGEMAT LOAN & EDUCATION PROJECT

To promote the BMP recommendation of using portable bridgemats at stream and ditch crossings, NCDFR has been loaning bridgemats to loggers across the state since the late-1990's. Bridgemats (Figure 7-1) have been purchased through grants awarded by the federal Environmental Protection Agency (EPA) Nonpoint Source (NPS) Section 319 Grant Program and the Albemarle-Pamlico National Estuary Program. The successful efforts and examples set by NCDFR has led to similar bridgemat projects by the state forestry agencies in Florida, Georgia, Tennessee, Kentucky and Virginia. Additional bridgemats will be incorporated into North Carolina's project during 2007. Table 7-2 shows an accounting of the project.

Figure 7-1 Portable Bridgemats Protecting a Stream Crossing

Table 7-2 Success of the Bridgemat Project (2000 to 2005)

Year	Bridgemat Sets Available	Number of Times Bridgemats Loaned	Number of Crossings Protected	Acres of Timberland Accessed by Bridgemats
2000	6	7	13	433
2001	6	15	25	933
2002	6	12	14	244
2003	10	21	25	775
2004	10	33	49	1,085
2005	16	38	46	1,405
TOTALS		**126**	**172**	**4,875**

7.2.4 BMP VIDEO TRAINING SERIES

Starting in 2005, NCDFR began production of a series of training and informational videos that focus on specific problem areas related to FPG compliance or BMP implementation. A fourth video is planned for release during 2007-2008, which will outline proper site stabilization techniques. Starting in 2007, NCDFR also plans to begin in-woods "tailgate" BMP video training sessions with logging crew woods-workers to deliver these BMP messages directly to its audience. The videos produced thus far are listed below, with copies available free of charge from NCDFR.

- Video 1 (11:23 minutes) Forestry Stream Crossings with Bridgemats (July 2005).
- Video 2 (24:24 minutes) Forestry Stream Crossings (July 2005).

- Video 3 (17:45 minutes) BMPs for Logging Skid Trails (July 2006).

Each of these videos has been incorporated into the annual continuing education modules required through the North Carolina ProLogger Program. The logger training and certification program has approximately 1,500 members. More information about ProLogger is available from the North Carolina Forestry Association Web site (www.ncforestry.org).

7.3 FOREST RESOURCES

7.3.1 FOREST OWNERSHIP TRENDS

Nearly 59 percent (18 million acres) of North Carolina is forestland. Hardwoods are the predominant forest species at an estimated 12.7 million acres (nearly 71 percent of the total). Figure 7-2 shows timberland ownership as reported in the most recent USDA Forest Service Report (Brown, 2004). In North Carolina, non-industrial private forest (NIPF) landowners own the majority of forestland. NIPF landowners include individual and corporate timberland owners. Forest industry and national forest ownership are the second and third largest with 1.5 and 1.1 million acres, respectively.

Between 1990 and 2002, nearly 1 million acres of timberland were lost. Much of this timberland was lost as a result of conversion to a non-forestry land use, primarily urbanized development. Timberland owned by forest industry declined 33 percent during this same time period. In 2006, hundreds-of-thousands of acres of timberlands were sold by International Paper Company, one of the two leading industry landowners in North Carolina. This sale suggests that the traditional forest industry class of owners will no longer represent a major holding of forests in the state. It remains uncertain whether the new class of owners (investment and real estate groups) will continue to manage these lands to the same high level of sustainability and water quality protection that the forest industry historically has.

7.3.2 FOREST INDUSTRY AND MARKETS

The forest industry is estimated to contribute nearly $18 billion annually to North Carolina's economy and could easily be considered the most economically significant manufacturing sector remaining in the state. While forest companies have reduced their land holdings, they continue to support large-scale manufacturing facilities. Examples include the five pulp and paper mills in the state as well as numerous sawmills, plywood and structural panel mills all of which are known as "primary processors." In North Carolina, primary processors must pay a fee to the state according to the amount of raw material they consume each year. These fees contribute to funding NCDFR's cost-share payment program for forest landowners. The program assists with tree planting and enhancing forest tree growth.

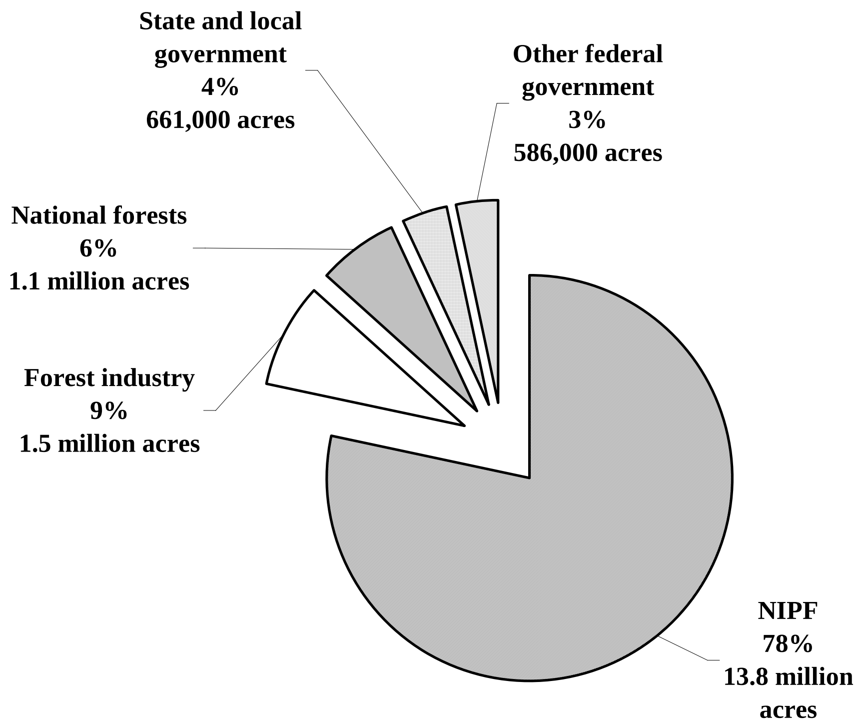


Figure 7-2 Forestland Ownership in North Carolina (Brown, 2004)

7.3.3 FOREST CERTIFICATION AND BMPS

Forest certification programs establish protocols on how forestland owners and forest products companies should manage, utilize and protect forests in a way that promotes the sustainability of the resource. Each certification program requires its member-subscribers to help maintain clean water by requiring them to implement or exceed the recommended BMPs described by each state in which they conduct their forest management or raw material procurement activities. By subscribing to a forest certification program, a member company or landowner vows to implement BMPs even if there are no laws or rules that otherwise require them to do so.

Forest certification programs have become a market-based, demand-driven method to encourage BMP usage across the country. Each certification program member-subscriber must undergo and pass an independent third-party audit in order to remain certified by the program. In essence, forest certification accomplishes the enhanced protection of water quality through the required use of BMPs without the need for further regulation of forest owners.

7.4 TECHNICAL ASSISTANCE

7.4.1 NORTH CAROLINA DIVISION OF FOREST RESOURCES (NCDFR)

Currently, the NCDFR has an assigned Water Quality Forester within 10 of its 13 Districts. Three of these positions were added in 2005, representing the first program expansion since its inception in 1999. While County Ranger staff are the lead contact for all forestry issues at the local level, the Water Quality Foresters serve as the field experts regarding technical assistance and guidance on FPG, BMP, harvesting, wetland and other water quality topics. In many cases, the Water Quality Foresters come to know area loggers and landowners on a first-name basis and foster these relationships. Though difficult to quantify, it would seem certain that nurturing this local network of contacts proves valuable for promoting compliance with water quality regulations and improved use of BMPs. Implementation rates of BMPs have shown to be slightly higher in Districts that have a Water Quality Forester. As required by agency protocol, these foresters also undertake wildfire control and limited forest management work.

In addition to the Water Quality Foresters, the NCDFR administers several programs that may directly or indirectly benefit North Carolina's water resources. All of these programs are explained on the NCDFR Web site (www.dfr.state.nc.us).

- Educational State Forests and State Forests
- Forest Development Program
- Forest Land Enhancement Program
- Forest Legacy Program
- Forest Stewardship Program
- Forestry Nonpoint Source (NPS) Unit
- FPG Self-Audit Program
- Nursery & Tree Improvement Program
- Southern Pine Beetle Prevention Program
- Urban & Community Forestry Program
- Water Resources Assessment and Technical Response Support
- Young Offenders Forest Conservation Program: Building, Rehabilitating, Instructing, Developing, Growing, Employing (BRIDGE)

7.4.2 USDA FOREST SERVICE

As the largest forestry research organization in the world, the USDA Forest Service provides technical and financial assistance to state and private forest agencies and manages public lands in national forests and grasslands. There are four National Forests in North Carolina: Croatan, Nantahala, Pisgah and Uwharrie. In the Nantahala National Forest, the 5,750-acre Coweeta Hydrologic Laboratory near Franklin has been the site of comprehensive research regarding the interaction of forest practices and watershed hydrology since its establishment in 1933. Scientists have conducted a variety of watershed experiments and the knowledge gained in these early trials have laid the foundation for the development of BMPs to protect the southeast's water resources. More information about Coweeta is available at http://coweeta.ecology.uga.edu.

Forest research stations are also locatedin in Asheville and Raleigh. More information about the forest research stations and the USDA Forest Service is on the Web at www.cs.unca.edu/nfsnc and www.fs.fed.us.

7.4.3 OTHER AFFILIATED AGENCIES

Because North Carolina's forestland owners have historically been closely aligned with farming and hunting, the statewide network of affiliated state and federal natural resource agencies oftentimes have local staff with knowledge of BMPs and water quality topics. These agencies include:

- NC Cooperative Extension Service (www.ces.ncsu.edu)
- NC Division of Soil & Water Conservation (www.enr.state.nc.us/DSWC)
- NC Wildlife Resources Commission (www.ncwildlife.org)
- USDA Natural Resources Conservation Service (www.nc.nrcs.usda.gov)

REFERENCES

Brown, M.J. January 2004. *Forest Statistics for North Carolina, 2002.* Southern Research Station Resource Bulletin SRS-88. USDA.

CHAPTER 8 – LAND-DISTURBING ACTIVITIES AND WATER QUALITY IMPACTS

Land-disturbing activities are often associated with road construction and maintenance, industrial, commercial and residential development and mining operations. All of these can be a major source of pollution because of the cumulative number of acres disturbed at any given time. Even though such activities are short-lived and considered temporary sources of pollution, the impacts to water quality and overall stream function can be severe and long lasting.

To avoid potential environmental and financial problems, it is essential to use the proper best management practices (BMPs) to control erosion and sedimentation. It is also imperative that the practices be maintained throughout the duration of the development or land-disturbing activity. This chapter provides an overview of land-disturbing activities and impacts to water quality. In includes definitions of erosion and sediment, reviews the role of state and local governments and provides a list of BMPs for controlling both sediment and erosion.

8.1 LAND-DISTURBING ACTIVITIES

Because construction activities can dramatically increase sediment delivery to streams, construction activities are regulated under the North Carolina Sedimentation Pollution Control Act (SPCA) of 1973 (http://www.dlr.enr.state.nc.us/images/Sedimentation Pollution Control Act of 1973, 2006 amendments.pdf). The Act requires an approved Sedimentation and Erosion Control Plan for any activity that disturbs one or more acres of land. North Carolina defines a land-disturbing activity as any use of the land by any person in residential, industrial, educational, institutional or commercial development, highway and road construction and maintenance that results in a change in the natural cover or topography and that may cause or contribute to sedimentation (15A NCAC 04A .0105). The Sedimentation and Erosion Control Plan explains the erosion control measures (i.e., barriers, filters, sediment traps) that will be used to retain sediment on site. The Act exempts agriculture, forestry, mining and emergency land-disturbing activities; however, each of these activities has additional rules or requirements for controlling sediment and erosion. Chapter 6 contains information about agricultural activities and Chapter 7 contains information about forestry activities.

The North Carolina Mining Act of 1971 (http://www.dlr.enr.state.nc.us/pages/miningprogram.html) applies to all persons or firms involved in any activity or process that disturbs or removes surface soil for the purpose of removing minerals or other solid matter from the earth. The Act also applies to activities that prepare, wash, clean or in any way treat minerals or other solid materials in order to make them suitable for commercial, industrial or construction use. While mining operations range from large quarries to small borrow pits, the Act applies only to those operations that impact one acre or more.

8.2 IMPACTS TO WATER QUALITY

8.2.1 EROSION VS. SEDIMENTATION

Erosion is a natural process by which soil and rock material is loosened and removed. Natural erosion occurs primarily on a geologic time scale, but when human activities alter the landscape, the erosion process can be greatly accelerated. The amount of damage caused by erosion depends on many factors such as the amount of rainfall, type of land cover, slope length and gradient and soil particle size (Erosion and Sediment Control Planning and Design Manual, June 2006, http://www.dlr.enr.state.nc.us/pages/manualsandvideos.html).

Erosion starts with a single rain event. The rain will either infiltrate, or absorb, into the soil or begin to gather and flow down slope. As velocity increases, the water will begin to pick up soil particles. Stormwater, or runoff, velocity is dependent upon the slope gradient, rainfall amount and type of land cover. If there is dense vegetation, the roots will trap or hold the soil in place allowing for very little erosion to occur. If the land has been disturbed and there is little to no vegetation, stormwater will easily gather large amounts of soil. The sediment-laden stormwater becomes abrasive, cuts gullies into hillsides and flows into the nearest body of water. The amount of erosion that occurs upstream is directly related to the amount of sedimentation (sediment deposition) downstream.

Sedimentation occurs when the water in which the soil particles are carried is sufficiently slowed for a long enough period of time to allow particles to settle out. Heavier particles, such as gravel and sand, settle out sooner than finer particles, such as clay. The length of time a particle stays in suspension increases as the particle size decreases. Clay particles stay in suspension for days or even years and contribute significantly to water clarity and turbidity.

Water Quality Impacts: Sedimentation

- Habitat Degradation – Sediment damages aquatic life by destroying stream habitat, clogging fish gills and reducing water clarity.
- Polluted Water – Sediment often carries other pollutants including nutrients, bacteria and toxic/synthetic chemicals. Pollution can also threaten public health if it contaminates drinking water sources or fish tissue.
- Increased Costs for Treating Drinking Water – Water with large amounts of sediment requires costly filtration to make it suitable for drinking. Water supply reservoirs lose storage capacity when they become filled with sediment, necessitating expensive dredging efforts.

Sedimentation is important to the maintenance of diverse aquatic habitats. Streams naturally tend toward a state of equilibrium between erosion and sedimentation. As streams meander through floodplains, the outside of the stream cuts into the streambank eroding it away, while the inside of the stream deposits sediments to create sand bars further downstream.

8.2.2 HABITAT DEGRADATION

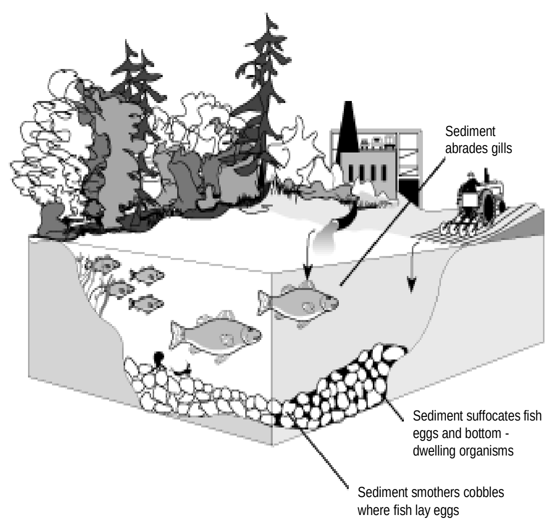
Habitat degradation in streams is identified as a notable reduction in habitat diversity or a negative change in habitat. It includes sedimentation, streambank erosion, channelization, lack of riparian vegetation, loss of pools and/or riffles, loss of organic (woody and leaf) habitat and streambed scour.

Land-disturbing activities are one of the main causes of habitat degradation. When land-disturbing activities are not managed properly it could result in frequent flooding, increased costs of treating municipal drinking water supplies and loss of biodiversity. In most cases, these activities involve the removal of native and riparian vegetation, which significantly loosens sediment. This can have severe impacts on nearby streams. Once washed into a stream by a rain event, overloading of sediment particles fills pools and covers or embeds riffles that are vital to aquatic, insect and fish habitats. Suspended sediment can decrease primary productivity (i.e., photosynthesis) by shading sunlight from aquatic plants, thereby affecting the overall productivity of a stream system. As the excess sediment in the water column settles out, the storage volume of the stream decreases thereby increasing the frequency of floods.

8.2.3 SEDIMENT

The impact of sediment on fish populations depends on both the concentration and degree of sediment. It also depends on the duration (or dose). For example, suspended sediments may be present at high concentrations for short periods of time, or at low concentrations for extended periods of time. The greatest impacts to fish populations occur when sediment is present in high concentrations for extended periods.

Suspended sediments can clog the gills of fish, reducing their respiratory abilities. Fish stressed by respiratory difficulties may, in turn, have a reduced tolerance level to disease, toxicants and chronic turbid conditions (Waters, 1995). The amount of sedimentation also impacts the quality and amount of fish spawning and rearing habitat, and aquatic macroinvertebrate community density, diversity and structure (Lenat et *al*., 1979). The degree of sedimentation (also referred to as siltation) can be estimated by observing the amount of streambed covered, the depth of sedimentation and the percent of embeddedness (Figure 8-1).



Sedimentation is one of the leading pollution problems in the Nation's rive streams. Over the long term, unchecked siltation can alter habitat with profound effects on aquatic life. In the short term, silt can kill fish directly, destroy spawning beds and increase water turbidity resulting in depresse photosynthetic rates.

Press & Siever

Figure 8-1 The Effects of Sedimentation in Rivers and Streams

8.2.4 NUTRIENTS

Some land-disturbing activities, such as agriculture and forestry and residential/commercial fertilizer applications, can have a negative impact on the nutrient load in a waterbody. This can mainly be seen in large, slow-moving waters. Pesticides and fertilizers are heavily used in both farming and tree production. Nutrients that are not used by plants travel to nearby streams during a rain event. Excessive nutrient concentrations stimulate algal blooms and plant growth in ponds, lakes, reservoirs and estuaries.

8.2.5 STREAMFLOW

Sediment transport within a stream is often divided into two categories: suspended load and bedload. Suspended load is composed of small particles that remain in suspension in the water influencing both water quality and aquatic habitat. Bedload is composed of larger particles that slide or roll along the stream bottom. The suspension of particles depends on water velocity and stream characteristics. When evaluating aquatic communities and habitat, biologists are primarily concerned with the concentration of the suspended sediments and the degree of sedimentation on the streambed (Waters, 1995).

The movement of sediment through a stream channel network is a function of past and present land activities. Under many conditions, the amount of sediment carried by a stream will increase as erosion in the watershed increases and decline as erosion decreases. A stream has a finite capacity for transporting sediment. Once the supply of sediment exceeds the stream's carrying capacity, any additional sediment will be deposited in channels and floodplains. These stored deposits can be remobilized into the stream system years, or even decades, later.

The vast majority of sediment transport in a stream occurs during periods of high flow. The relationship between sediment load and the ability of a stream to transport sediment directly affects habitat type, channel morphology and bedload particle size.

Stormflows are also important in determining the rate of streambank erosion and channel migration. Increased streambank erosion and channel migration can affect the riparian vegetation and increase the amount of active sediment in the stream channel.

Activities that Increase Sediment Loads

- Construction activities
- Unpaved private access roads
- Road construction and maintenance
- Golf courses
- Uncontrolled urban runoff
- Mining operations
- Timer harvesting
- Agriculture and livestock operations

8.3 STATE AND LOCAL ROLES

Controlling sediment that results from land-disturbing activities is the responsibility of many stakeholder groups including homeowners, developers/contractors, local governments and the NC Division of Land Resources (DLR).   The mission of DLR's Land Quality Section (http://www.dlr.enr.state.nc.us/pages/landqualitysection.html) is to promote and allow development within our State while preventing pollution by sedimentation. The Sedimentation Pollution Control Act (SPCA) of 1973 sets basic performance standards adopted by the Sedimentation Control Commission (SCC). It is the responsibility of the land developer to prepare (when needed) a sedimentation and erosion control plan and employ appropriate measures (BMPs) to meet the performance standards.

8.3.1 MAIN SEDIMENTATION AND EROSION CONTROL LAWS

For activities that disturb more than one acre of land, there are five mandatory standards that a developer must adhere to per the SPCA. These five standards are:

- Buffer zones along streams or rivers must be sufficient to control visible siltation within the first 25 percent of the buffer zone closest to the land-disturbing activity. There must also be a 25-foot minimum width buffer along trout waters.
- Ground cover must be established on exposed slopes within 21 calendar days after completion of any phase of grading.
- Permanent ground cover must be established within 15 working days or 90 calendar days of completion of the project, whichever is shorter, and measures must be provided to keep sediment on site.
- Any land-disturbing activities of one acre or more must have an approved erosion and sediment control plan.
- The land-disturbing activity shall be conducted in accordance with the approved erosion and sedimentation control plan.

Sediment Control Related Programs

Construction and Urban Development
- Sediment Pollution Control Act
- Federal Urban Stormwater Discharge Program
- Water Supply Protection Program
- HQW and ORW Stream Classification

Agriculture
NC Agriculture Cost Share Program
- NC Cooperative Extension Service and Agricultural Research Service
- Watershed Protection and Flood Prevention Program (PL 83-566)
- Food Security Act (FSA) of 1985 and the Food, Agriculture, Conservation and Trade Act (FACTA) of 1990

Forestry
- Forest Practice Guidelines
- National Forest Management Act
- Forest Stewardship Program
- Forestry Best Management Practices
- Forest Management Program Services

Mining
- Mining Act of 1971

Wetland Alterations
- Section 10 of the Rives and Harbors Act of 1899
- Section 404 of the Clean Water Act
- Section 401 Water Quality Certification (from the Clean Water Act)
- NC Dredge and Fill Act (1969)

8.3.2 PROCESS FOR SEDIMENTATION AND EROSION CONTROL PLANS

An approved erosion and sediment control plan is required for any land-disturbing activity over one acre. LQS must approve a plan 30 days prior to the initial land-disturbing activity. An express permit allows for the land-disturbance to begin as soon as the plan is approved. If the activity involves the utilization of a ditch to de-water or lower the water table of the property, a copy of the plan is furnished to the NC Division of Water Quality (DWQ). Plans are reviewed by LQS or a local government that has been delegated that authority by the SCC. Local governments may also furnish a copy of the plan to the county Soil and Water Conservation District (SWCD) for comments. No land-disturbing activity may begin until the plan is approved. Violations of the SPCA are subject to civil penalties of up to $5,000 per day.

8.3.3 LOCAL PROGRAMS

Because DLR's planning and inspection staff must oversee a wide variety of projects that stretch across a large geographic area, careful pre-construction planning may be overlooked due to a lack of staff time and resources. The Act, however, allows local governments to take responsibility for reviewing and enforcing the SPCA within their jurisdiction as long as the local program is as stringent as the State's regulations. The SCC has delegated 45 county and municipal governments the authority to administer their own sedimentation and erosion control program. Local programs provide advantages for both development and environmental protection. Local programs can:

- Unify the permitting process for approval of planning and zoning, streets, utilities and erosion control.
- Review plans more quickly than regional LQS staff.
- Be tailored to the needs of the community. Several programs in the mountains require plans on sites less than one acre because of the difficulty of controlling erosion on steep slopes.
- Inspect projects frequently, and identify problems before severe sediment damage has occurred.
- Suspend building inspections or issuance of a certificate of occupancy until violations have been corrected.

8.3.4 PERMITS – SECTION 401 AND 404

Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from regulation (e.g. certain farming and forestry activities). The basic premise of the program is that no discharge of dredged or fill material may be permitted if: (1) a practicable alternative exists that is less damaging to the aquatic environment or (2) the nation's waters would be significantly degraded. In other words, when a contractor applies for a permit, he/she must show that he/she has, to the extent practicable, taken steps to avoid wetland impacts, minimized potential impacts to wetlands and can provide compensation for any remaining unavoidable impacts.

Proposed activities are regulated through a permit review process. An *individual permit* is required for potentially significant impacts. Individual permits are reviewed by the U.S. Army Corps of Engineers (USACE), which evaluates applications under a public interest review, as well as the environmental criteria set forth in the CWA Section 404(b)(1) Guidelines. However, for most discharges that will have only minimal adverse effects, a *general permit* may be suitable. General permits are issued on a nationwide, regional or State basis for particular categories of activities. The general permit process eliminates individual review and allows certain activities to proceed with little or no delay, provided that the general or specific conditions for the general permit are met (EPA, *Wetland Regulatory Authority*).

Section 401 of the Clean Water Act delegates authority to the states to issue a 401 Water Quality Certification (http://h2o.enr.state.nc.us/ncwetlands/) for all projects that require a Federal Permit (such as a Section 404 Permit). The "401" is essentially a verification by the state that a given project will not degrade waters of the State or otherwise violate water quality standards. If the USACE determines that a 404 Permit is required then a 401 Water Quality Certification is also required. The USACE also determines which type of permit is applicable to the project, a Nationwide, Regional, General or Individual Permit. For each of the Nationwide, Regional or General Permit, a matching General Certification must be issued by DWQ in order for the Permit to be valid. An Individual 401 Water Quality Certification is necessary if an Individual 404

Permit is required. To learn more about the permitting process, visit the USACE Web site (http://www.saw.usace.army.mil/wetlands/permit_primer.html).

8.4 Reducing Impacts to Water Quality

To accommodate the rapidly growing population throughout the State of North Carolina, thousands of acres of land are exposed each year. Without proper planning and protective measures, these exposed areas are vulnerable to accelerated erosion and sedimentation that have a lasting, damaging effect on the State's waterways. Federal, State and local government agencies have implemented various programs designed to minimize soil loss from land-disturbing activities, and even though North Carolina does not have a numeric water quality standard for suspended sediment, there is a numeric standard for point source dischargers. Point source dischargers must meet minimum federal effluent guidelines of 30 mg/l for total suspended solids (TSS). In addition, a TSS limit of 10 mg/l applies to discharges to High Quality Waters (HQW) that are trout waters or primary nursery areas, and a 20 mg/l limit applies to discharges to other HQWs. Many point source dischargers also have limits for biochemical oxygen demand (BOD). BOD limits usually dictate a degree of treatment that assures the removal of solids below federal requirements.

There are also numerical instream turbidity standards to measure water clarity. Instream turbidity standards are measured using Nephelometric Turbidity Units (NTU) and must be:

- 50 NTU in streams not designated as trout (Tr) waters.
- 25 NTU in lakes and reservoirs not designated as Tr waters.
- 10 NTU in Tr waters.

Land-disturbing activities that implement approved BMPs are considered to be in compliance with these standards.

8.4.1 Best Management Practices (BMPs)

The BMPs listed below are some of the most commonly used measures to reduce erosion and sedimentation. A full explanation of these and the measures listed in Table 8-1 can be found in Chapter 6 of the *Erosion and Sediment Control Planning and Design Manual* written by the LQS. It is available online (http://www.dlr.enr.state.nc.us/pages/manualsandvideos.html).

Rolled Erosion Controlled Products (RECP) are intended to protect soil and hold seed and mulch in place on slopes and in channels so that vegetation can become well established. Turf reinforcement mats can be used to permanently reinforce grass in drainage ways during high flows. Nets are made of high tensile material woven into an open net which overlays mulch materials. Blankets are made of interlocking fibers, typically held together by biodegradable or photodegradable netting. They generally have lower tensile strength than nets, but cover the ground more completely. RECPs should be used to aid permanent vegetation stabilization of slopes 2:1 or greater and with more than 10 feet of vertical relief.

Temporary Slope Drains are a flexible tubing or conduit extending temporarily from the top of a cut or fill slope to the bottom. They are used to convey concentrated runoff down the face of a cut or fill slope without causing erosion. This practice applies to construction areas where stormwater runoff above a cut or fill slope will cause erosion if allowed to flow over the slope.

Outlet Stabilization Structure is a structure designed to control erosion at the outlet of a channel or conduit. This practice applies where the discharge velocity of a pipe, box culvert, diversion, open channel, or other water conveyance structure exceeds the permissible velocity of the receiving channel or disposal area.

Hardware Cloth and Gravel is a temporary measure of wire-mesh hardware cloth around steel posts supporting washed stone placed around the opening of a drop inlet. It is used to prevent sediment from entering yard inlets, grated storm drains or drop inlets during construction. Use this practice around a catch basin or a drop inlet where the flow is light to moderate.

Rock Pipe Inlet Protection is a horseshoe shape rock dam structure at a pipe inlet with a sediment storage area around the outside perimeter of the structure. This structure is used to prevent sediment from entering, accumulating in and being transferred by a culvert or storm drainage system prior to stabilization of the disturbed drainage area. It may be used at pipes with a maximum diameter of 36 inches.

Temporary Sediment Trap is a small, temporary ponding basin formed by an embankment or excavation. These traps are used to detain sediment-laden runoff and trap the sediment to protect receiving streams, lakes, drainage systems, and protect adjacent property. Traps maybe installed at the outlets of diversions, channels, slope drains, or other runoff conveyances that discharge sediment-laden water. Because the sediment must be removed and properly disposed of, an access must be maintained. The maximum drainage area is 5 acres. A temporary sediment trap should not be located in an intermittent or perennial stream.

Sediment Basin is an earthen embankment suitably located to capture sediment. The purpose of a sediment basin is to retain sediment on a construction site, and prevent sedimentation in streams, lakes, and drainage ways. Installation requires a drainage area of less than 100 acres, the location provides a convenient concentration point for sediment-laden flows from the area served, access for sediment removal and proper disposal under all weather conditions, and a maximum life of three years unless designed as a permanent structure. A sediment basin should not be located in an intermittent or perennial stream.

Sediment Fence is a temporary sediment control measure consisting of fabric buried at the bottom, stretched, and supported by posts. The fence is used to retain sediment from small-disturbed areas by reducing the velocity of sheet flow to allow sediment deposition. They should be placed below small-disturbed areas that are less than ¼ acre per 100 feet of fence. Do not install sediment fences across streams, ditches, waterways or other areas of concentrated flow.

Rock Dam is a rock embankment located to capture sediment in a naturally formed drainage feature. The rock dam maybe used in drainage areas too large for the use of a temporary sediment trap, but must not exceed 10 acres. They are preferred where a stable, earthen embankment would be difficult to construct, and riprap and gravel are readily available. The site must be accessible for periodic sediment removal. A rock dam should not be located in an intermittent or perennial stream.

Skimmer Sediment Basin is an earthen embankment suitably located to capture runoff, with a trapezoidal spillway lined with an impermeable geotextile or laminated plastic membrane, and equipped with a floating skimmer for dewatering. Sediment basins are designed to provide an area for runoff to pool and settle out a portion of the sediment carried down gradient. The basic concept is that the skimmer does not dewater the basin as fast as runoff enters it, but instead allows the basin to fill and then slowly drain over hours or days. This allows sediment more time to settle out prior to discharge. Do not locate the skimmer sediment basin in an intermittent or perennial stream.

Porous Baffles are installed inside a temporary sediment trap, rock dam, skimmer basin, or sediment basin to reduce the velocity and turbulence of the water flowing through the measure, and facilitate the settling of sediment from the water before discharge. Sediment traps and basins are designed to temporarily pool runoff water to allow sediment to settle before the water is discharged. Unfortunately, they are usually not very efficient due to high turbulence and short-circuiting which takes the runoff quickly to the outlet with little interaction with most of the basin. Baffles improve the rate of sediment retention by distributing the flow and reducing turbulence. This process can improve sediment retention.

Temporary Stream Crossing is a bridge, ford or temporary structure installed across a stream or watercourse for short-term use by construction vehicles or heavy equipment. They provide a means for construction vehicles to cross streams or watercourses without moving sediment into streams, damaging the streambed or channel, or causing flooding.

Check Dam is a small temporary stone dam constructed across a drainage way. Check dams reduce erosion in a drainage channel by reducing the velocity of flow. Do not use check dams in intermittent or perennial streams.

8.4.2 HEADWATER STREAM PROTECTION

Many streams in a given river basin are only small trickles of water that emerge from the ground. A larger stream is formed at the confluence of these trickles. This constant merging eventually forms a large stream or river. Most monitoring of fresh surface waters evaluates these larger streams. The many miles of small trickles, collectively known as headwaters, are not directly monitored and in many instances are not even indicated on maps. These streams account for approximately 80 percent of the stream network and provide many valuable services for quality and quantity of water delivered downstream (Meyer et *al*., 2003). However,

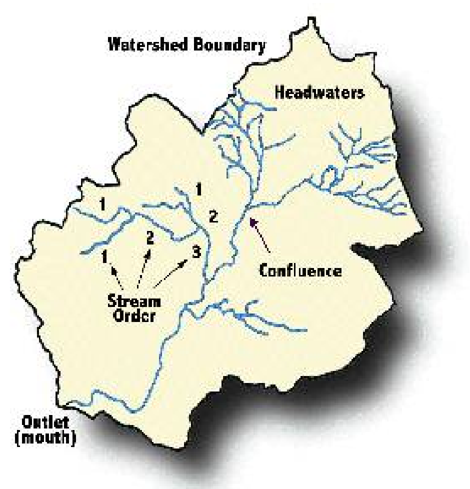


Figure 8-2 Headwater Streams within a Watershed

degradation of headwater streams can (and does) impact the larger stream or river. There are three types of headwater streams – perennial (flow year-round), intermittent (flow during wet seasons) and ephemeral (flow only after precipitation events). All types of headwater streams provide benefits to larger streams and rivers. Headwater streams control flooding, recharges groundwater, maintain water quality, reduce downstream sedimentation, recycle nutrients, and create habitat for plants and animals (Meyer et *al*., 2003) (Figure 8-2).

Table 8-1 Best Management Practices (BMPs) for Land Disturbing Activities

Site Preparation Land Grading Surface Roughening Topsoiling Tree Preservation and Protection Temporary Gravel Construction Entrance/Exit	***Inlet Protection*** Hardware Cloth and Gravel (Temporary) Block and Gravel Inlet Protection (Temporary) Sod Drop Inlet Protection Rock Doughnut Inlet Protection Rock Pipe Inlet Protection
Surface Stabilization Temporary Seeding Permanent Seeding Sodding Tree, Shrubs, Vines, and Ground Covers Mulching Riprap Vegetative Dune Stabilization Rolled Erosion Controlled Product	***Runoff Control Measures*** Temporary Diversions Permanent Diversions Diversion Dike (Perimeter Protection) Right-of-Way Diversion (Water Bars) Grass-Lined Channels Riprap and Raved Channels Temporary Slope Drains Paved Flumes (Chutes)
Sediment Traps and Barriers Temporary Sediment Trap Sediment Basin Sediment Fence Rock Dam Skimmer Sediment Basin Porous Baffles	***Stream Protection*** Temporary Stream Crossing Permanent Stream Crossing Vegetative Streambank Stabilization Structural Streambank Stabilization Buffer Zones
Outlet Protection Level Spreader Outlet Stabilization Structure	***Other Related Practices*** Construction Road Stabilization Subsurface Structure Check Dam with/out Weir Dust Control Sand Fence Flocculants

In smaller headwater streams, fish communities are not well developed and benthic macroinvertebrates dominate aquatic life. Benthic macroinvertebrates are often thought of as "fish food" and, in mid-sized streams and rivers, they are critical to a healthy fish community. However, these insects, both in larval and adult stages, are also food for small mammals, such as river otter and raccoons, birds and amphibians (Erman, 1996). Benthic macroinvertebrates in headwater streams also perform the important function of breaking down coarse organic matter, such as leaves and twigs, and releasing fine organic matter. In larger rivers, where coarse organic matter is not as abundant, this fine organic matter is a primary food source for benthic macroinvertebrates and other organisms in the system (CALFED, 1999). When the benthic macroinvertebrate community is changed or extinguished in an area, even temporarily, as occurs during land use changes, it can have repercussions in many parts of both the terrestrial and aquatic food web.

Headwater streams also provide a source of insects for repopulating downstream waters where benthic macroinvertebrate communities have been eliminated due to human alterations and pollution. Adult insects have short life spans and generally live in the riparian areas surrounding the streams from which they emerge (Erman, 1996). Because there is little upstream or stream-to-stream migration of benthic macroinvertebrates, once headwater populations are eliminated, there is little hope for restoring a functioning aquatic community. In addition to macroinvertebrates, these streams support diverse populations of plants and animals that face similar problems if streams are disturbed. Headwater streams are able to provide these important ecosystem services due to their unique locations, distinctive flow patterns, and small drainage areas.

Because of the small size of headwater streams, they are often overlooked during land use activities that impact water quality. All landowners can participate in the protection of headwaters by keeping small tributaries in mind when making land use management decisions on the areas they control. This includes activities such as retaining vegetated stream buffers, minimizing stream channel alterations, and excluding cattle from streams. Local rural and urban planning initiatives should also consider impacts to headwater streams when land is being developed. For a more detailed description of watershed hydrology and watershed management, refer to EPA's Watershed Academy website at http://www.epa.gov/OWOW/watershed/wacademy/acad2000/watershedmgt/principle1.html.

8.4.3 RIPARIAN ZONE PROTECTION

Riparian zones are one of the most important defenses against pollutants for a river. The vegetated area acts as a buffer to reduce the amount of pollutants that reach the water. As runoff works its way down slope pollutants such as fertilizers, pesticides, sediment, debris and nutrients get pulled into the stormwater. Once the runoff reaches the riparian zone it is given a chance to be cleansed before entering the receiving river.

The ground cover of the zone reduces the velocity of the runoff that will then be able to percolate into the soil. The roots filter out certain pollutants such as fertilizers, pesticides and nutrients, which will be beneficial to the growth of the plant. Soil traps other pollutants that were not captured by the plants such as sediment, trash and debris. The runoff then reaches the river in a cleaner state. Without being processed through this zone, the runoff and its pollutants would flow straight into the river.

Studies done by the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) have shown that if properly installed and maintained, riparian zones have the capacity to remove up to 50 percent of more of nutrients and pesticides, 60 percent or more of certain pathogens and 75 percent or more of sediment. The zones show endless benefits to the environment and the community such as lower costs for treatment plants, a more aesthetically pleasing natural area for residents and/or tourists, a protective habitat for juvenile animals to find food, reduces flooding and conserves biodiversity.

The SPCA states "no land-disturbing activity during periods of construction or improvement to land shall be permitted in proximity to a lake or natural watercourse unless a buffer zone (i.e. riparian zone) is provided along the margin of the watercourse of sufficient width to confine visible siltation within the twenty-five percent of the buffer zone nearest the land-disturbing activity. Waters that have been classified as trout waters by the Environmental Management Commission (EMC) shall have an undisturbed buffer zone 25-feet wide or of sufficient width to confine visible siltation within the 25 percent of the buffer zone nearest the land-disturbing activity, whichever is greater." More information on this Act and width calculations for buffer zones can be found in the *Erosion and Sediment Control Planning and Design Manual* written by the LQS. It is available online at www.dlr.enr.state.nc.us/pages/manualsandvideos.html.

8.4.4 LIMIT STEEP SLOPE DEVELOPMENT

Dramatic elevation changes and steep slopes define mountain topography. Building sites perched along mountainsides provide access to unparalleled vistas and are a major incentive for development. However, construction on steep slopes presents a variety of risks to the environment and human safety.

Poorly controlled erosion and sediment from steep slope disturbance negatively impact water quality, hydrology, aquatic habitat, and can threaten human safety and welfare. Soil types, geology, weather patterns, natural slope, surrounding uses, historic uses, and other factors all contribute to unstable slopes. Steep slope disturbance usually involves some form of grading. Grading is the mechanical excavation and filling of natural slopes to produce a level working surface. Improper grading practices disrupt natural stormwater runoff patterns and result in poor drainage, high runoff velocities, and increased peak flows during storm events. There is an inherent element of instability in all slopes and those who choose to undertake grading and/or construction activities should be responsible for adequate site assessment, planning, designing, and construction of reasonably safe and stable artificial slopes.

In cases where construction activities occur on steep slopes, slope stabilization should be mandated through a Site Grading Plan and/or Site Fingerprinting. Site Grading Plans identify areas intended for grading and address impacts to existing drainage patterns. They identify practices to stabilize, maintain and protect slopes from runoff and include a schedule for grading disturbance as well as methods for disposal of borrow and fill materials. Site Fingerprinting is a low-impact development (LID) BMP that minimizes land disturbances. Fingerprinting involves clearing and grading only those onsite areas necessary for access and construction activities. Extensive clearing and grading accelerates sediment and pollutant transport off-site. Fingerprinting and maintenance of vegetated buffers during grading operations provide sediment control that reduces runoff and off-site sedimentation (Yaggi and Wegner, 2002).

Local communities also have a role in reducing impacts from steep slope development. These impacts can also be addressed through the implementation of city and/or county land use and sediment and erosion control plans. Land use plans are a non-regulatory approach to protect water quality, natural resources and sensitive areas. In the planning process, a community gathers data and public input to guide future development by establishing long-range goals for the local community over a ten- to twenty-year period. They can also help control the rate of development, growth patterns and conserve open space throughout the community. Land use plans examine the relationship between land uses and other areas of interest including quality-of-life, transportation, recreation, infrastructure and natural resource protection (Jolley, 2003).

Sediment and Erosion Control Plans are a regulatory approach to reducing the impacts of steep slope development and ensure that land disturbing activities do not result in water quality degradation, soil erosion, flooding, or harm to human health (i.e., landslides). The DLR LQS has the primary responsibility for assuring that erosion is minimized and sedimentation is reduced during construction activities. Under the SPCA, cities and counties are given the option to adopt local ordinances that meet or exceed the minimum requirements established by the State. Local programs must be reviewed and approved by the SCC. Once approved, local staff performs plan reviews and enforces compliance. If for some reason the local program is not being enforced, the SCC can assume administrative control of the local program until the local government assures the State that it can administer and enforce sediment and erosion control rules. The SPCA as well as an example of a local ordinance can be found on the DLR Web site (http://www.dlr.enr.state.nc.us/pages/sedimentation.html).

The requirements outlined in the SPCA were designed to be implemented statewide and may not fully capture the needs of mountain communities. For example, only projects disturbing more than one-acre of land are required to produce a sediment and erosion control plan. Many small construction projects fall below this threshold. In steep mountainous terrain, even these small disturbances can produce an astounding volume of sediment runoff. DWQ strongly encourages local governments to adopt Sediment and Erosion Control ordinances that exceed the State's minimum requirements.

8.4.5 LIMIT PRIVATE ACCESS ROAD CONSTRUCTION

Improperly designed, constructed and maintained private access roads are a significant source of sediment because landowners often do not realize the importance of building driveways for long-term service.

While some landowners rely entirely on a contractor to design a private road, others will attempt to design the road themselves without ever consulting a reputable, knowledgeable source. The consequences of an improperly designed and constructed private access road may be significant and can include the loss of the road as well as adjacent property. Water quality problems can also arise, especially if a road is washed-out.

While the responsibility for designing, building and maintaining a private access road rests with the landowner, local governments, citizens and state/federal agencies can all help overcome many of the problems associated with private access roads.

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CHAPTER 9 – WASTEWATER AND WATER QUALITY IMPACTS

Wastewater is used water. It includes substances such as human waste, food scraps, oils, soaps and chemicals from homes, businesses and industries. Effluent is the treated water discharged from wastewater treatment plants or other point source dischargers such as municipalities and manufacturing facilities. In order to protect water quality and aquatic life, wastewater treatment is subject to local, state and federal rules and regulations. This chapter provides an overview of the wastewater treatment process, identifies water quality impacts associated with wastewater discharge and reviews federal and state programs used to manage wastewater throughout the United States.

9.1 WASTEWATER TREATMENT

There are two generally recognized wastewater categories that are not entirely separable – domestic wastewaters and industrial wastewaters. Domestic wastewaters are usually of a predictable quality and quantity and originate from domestic, household activities but will usually include wastewater discharged from commercial and business buildings. Industrial wastewater, however, originates from manufacturing processes that are usually more variable and often more difficult to treat (NYDEC, 1977). Wastewater can be treated close to where it originates (i.e., on-site septic systems or small package plants), or it can be transported long distances by a network of pipes and pump stations to municipal wastewater treatment plants.

Physical, Chemical and Biological Wastewater Treatment Methods

Physical
- Screening
- Aeration
- Sedimentation (Clarification)
- Filtration

Chemical
- Chlorination
- Neutralization
- Coagulation
- Adsorption
- Ion Exchange
- Precipitation

Biological

Aerobic
- Activated Sludge Treatment Methods
- Trickling Filtration
- Oxidation Ponds
- Lagoons
- Aerobic Digestion
- Biological Nutrient Removal

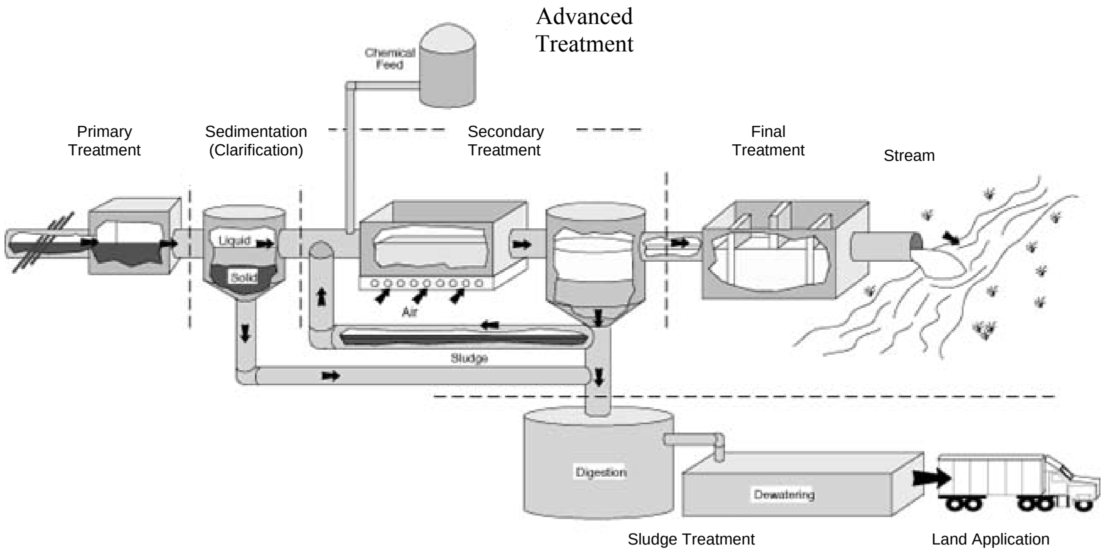
Anaerobic
- Anaerobic Digestion
- Septic Tanks
- Lagoons
- Biological Nutrient Removal

9.1.1 MUNICIPAL WASTEWATER TREATMENT PLANTS (PUBLICLY OWNED TREATMENT WORKS)

Domestic wastewater, or sewage, treatment plants remove physical, chemical and biological contaminants from wastewater that is collected from homes, businesses and industries. Typically, wastewater treatment, also known as publicly owned treatment works (POTWs), involves three stages – primary, secondary and tertiary treatment (Figure 9-1). Disinfection and sludge treatment and disposal are also are part of most systems. The following provides a brief description of each treatment stage.

<u>*Primary Treatment:*</u> Equipment used during this stage is designed to remove or reduce the size of large, suspended or floating solids (i.e., pieces of wood, cloth, paper, plastics, garbage, fecal matter, etc.), remove heavy inorganic solids such as sand, gravel, metal and glass and remove excess oils and grease. Many facilities may also have an aeration step, which introduces air, or oxygen, into the system. By agitating the wastewater with air, lighter suspended solids will collect, or flocculate, into heavier masses, which then settle for easy removal. Aeration also helps to separate grease, oils, plastics and soaps from the wastewater stream while wastewater solids create a "scum" on

Figure 9-1 Typical Process Flow Diagram of a Wastewater Treatment Plant (Jacob and Cordaro, Fall 2000)



top of the settling or aeration tank. Slow-moving rakes then remove the scum from the surface of the tank. The scum and the sludge, or wastewater solids, at the bottom of the tank are collected and kept in large, heated and enclosed tanks called "digesters". Here, bacteria digest the material which reduces its volume, odor and the number of disease-causing bacteria. The finished product is then sent to landfills, but in some cases, it can be used as compost and applied to land (NYDEC, 1997; USGS, August 2006).

Sedimentation (Clarification): Primary settling tanks, clarifiers or sedimentation tanks or basins is designed to physically remove organic and inorganic solids. Velocity is slowed and wastewater is dispersed which allows for heavy materials to settle to the bottom and lighter materials to float to the top. Sedimentation removes suspended solids from the wastewater stream and produces a homogeneous liquid capable of being treated biologically (secondary treatment) and a sludge that can be treated or processed separately (NYDEC, 1977). Sedimentation removes nearly 60 percent of the suspended solids from the wastewater stream (USGS, 2005).

Secondary Treatment: Secondary treatment depends primarily on aerobic microorganisms to biochemically decompose the organic and inorganic solids that remain in the wastewater after primary treatment. The aerobic microorganisms utilize the colloidal and dissolved organics in the wastewater stream as their food source. They must also have a sufficient amount of oxygen available for survival. Trickling filters, sludge settling tanks, intermittent sand filters and stabilization ponds are all devices used during the secondary treatment process (NYDEC, 1977). Secondary treatment removes nearly 90 percent of the suspended and dissolved solids from the wastewater stream (USGS, 2005).

Tertiary Treatment: Primary and secondary treatment remove the majority of physical, biological and chemical contaminants from the wastewater, but tertiary treatment provides a final stage to increase the quality of the effluent before it is discharged into the receiving stream. It can be defined as "any treatment process in which unit operations are added to the flow scheme following conventional secondary treatment" (NYDEC, 1977). Tertiary treatment can be used to remove additional organic material, dissolved solids and nutrients (i.e., nitrogen and phosphorus) from the effluent.

Disinfection: The purpose of disinfection is to substantially reduce the number of microorganisms (some of which may be pathogenic) from the effluent before it is discharged to the receiving stream. The effectiveness of this step depends on the quality of the water being treated (i.e., pH, cloudiness, etc.), type of disinfection being used, contact time and dose. Chlorination remains the most common form of wastewater disinfection (NYDEC, 1977).

Chlorination may also be used to prevent wastewater decomposition during any stage of treatment. Chlorine controls odors and protects mechanical equipment throughout the treatment process. Chlorine also aids in sedimentation, filtering and activated sludge bulking and reduces or delays biochemical oxygen use (NYDEC, 1977).

Sludge Treatment and Disposal: Wastewater sludge is the mixture of wastewater and settled solids (NYDEC, 1977). In order to insure safe and effective disposal, the sludge is treated to reduce the amount of organic mater and the number of disease-causing microorganisms. The most common treatment options are anaerobic digestion, aerobic digestion and composting. Anaerobic digestion is a bacterial process that is carried out in the absence of oxygen, usually in an enclosed tanks (digestors) that can be heated (Figure 9-1). The type of anaerobic bacteria being used in this process will determine the amount of heat, or temperature, required to properly digest (break down) the sludge. Aerobic digestion is a bacterial process that requires oxygen. Under aerobic condition, bacteria readily consume the organic matter and convert it to carbon dioxide (CO2). Composting is also an aerobic process but it involves mixing the sludge with a carbon source such as sawdust, straw or wood chips. All three treatment options reduce the volume, odor and the number of disease-causing microorganisms. The finished product is either sent to landfills or, in certain cases, land applied to add nutrients to soil (USGS August 2006).

9.1.2 INDUSTRIAL WASTEWATER TREATMENT

Industrial wastewater varies widely in composition, strength, flow and volume depending on the specific industry or manufacturing establishment in the community. Typical industrial facilities that produce significant volumes of wastewater include paper and fiber plants, steel mills, refining and petrochemical operations, chemical and fertilizer plants, meat packers and poultry processors, food processing and packing operations, power companies and many others. Industrial wastewater may consist of heavy organic material, metals and chemicals that can damage municipal sewer lines and structures. Industrial wastewater may also contain compounds that are resistant to biological degradation.

Because of its potential to damage municipal treatment systems, many industrial facilities are required to pre-treat or partially treat their wastewater before it is discharged to the municipal sewer. Industrial facilities can employ several mechanical and/or chemical measures (i.e., sedimentation, flocculation, skimming, etc.) to remove solids, oils and greases, organics, acids, metals and toxic substances from the wastewater and must follow state and federal regulations related to water quality and industrial waste. Rules and regulations associated with industrial wastewater that discharges to municipal treatment systems can be found on the US Environmental Protection Agency (EPA) Pretreatment Program Web site (http://cfpub1.epa.gov/npdes/home.cfm?program_id=3). State rules and regulations can be found on the DWQ Pretreatment Emergency Response Collection Systems (PERCS) Unit Web site (http://h2o.enr.state.nc.us/percs/Pretreatment/PERCSPretreatmentHome.html). Industrial wastewater can also be directly discharged into surface water. Section 9.3.1 includes information related to permitted activities within the State of North Carolina.

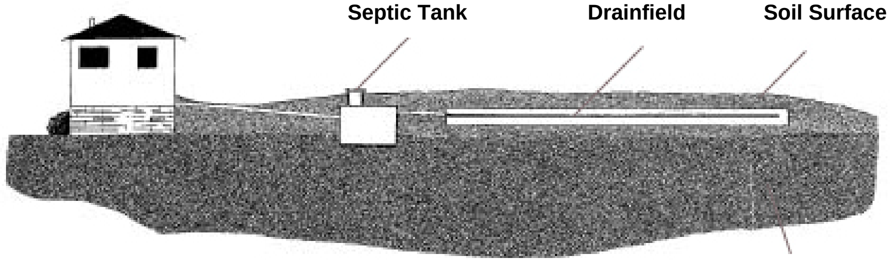
9.1.3 On-Site Wastewater Systems (Septic Systems)

More than 52 percent of all housing units in North Carolina are served by on-site wastewater systems. Most on-site wastewater treatment systems are conventional septic systems that consist of a tank, a distribution box and a series of subsurface absorption lines with perforated pipes laid in a gravel bed. The septic system provides a natural method of treatment and disposal of household wastes for homes that are not part of a municipal sewage treatment system. Septic systems can be a safe and effective method for treating domestic wastewater as long as they are sized, sited and properly maintained. Advanced on-site wastewater systems utilize pre-treatment methods such as filters and aerobic treatment and use improved distribution systems such as pressure dosing on sensitive sites.

In a septic system, household wastewater is separated into solids, liquids and gases by bacteria and sedimentation in a two-chambered septic. The gases exit the system through the plumbing roof vent while the solids float to the surface or settle to the bottom of the first chamber of the tank. It is recommended that the solids be removed, or pumped, from the first chamber once every five years to ensure proper maintenance of the system. The liquid passes through the center of the chamber wall and receives additional sedimentation and bacterialogical treatment in the second chamber before passing through a filter at the outlet end of the tank. The treated liquid, or effluent, is then distributed throughout the drainfield through a series of shallow subsurface pipes. Final treatment of the effluent occurs as the soil absorbs and filters the liquid, and microbes break down the remaining waste into harmless organic material (Figure 9-2).

If the tank and/or drainfield are improperly located, poorly constructed or not maintained, nearby wells and surface waters may become contaminated. In some cases, wastewater illegally discharges from homes directly to streams or the land surface through what is known as a "straight pipe". Straight pipes can carry black water, grey water or both. Black water refers to raw sewage from toilets being discharged directly from homes into streams or the ground. Grey water refers to the water that is used for washing dishes, bathing and laundry. It has a cloudy appearance and often contains bacteria, nutrients, soaps, oils and greases. Straight piping and failing septic systems are considered illegal wastewater discharges.

Figure 9-2 Schematic Layout of a Typical Septic System (NCCES, December 2002).



Many informational brochures related to siting, constructing and maintaining septic systems can be found on the NCDENR Division of Environmental Health On-Site Wastewater Protection Section Web site (http://www.deh.enr.state.nc.us/osww_new//index.htm).

9.2 IMPACTS TO WATER QUALITY

Many of the wastewater treatment processes are designed to mimic the natural treatment processes that occur in the environment. If not overloaded, bacteria in the environment will consume organic contaminants, and the number of disease-causing microorganisms will be reduced by natural conditions (i.e., predation, exposure to UV radiation, temperature, etc.). Consequently, if the receiving environment can provide a high level of dilution, a high degree of wastewater treatment may not be required. Recent studies, however, indicate that very low levels of certain contaminants in wastewater (i.e., human birth control pills, animal husbandry hormones, prescription medications, etc.) can have an unpredictable adverse impact on the natural biota and potentially humans. In the coming decades, rules and regulations may have to account for these medicinal contaminants in wastewater streams.

9.2.1 NUTRIENTS

Nutrients in surface waters come from both point and nonpoint sources including agriculture and urban runoff, wastewater treatment plants, forestry activities, atmospheric deposition and illegal septic system discharges and straight pipes. While nutrients are beneficial to aquatic life in small amounts, excessive levels can stimulate algal blooms and plant growth, depleting dissolved oxygen in the water column. More information on nutrients and management strategies to control them can be found in Chapter 11.

9.2.2 OXYGEN-CONSUMING WASTES – DISSOLVED OXYGEN CONCENTRATIONS

Maintaining adequate dissolved oxygen (DO) concentrations are critical to the survival of aquatic life and to the general health of North Carolina's surface waters. Oxygen-consuming wastes such as decomposing organic matter and some chemicals found in wastewater can reduce dissolved oxygen levels in surface water through chemical reactions or biological activity. Sources of dissolved oxygen-consuming wastes include wastewater treatment plant effluent, illegal straight pipe discharges, aquaculture waste, the decomposition of organic matter (such as leaves, dead plants and animals) and organic waste that is deposited, washed or discharged into surface waters. Bacterial decomposition of this organic waste can rapidly deplete DO levels, especially if they are not adequately treated at a wastewater treatment plant prior to being discharged into surface waterbodies. The daily average DO standard for most waters in the state, except for those classified as trout (Tr) or swamp (Sw) waters, is 5.0 milligrams per liter (mg/l). Trout waters have a daily average DO standard of 6.0 mg/l. Nonpoint source inputs, which typically occur as a result of rainfall events, are generally a minor source of oxygen-consuming wastes.

Biochemical oxygen demand (BOD) and ammonia nitrogen (NH_3-N) associated with wastewater treatment plants are generally the two oxygen-consuming measurements of greatest concern. BOD is the amount of oxygen required by microorganisms to decompose the organic material found in streams and wastewater effluent. During summertime conditions, when water temperatures are high and streamflow is low, point sources of BOD and NH_3-N have the greatest impact on instream DO concentrations.

Some chemicals also react and bind with DO consequently limiting its availability. Industrial discharges with oxygen-consuming waste, for example, may be extremely resilient and continue to use oxygen for long distances downstream.

The primary water quality impact of oxygen-consuming wastes is similar to that of low DO levels because oxygen-consuming wastes use (or consume) the oxygen that is needed to maintain aquatic life. As the oxygen is used, levels can fall below that which is necessary to sustain life, resulting in a reduction, or even death, to aquatic communities. Low DO levels can also affect the reproduction and growth functions of fish (Alabaster and Lloyd, 1982).

9.2.3 Chlorinated-Organic Compounds

Even though disinfection substantially reduce the number of microorganisms from wastewater effluent, chlorination of residual organic material can generate chlorinated-organic compounds that may be carcinogenic or harmful to the environment. Residual chlorine or chloramines may also be capable of chlorinating organic material in the natural aquatic environment to form compounds known as trihalomethanes (THMs). In high concentrations, some THMs are carcinogenic (cancer causing). Many are persistent and can pose a threat to human health for many generations.

9.2.4 Total Suspended Solids

Total suspended solids (TSS) are solids (i.e., sediment, decaying plant and animal material, industrial waste, sewage) that can be filtered out of the water column. High TSS can block light from reaching submerged aquatic vegetation, which slows down the rate of photosynthesis and reduces the amount of dissolved oxygen in the water column. If light is completely blocked from bottom dwelling plants, the plants will stop producing oxygen and die. As plants decompose, bacteria will use up even more oxygen from the water, ultimately leading to fish kills.

High TSS can also increase surface water temperature and decrease water clarity. Surface water temperature increases because the suspended particles absorb heat from sunlight. Because warmer waters hold less dissolved oxygen, dissolved oxygen levels tend to fall even further. The decrease in water clarity caused by TSS can affect the ability of fish to see and catch food. Suspended sediment can also clog fish gills, reduce growth rates, decrease resistance to disease and prevent egg and larval development. When suspended solids settle to the bottom of a waterbody, they can smother fish eggs, as well as suffocate newly hatched insect larvae. Settling sediments can fill in spaces between rocks, reducing habitat availability (Mitchell and Stapp, 1992).

9.2.5 THERMAL POLLUTION

All aquatic species require specific temperature ranges in order to be healthy and reproduce. Thermal pollution is a temperature change in natural waterbodies caused by human influence. The main cause of thermal pollution is the use of water as a coolant to manufacturing or industrial processes or the generation of electricity. Water used as coolant is returned to the natural environment at a higher temperature, which can alter aquatic ecosystems by decreasing the oxygen level and kill fish that are vulnerable to small increases in temperature. 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.

9.2.6 COLOR

Color is generally associated with industrial wastewater and municipal wastewater treatment plants that receive industrial wastes from textile manufacturers that dye fabrics and pulp and paper mills. Color can affect the aesthetic quality of a waterbody and interfere with sunlight penetration. Submerged aquatic vegetation needs light for photosynthesis. If color blocks out light, photosynthesis will be reduced, thus reducing the production of oxygen needed for the survival of aquatic life. If light levels get too low, photosynthesis may stop altogether, causing algae to die. In addition, fish may not be able to see in waters polluted with color, making it difficult to find food. Color is usually not a toxicological problem. There is no current data showing that colored effluent poses any threats to human health or that it is the sole source of aquatic life impacts.

9.2.7 BACTERIA

No matter what the bacteria or microorganism type (i.e., virus, protozoan parasites), point and nonpoint source pollution contribute to the bacterial numbers in waterbodies. Point source pollution includes illegal household wastewater straight pipes, municipal wastewater treatment plants, sewage spills and permitted discharges. Nonpoint source pollution includes agricultural runoff, animal waste, human waste, leaky sewer lines, failing septic systems, stormwater runoff from developed land including roads, buildings and residential yards and surface or land application of human and/or animal waste. Some of the waterborne pathogenic diseases caused by certain types of microorganisms include ear infections, typhoid fever, viral and bacterial gastroenteritis, cholera and hepatitis A.

Reducing the number of microorganisms in wastewater requires disinfection, which typically involves the use of chlorine and other disinfectant agents. Although these materials may kill bacteria and other disease-causing microbes, the disinfectants also kill other microbes that are essential to the aquatic environment, often endangering the survival of species dependent on these other microbes. Many wastewater treatment facilities have added a dechlorination to the treatment process to remove residual chlorine from effluent before it is discharged to surface waters. The process should protect the surrounding aquatic environment and also achieve the water quality standard for chlorine.

9.3 WASTEWATER RULES AND REGULATIONS

9.3.1 NPDES PERMITTED ACTIVITIES

The Clean Water Act of 1972 initiated strict control of wastewater discharges with responsibility of enforcement given to the EPA. The EPA then created the National Pollutant Discharge Elimination System (NPDES) to track and control point sources of pollution. The primary method of control is the issuance of discharge permits with limitations on wastewater flow and constituents. The EPA delegated permitting authority to the State of North Carolina in 1975. All wastewater discharges to surface waters in the State of North Carolina must receive a permit to control water pollution.

Types of Wastewater Discharges

Major Facilities

Wastewater treatment plants with flows ≥1 MGD (million gallons per day); and some industrial facilities (depending on flow and potential impacts to public health and water quality).

Minor Facilities

Facilities not defined as Major.

100% Domestic Waste

Facilities that only treat domestic-type waste (from toilets, sinks, washers).

Municipal Facilities

Public facilities that serve a municipality. Can treat waste from homes and industries.

Nonmunicipal Facilities

Non-public facilities that provide treatment for domestic, industrial or commercial wastewater. This category includes wastewater from industrial processes such as textiles, mining, seafood processing, glass-making and power generation, and other facilities such as schools, subdivisions, nursing homes, groundwater remediation projects, water treatment plants and non-process industrial wastewater.

DWQ's NPDES Permitting and Compliance Program is responsible for administering NPDES for the state. The NPDES Permitting and Compliance Program must determine the quality and quantity of treated wastewater that can be discharged into a receiving stream. An NPDES permit will specify an acceptable level of a pollutant in a discharge (i.e., bacteria, nitrate, ammonia, pH, biochemical oxygen demand, total suspended solids, etc.) in order to protect water quality. Conservative methods are used to calculate the acceptable level, based on the assimilative capacity and designated uses of the receiving stream. The permittee may choose which technologies to use to achieve the level specified in the permit. NPDES permits ensure that both North Carolina's mandatory standards for clean water and federal minimum requirements are met. As a delegated state, North Carolina has the authority to establish state water quality standards more stringent than the federal standards established by EPA. The following are major components to permitting wastewater activities in the State of North Carolina:

NPDES Permit Review and Processing: NPDES permits are issued in two categories - individual and general. Individual permits are categorized as major or minor. Discharges from treatment systems treating domestic waste with a design flow of 1.0 million gallons per day (mgd) or more or those that have a pretreatment program are classified as major discharges. Minor discharges have a design flow of less than 1.0 mgd. Industrial and commercial discharges are classified based on several factors including flow, waste characteristics and water quality and health impacts.

General permits are developed for certain types of industrial facilities. The permit includes requirements that are appropriate for a typical facility within a specific industrial classification. General wastewater permits currently exist for the following activities: non-contact cooling water discharges, petroleum-based groundwater remediation, sand dredging, seafood packaging and domestic discharges from single family residences.

Wasteload Allocation Modeling: In order to assess the impacts of pollutants on surface water quality, DWQ develops and applies water quality models. A water quality model is a simplified representation of the physical, chemical and biological processes that occur in a waterbody. The type of model that is used is dependent upon the purpose for which it is needed, the amount of information that is available or attainable for its development and the degree of accuracy or reliability that is warranted. In most cases, DWQ develops and applies a given model to predict the response of a natural system to a given set of inputs that reflect various management strategies.

Compliance Monitoring and Enforcement: Facilities should strive to be in compliance with the NPDES permit, water quality standards and any other applicable water quality regulations, rules or statutes. Monitoring is required for facilities that receive an NPDES permit. Each facility must submit its discharge monitoring report (DMRs) no later than 28 days after the end of the reporting period. DWQ regional office staff review the DMRs and determine whether or not there were any permit limit or monitoring violations. Notices of violation and civil penalties are examples of enforcement tools DWQ uses to bring non-compliant facilities into compliance. DWQ can also issue Special Orders by Consent (SOC) and Moratoriums if a facility is non-compliant.

Pretreatment Program: The goal of the pretreatment program is to protect municipal treatment plants and publicly owned treatment works (POTWs), as well as the environment, from receiving hazardous or toxic wastes. The pretreatment program regulates nondomestic (industrial) users of POTWs that discharge toxic wastes under the Domestic Sewage Exclusion of the Resource Conservation and Recovery Act (RCRA). The program requires businesses and other entities that use or produce toxic wastes to pretreat their wastes prior to discharging wastewater into the sewage collection system of a POTW. Local governments that operate POTWs typically administer state-approved pretreatment programs and address four areas of concern: interference with POTW operations; pass-through of pollutants to a receiving stream; municipal sludge contamination; and exposure of workers to chemical hazards. Interference refers to a problem with plant operation including physical obstruction and inhibition of biological activity.

DWQ and local governments develop pretreatment limits by determining the maximum amount of each pollutant that a facility can accept at the influent (or headworks) while still protecting the receiving water, the POTW and the POTW's sludge disposal options. More information about the pretreatment can be found on the PERCS Unit Web site (http://h2o.enr.state.nc.us/percs/Pretreatment/PERCSPretreatmentHome.html).

Operator Certification and Training: Water pollution control systems must be operated by individuals certified by the North Carolina Water Pollution Control System Operators Certification Commission (WPCSOCC). The level of training and certification that the operator must have is based on the type and complexity of the wastewater treatment system. The Commission currently certifies operators in four grades of wastewater treatment, four grades of collection system operation, subsurface operation, spray irrigation operation, animal waste management and a variety of specialized conditional exams for specific technologies (e.g., oil/water separators).

Training and certification of operators is essential to the proper operation and maintenance of pollution control systems. Without proper operation and maintenance, even the most efficient treatment system will not function properly. The goal of the WPCSOCC is to train competent and conscientious professionals who will provide the best wastewater treatment, and thus protect the environment and public health. The Technical Assistance and Certification Unit (http://h2o.enr.state.nc.us/tacu/collect.html) of DWQ provides staff support to the Commission and assists in organizing operator training. Specialty courses and seminars for operators are also offered by the North Carolina combined section of the Water Environment Association/American Water Works Association (WEA/AWWA).

Non-Discharge and Regional Wastewater Treatment Alternatives: DWQ requires new and expanding NPDES permit applicants to provide documentation that considers alternatives to surface waters. This analysis includes a feasibility study on options such as the connection to a regional wastewater treatment facility or the use of non-discharge options such as spray irrigation, rapid infiltration basins and drip irrigation systems. It also takes into consideration the economic feasibility of the available options. If no other economically feasible option exists, the NPDES application will be forwarded for review and completion. If one or more alternative options are economically feasible, however, it must be reevaluated to determine which option is the best option.

Non-discharge is the preferred wastewater disposal alternative in most instances. Although these systems are operated without a discharge to surface waters, they still require a DWQ permit. The permit insures that treated wastewater is applied to the land at a rate that does not produce ponding or runoff into a waterbody. More information about land application and non-discharge requirements can be found on the DWQ Aquifer Protection Section – Land Application Unit (LAU) Web site (http://h2o.enr.state.nc.us/lau/main.html).

More information about NPDES can be found on the EPA Web site (http://cfpub.epa.gov/npdes/index.cfm) and the DWQ Permitting and Compliance Programs Web site (http://h2o.enr.state.nc.us/NPDES/NPDESweb.html).

9.3.2 NON-DISCHARGE PERMITS

DWQ has a non-discharge program that reviews and permits systems using land application as a means of waste disposal. These systems include spray irrigation, animal waste management systems, rapid infiltration basins, drip irrigation systems, land application of residuals programs, wastewater collection systems and beneficial reuse of wastewater systems.

The program, and all associated permits, is regulated by North Carolina General Statutes 143.215.1 and the Administrative Code Section 15A NCAC 2T .0100 - Waste Not Discharged to Surface Waters. These sections not only give DWQ the authority to issue permits; they also provide details on the permitting process and information that must be submitted with a permit application. The Non-Discharge Permitting Unit (NDPU) reviews and approves all systems.

Sanitary sewer collection systems used to collect the wastewater from NPDES discharge wastewater treatment facilities and non-discharge wastewater treatment facilities are both permitted by NDPU. The land application of residuals program and the distribution and marketing program are also permitted by NDPU, as required by EPA's 40 CFR Part 503 rules.

Non-discharge program permits are issued in several categories based on wastewater collection system type. Individual permits exist for gravity sewers, pump stations and force mains, pressure sewers and STEP systems. These applications require a final set of plans and specifications prior to the issuance of a permit.

DWQ also has a fast-track permitting system for gravity sewers. To help with the fast-track system, a list of Minimum Design Criteria was developed that includes the important requirements for the construction of a gravity sewer system.

The fast-track permit requires a four-page application, as well as an engineer seal and signature to insure that the gravity system will be built in accordance with state rules, regulations and the Minimum Design Criteria. Upon project completion, an engineer’s certification must be submitted along with record drawings. The fast-track process does not require plans to be submitted prior to permit issuance. This has significantly reduced permitting time.

The non-discharge program also requires wastewater systems that utilize land application for wastewater disposal to be permitted. The program has operational and monitoring requirements similar to those of the NPDES permit.

The primary difference is that treated effluent is not discharged to surface waters. It is usually discharged to a spray irrigation system for land application. Some other options for the land application of effluent include rapid infiltration basins and drip irrigation systems. When compared to spray irrigation, rapid infiltration systems are designed to have a much more intense and higher rate of land application. Most rapid infiltration systems are located in the sandy regions of the state where soils can handle an increased application volume. Drip irrigation systems, which are typically used for lower effluent volumes, are located statewide.

Every wastewater treatment facility in the State of North Carolina, including large NPDES systems, pretreatment systems and non-discharge systems, produce some form and amount of wastewater residuals. DWQ has a program that requires a permit for the land application of residuals. The program was developed around the EPA rules 40 CFR Part 257 and 40 CFR Part 503. More information about non-discharge permits can be found on the DWQ Non-Discharge Permitting Unit Web site (http://h2o.enr.state.nc.us/lau/main.html).

9.3.3 ON-SITE WATER PROTECTION SECTION (OSWPS)

The On-Site Water Protection Section (OSWPS) (http://www.deh.enr.state.nc.us/osww_new//index.htm) of NCDENR Division of Environmental Health (DEH) writes, oversees and enforces the rules and laws regulating the design, installation, repair, operation and maintenance of on-site wells and wastewater treatment systems for the protection of human and environmental health from microbial and chemical contamination. OSWPS provides regulatory and consultative services statewide to local health departments and numerous other clients, including builders, developers, land- and homeowners, system installers, system operators, engineers, soil scientists, geologists and environmental health consultants. However, an authorized environmental health specialist in each county health department conducts the actual implementation of the regulations (i.e., site evaluation, permitting of new systems).

All of the rules and regulations including horizontal setbacks, depth to groundwater, soils requirements, loading rates, etc., are specific to North Carolina and are based on scientific studies of microbial and chemical fate and transport. These rules are constructed to protect groundwater (well water) and surface water from microbial contamination as well as other contaminants. The on-site wastewater treatment regulations are devised to minimize migration of microbes and pathogens to groundwater and surface water. More information related to on-site wastewater management can be found on the DEH OSWPS Web site (www.deh.enr.state.nc.us/osww_new//index.htm).

9.3.4 WASTEWATER DISCHARGE ELIMINATION PROGRAM (WADE)

In North Carolina, the Wastewater Discharge Elimination (WaDE) Program (http://www.deh.enr.state.nc.us/osww_new//WaDE.htm) through OSWPS in DEH was established pursuant to Senate Law 1996-18es2, Section 27.26 (http://www.ncleg.net/gascripts/BillLookUp/BillLookUp.pl?Session=1995e2&BillID=H53), to identify and eliminate discharges from straight pipes and failing septic systems to land surfaces and streams. Funds appropriated by the NC General Assembly support a two-member team to address the straight pipe and failing septic system issues in North Carolina. Additional financial support has been secured through grants from the NC Clean Water Management Trust Fund (CWMTF) (http://www.cwmtf.net/) and the US Environmental Protection Agency (EPA) 319 Non-point Source Program (http://www.epa.gov/owow/nps/cwact.html). Strong collaboration with local and federal agencies as well as the public, the media and environmental groups is the hallmark of the WaDE program and the key to its successes thus far. More information about the WaDE program can be found on the DEH OSWPS Web site (www.deh.enr.state.nc.us/osww_new//WaDE.htm).

9.4 Reducing Water Quality Impacts

9.4.1 On-Site Wastewater Management

To protect public health and water quality, best management practices (BMPs) need to be implemented throughout the life cycle of an on-site wastewater disposal (septic) system. Life cycle management problems can be addressed in three phases. The first phase includes system siting, design and installation. The second phase involves the operation of the system and phase three involves maintenance and repair when the system malfunctions or fails.

As BMPs are applied in each life cycle phase, the primary factor for the success of the system is the participation of the local influencing health department and the cooperation of the developer, owner, design engineer, system operator and the state.

The following list is a summary of the current life cycle management practices and penalties utilized in North Carolina to implement the on-site sewage systems program.

Improvement Permit: The developer or property owner meets with a member of the environmental health staff of the local health department to review the proposed project. An application is then submitted to the local health department. The application contains information regarding ownership, plat of the property, site plan, type of facility, estimated sewage flow, proposed method of sewage collection, treatment and disposal. The improvement permit must be issued prior to other construction permits and allows only temporary electrical power to the site.

Construction Authorization: The local health department, with technical assistance from the state (when requested), evaluates the proposed sewage effluent disposal site for several factors, including slope, landscape position, soil morphology, soil drainage, soil depth and space requirements. After evaluating the site characteristics, the local health department assigns a site suitability classification, establishes the design sewage flow and the design-loading rate for the soil disposal system. Specific design requirements are included in the Construction Authorization. The permit includes system components and locations, setbacks and future repair areas and allows construction to begin for the on-site sewage system.

Design Review: The applicant is required to submit plans and specifications prepared by a professional engineer for the sewage collection, treatment and disposal system of complex systems, or for systems exceeding 3,000 gallons per day. Both the OSWPS and local health departments review the design plans. The designer must also include site specifications, installation procedures, phasing schedules, operation and maintenance procedures, monitoring requirements and designate the responsible parties for operation and maintenance.

Legal Document Review: For systems with multiple ownership or off-site disposal, the applicant must prepare and submit to the OSWPS and local health departments the legal review documents applicable to the project.

Operation Permit: An operation permit is issued to the owner of the on-site sewage system by the local health department when it determines that all the requirements in the rules, plans and specifications are met. All conditions on the improvement permit/construction authorization must also met and, if required, the design engineer for the sewage collection, treatment and disposal system certifies, in writing, that the system has been installed according to the approved plans and specifications. The operation permit may also be conditioned to establish performance requirements and may be issued for a specific period. The operation permit prevents permanent electrical service to the project and prevents occupancy of the facilities until it is issued. The operation permit applies to all on-site wastewater systems.

Surveillance: Once an on-site sewage system is placed into operation, the local health department must make routine inspections at least annually for large systems to determine that the system is performing satisfactorily and not creating a public health nuisance or hazard. Additionally, monitoring reports must be routinely submitted to the local health department as required in the permits. The state provides technical assistance to the local health department and the system operator in assuring adequate performance. While annual inspections are required, frequent performance checks must be made by the local health department.

If the local health department determines that an on-site wastewater system is malfunctioning (i.e., surfacing effluent, discharges to surface or groundwater, sewage backup into buildings), improvement, construction authorization and operation permits are required to pursue the required repairs and/or modifications.

Educational information should also be provided to new septic system owners regarding the maintenance of these systems over time. DWQ has developed a booklet that discusses actions individuals can take to reduce stormwater runoff and improve stormwater quality entitled *Improving Water Quality In Your Own Backyard*. The publication includes a discussion about septic system maintenance and offers other sources of information. To obtain a free copy, call (919) 733-5083. The North Carolina State University Cooperative Extension Service (NCCES) has also put together a homeowner's guide for septic system care entitled Improving Septic Systems. The guide can be found on the NCCES Web site (www.soil.ncsu.edu/assist/homeassist/septic/). The following Web site (www.wsg.washington.edu/outreach/mas/water_quality/septicsense/septicmain.html) also offers information about maintaining septic systems in three easy to follow steps.

9.4.2 MONITORING SANITARY SEWERS

Sewer connections can leak or rupture, allowing sewage to flow into surface waterbodies. Common causes of sewer failures and overflows are tree roots growing into sewer lines, excessive rainfall and age. Grease, a by-product of cooking, can also enter sanitary sewers through household and/or restaurant drains. Grease sticks to the inside of sewer pipes, building up over time. If the entire sewer pipe becomes blocked, sewage can overflow into yards, streets and surface water.

To help prevent bacterial contamination from human and industrial waste, communities should evaluate where sewer lines are in relation to a stream corridor, replace fractured or damaged sewer lines and monitor lines regularly. When evaluating the need for sewer line extensions, communities should keep in mind that extensions to existing water and sewer lines encourage more development, which often results in more impervious surface cover and nonpoint source pollution from cumulative and secondary impacts.

9.4.3 COMMUNITY INVOLVEMENT

Experience has shown that widespread community support is generally necessary to mount an effective campaign that addresses septic system contamination issues, and that this support is unlikely to be forthcoming in the absence of any significant perceived benefits (Herring, 1996). Local governments around the country are finding innovative ways to address improperly installed and/or failing septic systems. For example, in order to protect water quality in the Chesapeake Bay, Arlington County, Virginia has adopted an ordinance requiring all septic tanks be pumped at least once every five years (USEPA, 1993). Stinson Beach, California developed a management program for on-site systems after discovering that malfunctioning systems were threatening public health (Herring, 1996). Homeowners here pay a monthly fee to cover the cost of inspections and testing, in addition to any construction and repair costs (USEPA, 1993). In the Puget Sound area, where a significant shellfish resource has been threatened by fecal coliform contamination from a number of sources, most counties have established revolving loan funds to facilitate the repair of failing systems (Center for Watershed Protection, 1999).

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CHAPTER 10 – BACTERIA AND WATER QUALITY IMPACTS

Recreational waters, particularly coastal areas, are valued worldwide for their economic, ecological and cultural significance. Like many states, the livelihood of North Carolina communities that cater to water related activities can be severely impacted if bacteria levels are above the water quality standards because the high levels often result in closed swimming areas and/or restricted and even prohibited shellfish harvesting. This chapter reviews how bacteria is used as a water quality indicator. It includes how bacteria can impact water quality, provides an overview of water quality standards for freshwater and saltwater and reviews best management practices (BMPs) and management strategies that can reduce bacteria numbers in waterbodies throughout the state.

10.1 IDENTIFYING BACTERIA AND ITS SOURCE

Microbes are defined as any microscopic organism and include protozoa (single-celled organisms), viruses and bacteria. Most microbes are beneficial or harmless to human health, but some are pathogenic and can cause a variety of human illnesses (NCNERR, no date). In North Carolina, fecal coliform and enterococci serve as bacterial indicators of water quality. Increased levels in aquatic environments provide a warning of sewage treatment failure, a break in the integrity of a water distribution system or possible contamination with other disease causing pathogens.

Sources of Bacteria in Surface Waters

- Urban stormwater
- Animals including wildlife, livestock and domesticated pets
- Improperly designed or managed animal waste facilities
- Livestock with direct, easy access to streams
- Improperly treated discharges of domestic wastewater including leaking or failing septic systems and straight pipes
- Marinas

No matter what the bacteria or microorganism type (i.e., virus, protozoan parasites), point and nonpoint source pollution contribute to the bacterial numbers in waterbodies. Point source pollution includes municipal wastewater treatment plants, sewage spills and permitted discharges. Nonpoint source pollution includes agricultural runoff, animal waste, human waste, leaky sewer lines, on-site septic systems, straight pipes, stormwater runoff from developed land including roads, buildings and residential yards and surface or land application of human and/or animal waste. Identifying possible sources of microbes is the first step in developing strategies to reduce their numbers in recreational waters.

10.1.1 FECAL COLIFORM BACTERIA

Fecal coliform bacteria are a group of bacteria that are passed through the fecal excrement of humans, livestock and wildlife. The bacteria can be found in the digestive tract of warm-blooded animals and aid in the digestion of food. In themselves, fecal coliform bacteria do not pose a danger to people or animals; however, where fecal coliform are present, disease-causing bacteria may also be present. Fecal coliform contamination often indicates that water is polluted with human or animal waste, which can harbor other pathogens that may threaten human health. Under favorable conditions (i.e., warm, dark, moist, organic-rich environment), fecal coliform bacteria can survive in bottom sediments for an extended period of time (Howell et *al*., 1996; Sherer et *al*., 1992; Schillinger and Gannon, 1985; Center for Watershed Protection, 1999).

Consequently, the concentration of bacteria measured in a water column can reflect both recent inputs as well as the re-suspension of older inputs. In North Carolina, fecal coliform bacteria are used to assess the water quality of fresh surface water (Class B and C) and saltwaters used for shellfish harvesting (Class SA).

Reducing fecal coliform bacteria in wastewater requires a disinfection process, which typically involves the use of chlorine and other disinfectants. Although these materials may kill the fecal coliform bacteria and other disease-causing microbes, the disinfectants also kill other microbes that are essential to the aquatic environment. This often endangers the survival of species dependent on these other microbes.

10.1.2 ENTEROCOCCI BACTERIA

Like fecal coliform bacteria, enterococci are passed through the fecal excrement of humans, livestock and wildlife. The bacteria can be found in the digestive tract of warm-blooded animals and aid in the digestion of food. EPA approves the use of enterococci as an indicator of water quality in recreation bathing waters. In North Carolina, enterococci bacteria are used to assess surface saltwaters used for recreational purposes (Class SA, SB and SC).

10.1.3 HUMAN SOURCES OF BACTERIA

Not all sanitary sewer systems offer high levels of pollution reduction. Potential pathways for human sewage to enter surface water include combined sewer overflows, sanitary sewer overflows, illegal sanitary connections to storm drains, transient or inadvertent dumping and failing septic systems (Center for Watershed Protection, 1999).

In the United States, there are nearly 800 cities with combined sewer systems (EPA, July 2006b). Combined sewer systems can be found in many older cities and are designed to collect human sewage, industrial wastewater and stormwater in the same pipe. Most of the time, all three can be transported to a wastewater treatment plant where it is treated and discharged to surface water; however, overflows can occur during heavy rain events. The overflow from the combined sewer system (CSO) contains stormwater and untreated human and industrial waste, toxic materials and debris. No combined sewer systems are located in North Carolina (EPA, July 2006b).

Even when stormwater and wastewater are separated, sanitary sewer overflows (SSO) can also occur. SSOs are discharges of raw sewage from municipal sanitary sewer systems. They are often caused by blockages and/or breaks in sewer lines, power failures at pumping stations and/or when infiltration and inflow exceed the capacity of the wastewater treatment plant (Center for Watershed Protection, 1999). By leaving sewer lines, entering basements and pooling on city streets, SSOs can create a serious human health hazard (EPA, July 2006c). Many SSOs occur during storm events because stormwater enters leaking, or broken, sewer pipes (Center for Watershed Protection, 1999). Often referred to as urban wet weather flows (WWFs), CSO, SSO and stormwater can discharge treated and untreated waste directly to surface water. These discharges consist of point and diffuse nonpoint source pollution and often include high levels of bacteria. More information on CSOs and SSOs can be found on the EPA's NPDES Web site (http://cfpub.epa.gov/npdes/).

Because it is difficult to identify sewer versus stormwater pipes during construction activities, hundreds of improper connections to stormwater pipes can introduce human sewage to surface water. Commonly referred to as illicit connections, they can have a significant impact on bacterial counts in surface water (Center for Watershed Protection, 1999).

Illegal dumping of sewage from septage vacuum trucks, garbage trucks, recreational vehicles and portable toilets along with livestock carriers can also contribute to bacterial loads; however, it is difficult to quantify how much each of these may be contributing to surface waters. Failing septic systems and straight pipes are also considered illegal because of their potential impact to water quality. Septic systems must be properly located, installed and maintained if they are to effectively remove bacteria from human waste (Center for Watershed Protection, 1999). More information about on-site waste management can be found in Section 10.3.3 and 10.4.3

10.1.4 Non-Human Sources of Bacteria

Most of the bacteria present in stormwater runoff is generally assumed to be from non-human sources. Dogs, cats, raccoons, rats, beaver, gulls, geese, pigeons and even insects influence bacterial numbers in many urban and rural watersheds. Given their population density, daily defecation rate and pathogen infection rate, dogs and cats appear to be a major source of fecal coliform bacteria in urban watersheds. The excrement of dogs and cats also contains other microbes including *Giardia* and *Salmonella*, both of which can cause serious stomach ailments in humans (Center for Watershed Protection, 1999).

In highly urban areas, rats and pigeons can be a major source of bacteria, and in many suburban watersheds, raccoons live underground in stormwater pipes and use ledges in the storm drain inlets for shelter. Thus allowing easy transport of excrement and bacteria to the closest waterbody. Many researchers also believe that geese, gulls and ducks may be a major bacterial source in urban areas. More research needs to be conducted to confirm bacterial impacts from geese, gulls and ducks, but it is generally speculated that bacteria numbers will be highest in small impoundments and concrete storage reservoirs used for stormwater storage and/or treatment (Center for Watershed Protection, 1999).

Table 10-1 Numbers of Viable Bacteria Found Per Gram of Feces of Adult Animals (Median values from 10 animals) (NCNERR, Fall 2003)

Animal	E. coli	Enterococci
Cow	20,000	200,000
Horse	13,000	6,300,000
Pig	3,200,000	2,500,000
Sheep	3,200,000	1,300,000
Chicken	4,000,000	32,000,000
Dog	32,000,000	40,000,000
Cat	40,000,000	200,000,000
Human	5,000,000	160,000

If feedlots and pastures are not managed properly, livestock (i.e., cattle, horses, sheep, pigs, chickens, turkeys) can also have a significant impact on bacterial numbers (Table 10-1). Improperly designed or managed animal feedlots and/or animal waste operations not only increase bacterial numbers but also introduce sediment, nutrients and oxygen-consuming organics to the stream (EPA, March 2005). Livestock in streams and stormwater runoff from pasturelands are also potential sources for fecal coliform bacteria. Limiting direct, easy access to streams can dramatically reduce impacts from bacteria, and several rules and regulations are in place to properly deal with animal waste issues (Chapter 6).

10.2 IMPACTS ON WATER QUALITY AND HUMAN HEALTH

10.2.1 ENVIRONMENTAL IMPACTS

From a human perspective, bacteria often impacts the recreational use of a waterbody making an area undesirable for swimming, wading and even fishing. From a biological perspective, the mode of bacterial transport – sediment, organic material (i.e., excrement) and stormwater runoff – can impact aquatic habitat, erode streambanks and impact watershed function. Aerobic decomposition of the organic material can reduce dissolved oxygen levels. If the dissolved oxygen level is too low, it can kill aquatic organisms.

Variables that Influence Movement and Transport of Indicator Bacteria

- Water discharge rates (or instream flow)
- Storm events
- Land disturbances
- Proximity to surface water
- Land use – urban, forest, agriculture, septic tanks
- Runoff volume and rate – impervious surface cover, type of vegetation, BMPs

Wastewater treatment methods can indirectly impact an aquatic ecosystem as well. Reduction of fecal coliform bacteria in wastewater may require the use of chlorine or other disinfectant chemicals. Such material may kill the disease-causing bacteria, but these same bacteria may be essential to maintaining the aquatic ecosystem, endangering species that may be dependent on the bacteria for its survival.

10.2.2 HUMAN HEALTH HAZARDS

Large quantities of fecal coliform bacteria in water may indicate a higher risk of pathogens being present. Some of the waterborne pathogenic diseases include ear infections, typhoid fever, viral and bacterial gastroenteritis, cholera and hepatitis A. Like many other bacteria, fecal coliform can usually be killed by boiling water or by treating the water with chlorine. Thoroughly washing with soap after contact with contaminated water will also help prevent infections. Throughout the United States, municipalities that maintain public water supplies are required to monitor and kill harmful microorganisms before water is distributed for public consumption.

10.3 WATER QUALITY STANDARDS AND COASTAL STORMWATER REGULATIONS

Microbial or bacterial contamination is addressed through the Safe Drinking Water Act (SDWA) and the Clean Water Act. The SDWA enables regulation of contamination of finished drinking water and protection of source waters while the Clean Water Act enables protection of surface water for drinking, recreation and as an aquatic food source. Programs under the two Acts have historically followed separate paths using differing indicators of contamination and different approaches; however, concerns about future increases in microbial contamination and potential for emergence of new threats, such as endocrine disrupting chemicals, create a need to consider a strategy for the future that unites the influence of the two programs. Objectives of the strategy are to address all-important sources of contamination, anticipate emerging problems and use program and research activities efficiently to protect public health (EPA, July 2006a).

Throughout the nation, water quality standards for bacteria are based on human health for recreation and shellfish harvesting and consumption (15A NCAC 2B .0200). North Carolina evaluates waters for the support of primary recreation activities such as swimming, water-skiing, skin diving and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis. Waters of the state designated for these uses are classified as Class B, SB and SA.

North Carolina also evaluates waters used for secondary recreation activities such as wading, boating and other uses not involving human body contact with water where such activities take place on an infrequent, unorganized or incidental basis. These waters are classified as Class C, SC and WS. Table 10-2 identifies the major responsibilities of various DENR agencies in regulating recreational and shellfish waters.

Table 10-2 Microbial Related Activities and Responsible DENR Agency (adapted from NCNEER, Technical Paper – Addressing Microbial Pollution in Coastal Waters)

Microbial/Monitoring Activity	Responsible Agency
Microbial water quality monitoring for fresh and estuarine waters	DWQ Environmental Sciences Section (ESS)
Microbial water quality monitoring of estuarine and ocean waters for recreational beaches	DEH Shellfish Sanitation & Recreational Water Quality Section
Shoreline Surveys of shellfish growing areas	DEH Shellfish Sanitation & Recreational Water Quality Section
Regulating shellfish harvesting	Division of Marine Fisheries (DMF)
Recommending and tracking shellfish growing area closures	DEH Shellfish Sanitation & Recreational Water Quality Section
Assessing lose of use of swimming waters and shellfish harvesting	DWQ Planning Section
Developing total maximum daily loads (TMDLs)	DWQ Planning Section
Posting swimming advisories	DEH Shellfish Sanitation & Recreational Water Quality Section

10.3.1 Recreational Water Quality Standards

DWQ conducts monthly ambient water quality monitoring that includes fecal coliform bacteria testing. In addition to DWQ ambient monitoring, the DEH tests coastal recreational waters (i.e., beaches, sounds, bays) for bacteria levels to assess the relative safety of these waters for swimming. If an area has elevated bacteria levels, health officials will advise people not swim in the area by posting a swimming advisory and by notifying the local media and county health department.

The fecal coliform standard for freshwater is 200 colonies per 100 milliliters (ml) of water based on at least five consecutive samples taken during a 30-day period, not to exceed 400 colonies per 100ml in more than 20 percent of the samples during the same period (15A NCAC 2B .0219). The 200 colonies per 100ml standard is intended to ensure that waters are safe enough for water contact through recreation. Class B waters are impaired in the recreation category if the water quality standard for fecal coliform bacteria is exceeded. Fecal coliform bacteria are identified as the stressor to these waters. Class C and WS waters are not rated if the geometric mean exceeds 400 colonies per 100 ml.

Coastal recreational waters are monitored through the DEH Recreational Water Quality Monitoring Program (http://www.deh.enr.state.nc.us/shellfish/Water_Monitoring/RWQweb/home.htm). Water quality objectives and criteria have been established with the main goal of protecting public health. By evaluating and monitoring the quality of North Carolina's coastal recreational waters, DEH can notify the public when bacteriological standards for safe bodily contact are exceeded. Specific objectives of DEH are to:

- Identify swimming areas/beaches and classify them based on human recreational usage.
- Identify monitoring stations that exceed the enterococci geometric mean and single-sample maximum criteria using the Enterolert Most Probable Number (MPN) method for enumeration.
- Evaluate the public health significance of approximately twenty (20) ocean stormwater outfalls/drains.
- Document trends in coastal bacteriological water quality.

DEH has established Tier I, II and III swimming areas/beaches based on their recreational usage. Swimming advisory signs are posted and press releases issued for Tier I swimming areas or beaches (swimming areas used daily) when a minimum of five samples, equally spaced over 30 days, exceed a geometric mean of 35 enterococci per 100 ml or when a single sample exceeds 500 enterococci per 100 ml. The public is notified only by press release, without an advisory sign, when a single sample exceeds 104 enterococci per 100 ml and is less than 500 enterococci per 100 ml. If a second sample exceeds 104 enterococci per 100 ml, an advisory is posted and the public will be notified by press release. An advisory will also be issued when at least two of three samples from a monitoring site exceed 104 enterococci per 100 ml. For an advisory to be rescinded, the station must have two consecutive samples below 35 enterococci per 100 ml.

In cases where a station under advisory is subject to triplicate sampling, two of the three samples must be under the single-sample maximum of 104 enterococci per 100 ml. If two of the three samples are above the single-sample maximum of 104 enterococci per 100 ml, an advisory will be put into place. The advisory will be rescinded when two of the three re-samples are under the single-sample level, as long as the running geometric mean of 35 enterococci per 100 ml has not been exceeded.

Beaches that violate the single-sample maximum criteria are re-sampled at the time of the public notification and/or sign posting, depending on the level of the exceedence. If the re-sample is satisfactory, the advisory may be lifted as early as 24 hours from the time of the initial advisory notification or posting. If the re-sample is unsatisfactory, but the geometric mean is not exceeded, the sign remains posted. If the re-sampling causes the exceedence of the geometric mean, then the geometric mean criteria apply.

The timeframe for posting swimming advisory signs at Tier I beaches, based on the enterococci geometric mean, runs from the beginning of May through the end of September. Weekly sampling of Tier I beaches is from April to October. During April and October, advisories at all Tier I monitoring sites are based on the single-sample maximum for Tier II beaches/swimming areas (276 enterococci per 100 ml.).

Tier II and Tier III beaches/swimming areas are sampled twice monthly from April to October, with the advisories based entirely on the single sample maximum criteria. For Tier II sites (areas are used infrequently and usually by watercraft), public notification and a swimming advisory sign are posted when a single sample exceeds 500 enterococci per 100 ml. A public notification without the advisory sign occurs when a single sample exceeds 276 enterococci per 100 ml but is less than 500 enterococci per 100 ml. If a second sample exceeds 276 enterococci per 100 ml, an advisory is posted and the public is notified. Weekly sampling of the site continues until the enterococci counts are less than 276 enterococci per 100 ml.

Because of infrequent use, Tier III swimming areas/beaches do not receive public notification or advisory signs until the second sample exceeds 500 enterococci per 100 ml. If the second sample exceeds 500 enterococci per 100 ml, an advisory sign and public notification are issued. Weekly sampling of the site will continue until the enterococci counts are less than 500 enterococci per 100 ml.

Other swimming advisories will be posted as precautionary measures when the following activities occur:

- Pumping of floodwaters between the primary dune and the ocean beaches.
- Stormwater outfalls/drains discharge onto ocean beaches. Storm drains that have flow that may be able to reach ocean recreational waters are posted with advisory signs.
- Disposal of dredge material from closed shellfishing waters on ocean beaches.

These swimming advisories are rescinded 24 hours after visible discharge into the ocean ceases. Swimming advisories are not posted from November through March; however, all sampling stations are sampled once per month during the non-swimming season.

DWQ does not directly use enterococci data from the DEH Recreational Water Quality Monitoring Program to assign use support ratings. The use support ratings applied to the recreation category are currently based on the state's fecal coliform bacteria water quality standard where ambient monitoring data are available or on the duration of local or state health agencies posted swimming advisories. The advisories are based on the state's enterococcus bacteria standards. Waters are impaired for recreation when swimming advisories are posted for more than 61 days during a five-year assessment period. Enterococci bacteria are identified as the stressor in these waters.

10.3.2 SHELLFISH HARVESTING WATER QUALITY STANDARDS

The Shellfish Sanitation Section of DEH is responsible for monitoring and classifying coastal waters as to their suitability for shellfish harvesting for human consumption and the inspection and certification of shellfish and crustacean processing plants. Classifications of coastal waters for shellfish harvesting are done by means of a Sanitary Survey, which includes: a shoreline survey, a hydrographic survey and a bacteriological survey of growing waters. The shoreline survey identifies potential pollution sources. The hydrographic survey evaluates meteorological and hydrographic features of the area that may affect the distribution of pollutants. The bacteriological survey assesses water quality using bacteria as water quality indicators. Sanitary Surveys are conducted of all potential shellfish growing areas in coastal North Carolina and recommendations are made to the DMF of which areas should be closed for shellfish harvesting. Based on the results of the survey, waters are classified into one of five categories (Table 10-3).

DEH follows guidelines set by the Interstate Shellfish Sanitation Conference (ISSC) (http://www.issc.org/) contained in the *National Shellfish Sanitation Program (NSSP) Guide for the Control of Molluscan Shellfish Model Ordinance*. The U.S. Food and Drug Administration (FDA) administer the NSSP.

DWQ assesses use support for the shellfish-harvesting category based on the DEH growing area classification. By definition, conditionally approved-open (CAO) growing areas are areas that DEH has determined do not meet water quality standards; however, the pollutant event is known and predictable and can by managed by a plan. DWQ identifies these waters as impaired for shellfish harvesting. Conditionally approved-closed (CAC), restricted (RES) and prohibited (PRO) growing areas are also considered impaired for shellfish harvesting. Fecal coliform bacteria are identified as the stressor.

DWQ, DEH, Division of Coastal Management (DMC) (http://dcm2.enr.state.nc.us/) and DMF are engaged in developing a database with georeferenced (GIS) shellfish harvesting areas. The new database and GIS tools will be valuable for the several DENR agencies and local health departments to continue to work together to better serve the public. Using the new database with georeferenced areas and monitoring sites, DEH will be able to report the number of days each area is closed excluding closures related to large or named storms events.

10.3.3 ON-SITE WASTEWATER TREATMENT

The On-Site Wastewater Section (OSWS) (http://www.deh.enr.state.nc.us/osww_new//index.htm) of DEH writes, oversees and enforces the rules and laws regulating the design, installation, repair, operation and maintenance of on-site wastewater treatment systems for the protection of human and environmental health from microbial contamination. OSWS provides statewide regulatory and consultative services to local health departments and numerous other clients, including builders, developers, land- and homeowners, system installers, system operators, engineers, soil scientists, geologists and environmental health consultants. However, an authorized environmental health specialist in each county health department conducts the actual implementation of the regulations (i.e., site evaluation, permitting of new systems).

Table 10-3 Shellfish Growing Area Classifications and Criteria

DEH Classification	Definitions and Water Quality Criteria
Approved (APP)	DEFINITION: These areas are always open to shellfish harvesting and close only after rare, heavy rainfall events such as hurricanes. CRITERIA: The median fecal coliform Most Probable Number (MPN) or the geometric mean MPN of the water shall not exceed 14 per 100 milliliters (ml), and the estimated 90th percentile shall not exceed an MPN of 43 MPN per 100 ml for a 5-tube decimal dilution test. Under sampling for adverse pollution conditions, the median fecal coliform or geometric mean MPN of the water shall not exceed 14 per 100 ml, and not more than 10 percent of the samples shall exceed 43 MPN per 100 ml for a 5-tube decimal dilution test.
Conditionally Approved-Open (CAO)	DEFINITION: CAO areas permit shellfish harvesting when environmental conditions result in fecal coliform bacteria levels lower than the state standard in areas that otherwise might be closed for harvesting. These areas are open to harvesting much of the year but are closed immediately after certain rainfall events. There are concerns that these areas may be closed more often and stay closed for longer periods as development proceeds in coastal areas adjacent to Class SA waters. CRITERIA: Sanitary Survey indicates an area can meet approved area criteria for a reasonable period of time, and the pollutant event is known and predictable and can be managed by a plan. These areas tend to be open more frequently than closed.
Conditionally Approved-Closed (CAC)	DEFINITION: CAC areas permit shellfish harvesting when environmental conditions result in fecal coliform bacteria levels lower than state standards in areas that are typically closed to shellfish harvesting. These areas are monitored regularly to determine if temporary openings are possible. These waters are rarely open to shellfish harvesting. CRITERIA: Sanitary Survey indicates an area can meet approved area criteria for a reasonable period of time, and the pollutant event is known and predictable and can be managed by a plan. These areas tend to be closed more frequently than open.
Restricted (RES)	DEFINITION: Most of the RES and PRO areas receive runoff that consistently results in fecal coliform bacteria levels above the state standard. In many areas, contamination (fecal coliform bacteria) may be from several different sources at different times of year. CRITERIA: Sanitary Survey indicates limited degree of pollution, and the area is not contaminated to the extent that consumption of shellfish could be hazardous after controlled depuration or relaying.
Prohibited (PRO)	CRITERIA: Sanitary Survey is not routinely conducted; area is closed due to regulations related to the presence of point source discharges or marinas; or previous sampling data did not meet criteria for APP, CAO, CAC or RES classification.

All of the rules and regulations including horizontal setbacks, depth to groundwater, soils requirements, loading rates, etc., are specific to North Carolina and are based on scientific studies of microbial fate and transport. These rules are constructed to protect groundwater and surface water from microbial contamination as well as other contaminants. The onsite treatment regulations are devised to minimize migration of microbes and pathogens to groundwater and surface water. More information related to on-site waste management can be found on the DEH OSWS Web site (http://www.deh.enr.state.nc.us/osww_new//index.htm).

10.3.4 Coastal Stormwater Regulations

North Carolina's current stormwater regulatory programs for coastal areas were adopted in the late 1980's as three primary coastal programs:

- Coastal (State) Stormwater Program.
- Shellfishing (Class SA) Waters Program.
- Outstanding Resource Waters (ORW) Program.

Each of these programs requires engineered stormwater control structures for high-density projects; however, no engineered stormwater controls are required for low-density projects. High density is defined as more than 24 percent built-upon area or more than two dwelling units per acre. Recent reviews of scientific literature, however, show that varying degrees of stream degradation and impairment occurs when there are no structural stormwater controls and 10 to 15 percent impervious surface cover is established (Mallin et *al*., 2000).

Since 1990, over 1,157 acres of Class SA, ORW waters have been closed to commercial shellfish harvesting in North Carolina due to elevated levels of bacteria. The Shellfish Sanitation Program through DEH notes that stormwater runoff is the primary cause of bacterial contamination in more than 90 percent of the shellfish areas sampled (Street et *al*., 2005).

In light of the increased acreage of areas closed to shellfish harvesting, DWQ embarked on a study of the current conditions and impacts to the state's shellfish waters. DWQ found that between 1988 and 2005, 73 percent of new impervious surfaces in coastal areas were constructed under low-density provisions (<24 percent impervious surfaces), which do not require engineered stormwater controls. Instead these low-density projects rely on practices such as grass swales to protect water quality. The use of swales for low-density areas indicates only a 25 percent effectiveness rate in reducing bacterial contaminants. Instead of protecting water quality, grass swales may actually contribute to bacterial loading by providing a conduit to increase runoff volumes and rates. In contrast, engineered stormwater controls for high-density areas include wet ponds and wetlands with 70 and 78 percent bacteriological removal rates, respectively, if they are installed and maintained properly.

DWQ assessed recent data and information on acres of shellfish closures in six tidal creeks in New Hanover County in the Neuse River basin (Mallin, 2006). The research focused on a county whose population grew 25 percent between 1990 and 2000 and is expected to increase an additional 31 percent by 2020. The research found a strong correlation between bacteria levels and impervious surfaces in the watershed – the greater the amount of impervious surfaces, the greater the bacteria levels. This correlation has also been documented by other research in South Carolina's coastal tidal creeks (Holland, 2004). In addition, there is a strong association between turbidity and fecal coliform bacteria levels in these estuarine waters.

DWQ's assessment of research results show that the acreages of shellfish waters closed to shellfish harvesting has increased significantly between 1988 and 2005, and there have been new closures after the implementation of the current stormwater programs. North Carolina waters permanently closed to shellfishing have increased by approximately 19 percent since 1984. The reliance on no engineered stormwater controls for low-density projects is the major identifiable shortfall in the current programs. Without changes to these programs, there will be continued degradation of shellfishing waters. More information on stormwater regulations and BMPs can be found in Chapter 5.

10.4 Reducing Water Quality Impacts from Bacteria

> ***General Management Strategies to Address Bacteria in Surface and Groundwater***
>
> - ❑ Proper maintenance and pumping of septic tanks every three to five years.
> - ❑ Maintenance and repair of sanitary sewer lines.
> - ❑ Elimination of straight pipes.
> - ❑ Proper management of livestock to keep wastes from reaching surface water.
> - ❑ Encourage local health department to routinely monitor those areas known for organized swimming.

Even though state and federal agencies test water quality and regulate microbial pollution across the nation, it is actions taken by local governments and organizations that have the greatest potential to protect waterbodies from bacterial threats. The ideas and/or management strategies in this section are best implemented on the local level. Education, watershed planning, good site design, stormwater control and maintenance are practices that can be used to reduce total runoff volume and bacterial loading to improve water quality and habitat conditions.

10.4.1 Reducing and Treating Stormwater Runoff

For the most part, bacteria enter recreational waterbodies through stormwater runoff. There are many aspects of development that can influence bacteria export from urban areas. Some of the most common are the size of the disturbed area, size of vegetated buffer, amount of impervious surface cover and the design and use of sediment or stormwater control devices. Table 10-4 identifies structural and nonstructural BMPs for urban stormwater control. Structural BMPs are typically designed to reduce sediment and the pollutants associated with it (i.e., nutrients, microbes, metals). In addition to reducing sediment and bacterial loads, structural BMPs can also stabilize streambanks and protect the riparian zone. Nonstructural BMPs such as a design manual or a public outreach and education program encourage comprehensive and effective implementation of structural BMPs. BMP characteristics, pollutant-specific effectiveness, reliability, feasibility, costs and design considerations can be found in the DWQ Manual of Stormwater Best Management Practices. The 1999 manual is being updated and the draft 2005 version is available on the DWQ Web site (http://h2o.enr.state.nc.us/su/Manuals_Factsheets.htm#StormwaterManuals). Information can also be found on the NC State University Department of Biological and Agricultural Engineering – Stormwater Engineering Group Web site (www.bae.ncsu.edu/stormwater/).

Table 10-4 Structural and Nonstructural BMPs for Urban Stormwater Control

Structural BMPs	Nonstructural BMPs	
❑ Wet Detention Basin ❑ Constructed Wetlands ❑ Wet Retention Basin ❑ Dry Detention Basin ❑ Infiltration Basin ❑ Vegetative Practices (i.e., filter strips, grass swales with check dams) ❑ Sand Filter ❑ Oil and Grease Separator ❑ Rollover Curbing	❑ Preventive Measures (i.e., limit impervious surface cover) ❑ Pollutant Minimization ❑ Exposure Reduction (i.e., schedule/rotate land disturbance) ❑ Landscaping and Lawn Maintenance Controls ❑ Animal Waste Collection ❑ Curb Elimination ❑ Parking Lot and Street Cleaning	❑ Catch Basin Cleaning ❑ Riparian Area Protection ❑ Public Education ❑ Identification and Enforcement of Illegal Discharges ❑ Land Use Control (i.e., low impact development, comprehensive site planning, riparian zone protection, conservation easement)

10.4.2 LAND USE PLANNING TO REDUCE IMPACTS OF FUTURE DEVELOPMENT

A variety of land use planning techniques and policy options are available for a community to consider in addressing nonpoint source pollution management and general water quality problems. Zoning restrictions, development and design standards and BMPs can be incorporated into many existing town and county ordinances, but each locality must decide how best to allocate limited resources to protect water quality and prevent nonpoint source pollution while still supporting economic growth. The only mandate for local land use plans in North Carolina is the Coastal Area Management Act (CAMA), which requires land use plans for all twenty coastal counties. The land use plan examines the relationship between land uses and other areas of interest such as transportation, recreation, infrastructure and protection of natural resources. Through a planning process, a community gathers data and public input in an attempt to guide a community's future development (WECO, 2003).

Residents and visitors to North Carolina are beginning to speak out and demand more protection of the natural resources people enjoy. Several examples can be found throughout the State where citizen complaints and participation in local planning decisions have resulted in better and more protective measures being installed in new residential and commercial developments. This is particularly true in the twenty coastal counties.

Many communities are looking at the challenges and opportunities that development offers to their communities seriously. For example, much of the Bogue Sound in the White Oak River basin is closed to shellfish harvesting. Bogue Watch, which drains into Bogue Sound, is a new development in Carteret County that is designed to control stormwater runoff and protect the natural environment surrounding the sound. Site plans indicate that the development contains 287 lots with facilities (i.e., fishing piers, parks) on the water. The subdivision, which has nearly 25 percent of its land surface planned for impervious surfaces, will have six common areas with five waterfront parks and piers. There will also be five holding ponds for stormwater runoff, vegetated areas to filter runoff, 38 acres of open space and several large ponds for treated wastewater. Four lots are not being developed to allow for stormwater controls. Based on the local community, the developer determined that it was important to design Bogue Watch in such a way that it would balance the community's quality and way of life with environmental protection.

Outside of Carteret County in the White Oak River basin, the Town of Bath (Beaufort County) approved a 6-month moratorium on new subdivisions. The moratorium allowed the town board time to assess how the town wanted to develop its remaining waterfront lots and where the town needed to protect its resources. In addition, Pamlico County approved an ordinance to limit density and height of developments along the water.

> ***Planning Recommendations for New Development***
>
> - ❑ Minimize number and width of residential streets.
> - ❑ Minimize size of parking areas (angled parking & narrower slots).
> - ❑ Place sidewalks on only one side of residential streets.
> - ❑ Minimize culvert pipe and hardened stormwater conveyances.
> - ❑ Vegetate road right-of-ways, parking lot islands and highway dividers to increase infiltration.
> - ❑ Plant and protect natural buffer zones along streams and tributaries.

Proactive planning efforts at the local level are needed to assure that development is done in a manner that maintains water quality. Used effectively, land use planning can find a balance between water quality protection, natural resource management and economic growth. Growth management requires planning for the needs of future population increases, as well as developing and enforcing environmental protection measures. These actions are critical to water quality management and the quality of life for the residents of North Carolina. County and regional land use plans should incorporate proactive measures to meet future growth demands to prevent water quality deterioration and consider cumulative impacts to water quality. They should incorporate strategies such as land conservation, open space and riparian area protection to reduce the amount of stormwater runoff, and consequently, bacteria entering a surface waterbody

To prevent further impairment in urban watersheds, local governments should:

- ❑ Identify and protect waters that are threatened by development.
- ❑ Protect existing riparian habitat along streams and restore it where possible.
- ❑ Implement stormwater BMPs during and after development.
- ❑ Develop land use and site development plans that minimize disturbance in sensitive areas.
- ❑ Minimize impervious surfaces including roads and parking lots.
- ❑ Develop public outreach programs to educate citizens about stormwater runoff.

Action needs be taken at the local level to plan for new development in urban and rural areas. For more detailed information regarding recommendations for new development, refer to EPA's Watershed Academy Web site (www.epa.gov/owow/watershed/wacademy/acad2000/protection). Information can also be found on the Center for Watershed Protection Web site (www.cwp.org) and the Web site for the Low Impact Development Center (www.lowimpactdevelopment.org). Land use planning and management techniques can also be found in the Nonpoint Source Pollution Prevention and Control through Land Use Planning and Management Document available on the DWQ Web site (http://h2o.enr.state.nc.us/nps/CNPSCP/documents/FinalNPSManual.pdf). For an example of local community planning effort to reduce stormwater runoff, visit www.charmeck.org/Home.htm.

10.4.3 On-site Wastewater Management

Throughout the state, the increase in development has resulted in an increase in demand for individual wastewater treatment systems. Many require higher flows on small tracks of land. Wastewater from many households is not treated at wastewater treatment plants associated with NPDES discharge permits. Instead, it is treated on-site through the use of permitted septic systems. Poorly planned and/or maintained systems can fail and contribute to nonpoint source pollution. Wastewater from some of these homes illegally discharges directly to streams through what is known as a "straight pipe". In other cases, wastewater from failing septic systems makes its way to streams or contaminates groundwater. Straight piping and failing septic systems are illegal discharges of wastewater into waters of the state.

With on-site septic systems, the septic tank unit treats some wastes, and the drainfield associated with the septic tank provides further treatment and filtration of the pollutants and pathogens found in wastewater. A septic system that is operating properly does not discharge untreated wastewater to streams and lakes or to the ground's surface where it can run into nearby surface waters. Septic systems are a safe and effective long-term method for treating wastewater if they are sited, sized and maintained properly. If the tank or drainfield are improperly located or constructed, or the systems are not maintained, nearby wells and surface waters may become contaminated, causing potential risks to human health. Septic tanks must be properly installed and maintained to ensure they function properly over the life of the system. Information about the proper installation and maintenance of septic tanks can be obtained by calling the environmental health sections of the local county health departments.

Several studies have evaluated septic systems and the impact they can have on bacterial numbers within a waterbody. For example, research in areas of South Florida found that septic tanks in porous soils can readily pass through the soil and enter coastal waters near the shore within hours. In some areas, fecal bacteria counts were higher upon outgoing tides and in wetter years due to subsurface movement through saturated soils and increased runoff due to rain. Ditching and draining appear to facilitate the flow of septic waste to surface waters (Paul et *al*. 2000). The conclusion – sandy soils and high water tables appear to be unsuitable for septic systems, yet these systems are relied on heavily in many coastal areas (including eastern North Carolina) for waste management.

Research (Tschetter and Maiolo, 1984) has also shown a correlation between coastal population growth in North Carolina and the closure of waters to shellfishing. Unfortunately, this work is too general to be useful for land management purposes. A specific study of coastal watersheds in New Hanover County (Duda and Cromartie, 1982), however, found that closings generally occurred in areas that had more than one septic system drainfield per every seven acres of watershed. It is unclear how subsurface drainage networks may have contributed to the closings, or how widely the results of this investigation can be applied. The results, however, indicate that there is an empirical relationship between land development and shellfish water closures that should not be ignored if shellfish waters are to be adequately protected or restored.

Local governments around the country are finding innovative ways to address improperly installed and/or failing septic systems. For example, in order to protect water quality in the Chesapeake Bay, Arlington County, Virginia has adopted an ordinance requiring all septic tanks be pumped at least once every five years (USEPA, 1993). Stinson Beach, California developed a management program for on-site systems after discovering that malfunctioning systems were threatening public health (Herring, 1996). Homeowners here pay a monthly fee to cover the cost of inspections and testing, in addition to any construction and repair costs (USEPA, 1993). In the Puget Sound area, where a significant shellfish resource has been threatened by fecal coliform contamination from a number of sources, most counties have established revolving loan funds to facilitate the repair of failing systems (Center for Watershed Protection, 1995).

Experience has shown that widespread community support is generally necessary to mount an effective campaign that addresses septic system contamination issues, and that this support is unlikely to be forthcoming in the absence of any significant perceived benefits (Herring, 1996). In North Carolina, the Wastewater Discharge Elimination (WaDE) Program (http://www.deh.enr.state.nc.us/osww_new//WaDE.htm) through the OSWS in DEH was established pursuant to Senate Law 1996-18es2, Section 27.26 (http://www.ncleg.net/gascripts/BillLookUp/BillLookUp.pl?Session=1995e2&BillID=H53), to identify and eliminate discharges from straight pipes and failing septic systems to land surfaces and streams. Funds appropriated by the NC General Assembly support a two-member team to address the straight pipe and failing septic system issues in North Carolina. Additional financial support has been secured through grants from the NC CMTF and the EPA 319 Non-Point Source Program (http://www.epa.gov/owow/nps/cwact.html).

Strong collaboration with local and federal agencies as well as the public, the media and environmental groups is the hallmark of the WaDE program and the key to its successes thus far.

10.4.4 MONITORING SANITARY SEWERS

Sewer connections can leak or rupture, allowing sewage to flow into surface waterbodies. Common causes of sewer failures and overflows are tree roots growing into sewer lines, excessive rainfall and age. Grease, a by-product of cooking, can also enter sanitary sewers through household and/or restaurant drains. Grease sticks to the inside of sewer pipes, building up over time. If the entire sewer pipe becomes blocked, sewage can overflow into yards, streets and surface water.

To help prevent bacterial contamination from human and industrial waste, communities should evaluate where sewer lines are in relation to a stream corridor, replace fractured or damaged sewer lines and monitor lines regularly. When evaluating the need for sewer line extensions, communities should keep in mind that extensions to existing water and sewer lines encourage more development, which often results in more impervious surface cover and nonpoint source pollution from cumulative and secondary impacts.

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CHAPTER 11 – NUTRIENTS AND IMPACTS TO WATER QUALITY

Nutrients are chemical elements and compounds found in the environment that plants and animals need to grow and survive. For water-quality investigations, the various forms of nitrogen and phosphorus are the nutrients of interest. The forms include nitrate, nitrite, ammonia, organic nitrogen (in the form of plant material or other organic compounds) and phosphates (orthophosphate and others). Nitrate is the most common form of nitrogen and phosphates are the most common forms of phosphorus found in natural waters. High concentrations of nutrients in waterbodies can potentially cause eutrophication and hypoxia (USGS, December 2006).

Nitrogen and phosphorus are common components of fertilizers, animal and human wastes, vegetation, aquaculture and some industrial processes. Nutrients in surface waters come from both point and nonpoint sources including agricultural and urban runoff, wastewater treatment plants, forestry activities and atmospheric deposition. Nutrients in nonpoint source runoff come mostly from fertilizer and animal wastes. Nutrients in point source discharges typically come from human waste, food residues, cleaning agents and industrial processes.

This chapter provides an overview of nutrients (phosphorus and nitrogen) and how they can impact water quality, defines nutrient sensitive waters (NSW) and management strategies that have been adopted by the state to protect those waters, and reviews lake and estuary nutrient monitoring protocols and strategies.

11.1 IMPACTS TO WATER QUALITY

The primary limiting nutrients in freshwaters are phosphorus (P) and nitrogen (N). A limiting nutrient is a chemical necessary for plant growth. Once the limiting nutrient is exhausted, plant growth ceases. Phosphorus and nitrogen have different chemical properties and are involved in different chemical processes; however, both are transported to receiving waterbodies by rain, stormwater runoff, groundwater and industrial and residential waste effluents. Phosphorus is a mineral nutrient introduced into biological processes through the breakdown of rock and soil minerals. It is primarily found in two forms – organic and inorganic. Phosphorus readily absorbs to clay particles in the water column, which reduces its availability for uptake by algae, bacteria and macrophytes (aquatic plants).

Nitrogen (N_2), however, is primarily found in the air. Nitrogen gas is not readily available for plant uptake; however, a number of bacteria and cyanobacteria (blue-green algae) are able to convert nitrogen gas to a useable form. Most plants and animals utilize ammonium (NH_4^+) and nitrate (NO_3^-) ions – the mineral forms of nitrogen – in everyday biological functions (EPA, July 2000). Both are important factors to consider when evaluated watershed function and health.

11.1.1 ECOLOGICAL IMPACTS

While nutrients are beneficial to aquatic life in small amounts, excessive nutrient concentrations can stimulate algal blooms and plant growth in streams, ponds, lakes, reservoirs and estuaries and along shoreline. Through respiration and decomposition, algal blooms can deplete the water column of dissolved oxygen and contribute to serious water quality problems. Algal blooms can also be aesthetically undesirable, alter the native composition and species diversity of aquatic communities, impair recreational uses of surface waters, impede commercial fishing and pose problems for water treatment systems. In many waterbodies, light, temperature, algal buoyancy, organic and inorganic nutrients and predation by larger organisms (i.e., zooplankton, crustaceans, rotifers, etc.) will influence algal growth (Wetzel, 2001).

Algal growth and the depletion of dissolved oxygen caused by nutrient enrichment fluctuate seasonally, sometimes over the course of a single day (diurnal fluctuations). In the presence of sunlight, for example, algae and other plants produce oxygen through the process of photosynthesis. At night, however, photosynthesis and dissolved oxygen production slow down causing oxygen to be consumed by algae through respiration. During the summer months, the daily cycle of daytime oxygen production and nighttime depletion can result in supersaturation - a condition that occurs when dissolved oxygen levels are greater than the saturation value for a given temperature and atmospheric pressure. High dissolved gas levels can be lethal to fish populations by inhibiting respiratory processes.

Algae may also settle to the bottom of a waterbody and contribute to sediment oxygen demand (SOD) as it decomposes through bacterial action. This type of decomposition lowers dissolved oxygen concentrations in the bottom waters of lakes, rivers and estuaries. Hypoxia – waters that contain less than 2 parts per million (ppm, or 2 milligrams per liter) dissolved oxygen – can cause severe stress and even kill bottom dwelling organisms. This lose of biological activity and fish kills can lead to significant cultural and economic impacts on local communities dependent on recreational and commercial fisheries (EPA, July 2000).

Many aquatic plants positively affect water quality by removing and storing nutrients from the aquatic system. They also provide food and shelter for many aquatic organisms. Excess N and P inputs, however, can lead to excessive growth. Some examples of aquatic plants include milfoil, alligator weed and *Hydrilla*. Diurnal changes in pH and dissolved oxygen, which occur during photosynthesis and respiration, impact the release and/or uptake of heavy metals or other toxic substances in the water column. If water clarity is decreased (turbidity increases and sunlight cannot penetrate the water column), macrophytes can die, but algae may thrive and create a dense algal mat. Increased algal biomass and loss of macrophytes can reduce habitat availability, change water chemistry and alter aquatic species diversity and abundance (EPA, July 2000).

Chlorophyll *a*, a constituent of most algae, is a widely used indicator of algal biomass. North Carolina has a chlorophyll *a* standard of 40 μg/l (micrograms per liter) for lakes, reservoirs and slow-moving waters not designated as trout waters and a 15 μg/l standard for trout waters.

11.1.2 HUMAN HEALTH AND RECREATIONAL IMPACTS

Light, temperature, substrate, existing water chemistry and biological communities play a role in the nuisance level of algae and macrophytes within a waterbody. Algal blooms and macrophytes often interfere with aesthetic and recreational uses, cause taste and odor problems in drinking water supplies and can even become toxic depending upon the type of algal growth.

Human health problems associated with nutrient enrichment include the formation of trihalomethanes (THMs). THMs are produced when certain organic compounds (i.e., humic substances, algal metabolites and decomposition products) are chlorinated or brominated during the disinfection process for drinking water purposes. THMs are carcinogenic. Their production is highly dependent upon the density of algae and the level of eutrophication in the raw water supply (EPA, July 2000).

Nutrient enrichment can also cause methemoglobinemia ("blue-baby syndrome) in infants less than 6 months of age. Methoemoglobinemia or "blue-baby" syndrome is a potentially fatal blood disorder for infants less than six months old. The disorder reduces the oxygen-carrying capacity of blood. It is associated with nitrates in drinking water above the Maximum Contaminant Level (MCL) of nitrate as nitrogen (NO_3-N) at 10 ppm as set by the US Environmental Protection Agency (EPA) (Benton Franklin Health District, 2002; EPA, July 2000).

One of the most expensive impacts of nutrient enrichment is the increase in time and money required to treat drinking water. Algae and macrophytes can clog filters, corrode intake pipes and require greater volumes of water treatment chemicals (EPA, July 2000).

11.1.3 Reservoir and Lake Eutrophication

Eutrophication is a process where waterbodies, such as lakes, estuaries or slow-moving streams, receive excess nutrient that stimulate excessive plant growth (algae, periphyton attached to algae and nuisance plant weeds). When a surface waterbody becomes nutrient rich, is biologically productive and able to support high levels of algal or macrophytic growth, it is classified as eutrophic. As a group, reservoirs tend to have higher inflows. Thus, nutrient loads are higher in reservoirs than natural lakes and are more likely to be eutrophic. In North Carolina, this is especially true of piedmont reservoirs.

The classical lake succession sequence is usually depicted as a unidirectional progression corresponding to a gradual increase in lake productivity from oligotrophy to hypereutrophy. In watersheds that remain relatively undisturbed, lakes can retain the same trophic status for thousands of years. On the other hand, rapid changes in lake nutrient status and productivity are often the result of cultural eutrophication - human disturbances in the watershed - rather than gradual enrichment and filling of the lake through natural processes.

Lake Trophic Levels

Oligotrophic
Nutrient-poor and low biological productivity. Typical of cold-water lakes.

Mesotrophic
Intermediate nutrient availability and biological productivity.

Eutrophic
Nutirent-rich and highly productive.

Hypereutrophic
Extreme productivity characterized by algal blooms or dense macrophytes populations or both frequently having a high level of sedimentation.

Eutrophic conditions can, but do not always, interfere with the designated use of a waterbody. Eutrophication in North Carolina reservoirs is often associated with a shift in the phytoplankton community towards a system dominated by blue-green algae. Blue-green algae are notorious for taste and odor problems that often require additional (and more expensive) treatment to make the finished drinking water palatable. Blue-green algae are also a very poor food source for herbaceous fish and large zooplankton. This can lead to a change in the composition of lake fish and/or a need for more frequent stocking of prey fish (i.e., threadfin shad) to support the game fish population.

WATERS CLASSIFIED AS NSW

- ❑ Neuse River basin
- ❑ Tar-Pamlico River basin
- ❑ Chowan River basin
- ❑ New River watershed in the White Oak River basin
- ❑ Jordan Lake (Reservoir) watershed in the Cape Fear River Basin

11.1.4 COASTAL ECOSYSTEMS

Eutrophication of coastal rivers, estuaries and bays can change the structure of entire ecological communities and impact the economic viability of local fisheries. Indirectly, eutrophication can deplete oxygen from the water column creating hypoxic and anoxic conditions, which reduces habitat suitability for many species and changes interactions between predators and their prey. For example, periods of low oxygen tend to shift the seafloor community away from large, long-lived clams to much smaller, opportunistic, short-lived species that can colonize and complete their life cycle between periods of hypoxia. Zooplankton, which would normally migrate toward the bottom waters during the day to avoid predation, are forced to remain near the surface where they are readily seen by fish that prey on them. Directly, increased nutrients alter community structure by impacting algal species. Some species are well adapted to low-nutrient conditions, while others prefer high N and P levels. These differences allow for diverse algal species in coastal communities; however, eutrophication can alter their diversity and abundance (Howarth et *al*., 2000).

Changes in algal species can also impact the viability of local fisheries. Moderate nutrient enrichment can lead to an increase of economically viable fish. More algae means more zooplankton, a food source for many fish species. Severe nutrient enrichment, however, can limit the amount of viable fish and alter the biological diversity and abundance of some species. Coral reefs and seagrass beds can also be impacted by nutrient enrichment due to changes in both algal and fish species (Howarth et *al*., 2000).

11.2 NUTRIENT SENSITIVE WATERS AND NUTRIENT MANAGEMENT STRATEGIES TO PROTECT WATER QUALITY

Reductions in nutrient loads are needed to limit the potential for algal growth and fish kills and to assure the protection of instream chlorophyll *a* standards in the state's waterways. Point source controls typically include permit limitations for total phosphorus (TP) and/or total nitrogen (TN) levels through the National Pollutant Discharge Elimination System (NPDES) permitting process. Nonpoint source controls of nutrients generally include best management practices (BMPs) that control nutrient loading from agricultural land, urban areas and other nonpoint sources. Several structural and nonstructural BMPs are discussed throughout this document, but there are also several state mandated nutrient strategies in place to limit nutrient enrichment throughout several North Carolina watersheds.

11.2.1 NUTRIENT SENSITIVE WATERS

Nutrient sensitive waters (NSW) is a supplemental water classification applied to waters that are experiencing, or are subject to, excessive growths of microscopic or macroscopic vegetation. The NC Environmental Management Commission (EMC) defines excessive vegetative growth as that growth which can substantially impair the use of a waterbody for its best usage as determined by the classification applied to that waterbody (Rule 15A NCAC 02B.0223).

NSW may include any or all waters within a river basin that the EMC deems is necessary to effectively control excessive growths of aquatic vegetation. For the purposes of this classification, "nutrients" refers to phosphorus and nitrogen, although other nutrients or chemicals may be specified if it is determined that they are essential to the growth of aquatic vegetation.

No increase in nutrients over background levels is allowed within NSW waters unless it can be shown that:

- The increase is the result of natural variations;
- The increase will not endanger human health, safety or welfare; and
- Preventing the increase would cause a serious economic hardship without equal or greater public benefits.

In addition to being classified as NSW, waters in the Neuse and Tar-Pamlico River basins are protected by a set of permanent rules. The rules are part of a management strategy to reduce nutrient inputs throughout the entire river basin. Both sets of rules are the result of problems associated with excess nutrient enrichment in and near the estuaries – low dissolved oxygen levels, harmful algal blooms, fish kills and other symptoms of stress and diseases to the aquatic community.

11.2.2 NORTH CAROLINA'S NUTRIENT CRITERIA IMPLEMENTATION PLAN

North Carolina firmly believes that a proactive management strategy based on adaptive management techniques is the most viable method to control excessive nutrients from point and nonpoint sources. North Carolina has established itself as a leader in the field of site-specific, flexible nutrient control strategies through the implementation of a comprehensive nutrient management program for surface waters. This existing program has included nutrient response criteria, ambient monitoring programs, use support methodologies, nutrient TMDLs, nitrogen and phosphorous permit limits and the supplemental classification NSW for certain waters of the State.

North Carolina recognizes that additional proactive nutrient control measures are warranted based upon the latest advances in nutrient management practices and the continued eutrophication of waters. Accordingly, DWQ has developed a plan for nutrient control in surface waters across the state. The plan is designed to build upon and refine the nutrient control achievements that have already been attained in the State. It is the goal of the Nutrient Criteria Implementation Plan to reduce and protect surface waters from eutrophication by developing regionally-specific nutrient response criteria that will be augmented by site-specific nitrogen and phosphorous control mechanisms. Additional information that provides a defensible linkage of cause to response to effect will be a prerequisite to completely understand the causal variable data. The full details of the Nutrient Criteria Implementation Plan and North Carolina's agreement with Region 4 Environmental Protection Agency (EPA) can be found on the

Classifications and Standards Unit Web site (http://h2o.enr.state.nc.us/csu/swstdsfaq.html#NC_Nutrient_Plan).

11.2.3 NUTRIENT MANAGEMENT STRATEGIES – TAR-PAMLICO RIVER BASIN

The Tar-Pamlico River Basin is the fourth largest river basin in North Carolina and a major tributary to the Pamlico Sound. Together, the Pamlico Sound and neighboring Albemarle Sound constitute one of the most productive estuarine systems in the country and are part of the EPA's National Estuary Program.

The Tar-Pamlico River basin begins in the Piedmont of North Carolina and extends approximately 180 miles through the Coastal Plain to the Pamlico Sound. The Tar River collects water from approximately 2,300 miles of freshwater streams before entering the estuarine Pamlico River at Washington. The 5,400 square mile basin encompasses portions of 17 counties, including the cities of Rocky Mount, Tarboro and Greenville, as well as many agricultural and forested areas. The basin also provides a habitat for nine state or federally listed threatened or endangered freshwater mussel species and includes two national wildlife refuges (Lake Mattamuskeet and Swan Quarter).

Throughout the mid-1970s and 1980s, algal blooms and fish kills in the upper Pamlico estuary were linked to excessive nutrient levels in the river. Following a record-setting year of reported fish kills in 1989, the EMC supplementally classified the Tar-Pamlico River Basin as NSW. On December 14, 1989, the EMC approved the first phase of a nutrient management strategy (Phase I) that targeted point sources of pollution (i.e., wastewater, industrial and commercial effluent). Several of the discharges formed the Tar-Pamlico Basin Association (the Association). Working with the state and several environmental groups, the Association presented an innovative nutrient-trading program between point and nonpoint sources of pollution. The Association agreed to either reduce their nutrient loading to the estuary or, if they exceeded an annual collective loading cap, to fund agricultural BMPs through the state's existing Agricultural Cost Share Program (ACSP). This agreement allowed discharges in the Association to find more cost-effective ways to collectively meet the nutrient-loading cap. The Agreement also provided a more cost-effective nutrient reduction alternative if the Association couldn't meet its cap – payments for agricultural BMPs that are documented to be more cost effective than retrofits or treatment modifications during expansion. Phase I ran from 1990 to 1994.

Phase II (1995 to 2004) of the program was adopted by the EMC in December 1994 and used an estuarine model to establish an interim goal of a 30 percent reduction in total nitrogen loads to the estuary from the 1991 conditions and no increase in the phosphorus loads. The EMC noted that these rules could be adjusted in the future to reflect progress (or lack thereof) in achieving the goal. The goal would also be adjusted to reflect changes in technology and BMPs. Phase II also includes a separate nonpoint source strategy that initially began as a voluntary program in 1996. The voluntary plan relied on the existing program to achieve the goals through better targeting, coordination and increased efforts to obtain resource agency staff and cost share resources. It also included action plans for nine different nonpoint source categories: agriculture, forestry, urban stormwater, construction, on-site wastewater, solid waste disposal, wetlands, groundwater and atmospheric deposition.

In July 1998, the EMC determined that voluntary reduction of nonpoint source pollution was inadequate and called for rule development to achieve the nonpoint source reduction goals. Seven professionally facilitated stakeholder teams were formed to evaluate all aspects of the rule making process. Between December 1999 and September 2001, the EMC adopted a set of rules covering four subject areas for the Tar-Pamlico River basin – riparian buffers, nutrient management, urban stormwater and agriculture (Table 11-1). Since it was estimated that agricultural practices (i.e., crops, animal operations, etc.) were responsible for most of the nonpoint source nutrient loading in the estuary, the agricultural community was tasked with achieving most of the nonpoint source reductions. Annual reports are presented to the EMC to provide updates on the effectiveness of the nutrient management strategies implemented by the agricultural community.

Phase III of the nutrient management strategies was adopted by the EMC in April 2005 and continues the structure established in Phase II. The Phase III agreement updated the point source association membership and related nutrient caps. It proposed actions within the first two years of its adoption to improve the nutrient offset rate, resolve related offset credit issues and revisit alternative offset options. It also established a ten-year estuary performance objective. More information on the Tar-Pamlico River Nutrient Management Strategies can be found on the

Table 11-1 Rules Adopted by the EMC for Nutrient Management in the Tar-Pamlico River Basin

Rule Subject	Rule Number	Effective Date	Purpose
Riparian Buffers	15A NCAC 2B .0259	August 2000	Protects and preserves existing riparian buffers and maintain nutrient removal functions.
- Protection	15A NCAC 2B .0260	August 2000	Sets forth mitigation requirements that apply to the riparian buffer protection program.
- Mitigation	15A NCAC 2B .0261	August 2000	Defines the requirements for delegating implementation and enforcement of the buffer protection program.
Nutrient Management	15A NCAC 2B .0257	April 2001	Establishes the five-year goal of reducing nitrogen loading in the Pamlico estuary by 30 percent (based on 1991 levels) and capping phosphorus loading.
Stormwater Requirements (Basinwide)[1]	15A NCAC 2B .0258	April 2001	Achieve and maintain the goals for N and P reduction in the estuary; provide control for peak stormwater flows from new development to ensure existing riparian buffers and streams are not compromised by channel erosion; and minimize N and P loading from existing developed areas.
Agriculture – Nutrient Loading Goals	15A NCAC 2B .0255	April 2001	Specifies that agricultural operations (i.e., crops, horticulture, livestock, poultry) collectively meet the N and P reduction goals.
Agriculture – Nutrient Control Strategies	15A NCAC 2B .0256	September 2001	Defines processes by which agricultural operations will collectively limit N and P loading to the estuary.

1 In September 2004, DWQ updated the stormwater nutrient removal efficiencies for stormwater BMPs under the Rule .0258. The memo can be found on the DWQ website (http://h2o.enr.state.nc.us/nps/documents/BMPNutrientRemovalEfficiencies_001.pdf). The DWQ Stormwater Manual can alls be found on the DWQ Web site (http://h2o.enr.state.nc.us/su/Manuals_Factsheets.htm).

DWQ Planning Section Web site (http://h2o.enr.state.nc.us/nps/tarpam.htm#Buffer%20Protection%20Rules). Specific rule language can be found in the document *Classifications and Water Quality Standards Applicable to Surface Waters and Wetlands (15A NCAC 2B .0200)* (http://h2o.enr.state.nc.us/admin/rules/documents/rb080104.pdf).

11.2.4 Nutrient Management Strategies – Neuse River Basin

The Neuse River originates in north central North Carolina, flows southeast until it broadens and changes from a free-flowing freshwater river to a tidal estuary that eventually flows into the Pamlico Sound. The Neuse River basin is the third largest river basin in North Carolina and one of only four major river basins whose boundaries are located entirely within the state.

The Neuse River collects water from approximately 3,500 miles of freshwater streams, 16,000 acres of freshwater reservoirs and lakes and 37,000 acres of estuarine waters. The 6,200 square mile basin encompasses portions of 18 counties, including the cities of Raleigh, Durham, Goldsboro, Kinston, New Bern and Wilson, as well as many agricultural and forested areas.

Throughout the late 1970s and early 1980s, eutrophication in the lower Neuse River basin was evident with nuisance algal blooms prevalent in the upper part of the estuary. In 1988, following several years of nuisance algal blooms, the EMC supplementally classified all waters in the Neuse River basin as NSW. Years following the NSW classification still showed that excess nutrients were still a problem in the estuary. In 1996, given the long history of problems associated with excess nutrients in the Neuse River basin, the EMC held four public hearings concerning the adoption of rules to control nitrogen and phosphorus loading throughout the entire river basin. In December 1997, the EMC adopted permanent rules to support implementation of Neuse River Nutrient Sensitive Waters Management Strategies. The goal was to reduce the average annual load of nitrogen delivered to the Neuse River estuary from point and nonpoint sources by a minimum of 30 percent from the average annual load calculated from the period of 1991 to 1995 (Table 11-2). The regulated community had to comply with these rules within five years of the effective date of August 1, 1998. Annual reports are presented to the EMC to provide updates on the effectiveness of the nutrient management strategies implemented by the agricultural community. More information on the Neuse River Nutrient Management Strategies can be found on the DWQ Planning Section Web site (http://h2o.enr.state.nc.us/nps/Neuse_NSW_Rules.htm). Specific rule language can be found in the document *Classifications and Water Quality Standards Applicable to Surface Waters and Wetlands (15A NCAC 2B .0200)* (http://h2o.enr.state.nc.us/admin/rules/documents/rb080104.pdf).

11.2.5 Nutrient Management for Landowners

People often think of agriculture, industries and big business when it comes to water pollution, but individuals contribute to water pollution as well. Eroded soil, automotive fluids, fertilizer, pet waste, trash and other contaminants are often a part of every day activities. While each individual's contribution may seem very small, the cumulative effect over time can have a significant impact on North Carolina's waterways.

Individuals can reduce their water pollution contribution by reducing the volume of stormwater leaving their property and by reducing the amount of pollutants used for household cleaning and/or landscaping yards. Landowners often apply commercial fertilizers and pesticides before evaluating the soil's chemistry for nutrient concentrations. This often leads to over application of nutrients. The nutrients (i.e., nitrogen and phosphorus) that are not utilized by plants will become mobile during a rain event and enter the nearest waterbody as part of the stormwater runoff. Landowners should remember to use only the amount necessary and be careful to avoid paved or hardened surfaces that act as expressways for pollutants into the state's waterways. More stormwater management strategies for homeowners can be found in the brochure *Improving Water Quality in Your Own Backyard* available on the DWQ Web site (http://h2o.enr.state.nc.us/Wateryouknow.htm).

Table 11-2 Rules Adopted by the EMC for Nutrient Management in the Neuse River Basin

Rule Subject	Rule Number	Effective Date	Purpose
Basin Nutrient Reduction Goal	15A NCAC 2B .0232	August 1998	Establishes the five-year goal of reducing N loading in the Neuse River estuary by 30 percent (based on average annual loads from 1991 to 1995).
Riparian Buffer Protection	15A NCAC 2B .0233	August 2000	Protects and preserves existing riparian buffers in the basin to maintain nutrient removal functions.
Wastewater Discharge Requirements	15A NCAC 2B .0234	January 1998 (*Temporary*) August 1998 April 2003 (*Amended*)	Establishes minimum nutrient control requirements for point source discharges to maintain or restore the water quality in the estuary and protect designated uses.
Stormwater Requirements (Basinwide)[1]	15A NCAC 2B .0235	August 1998	Identifies local governments that must implement stormwater controls to control nutrient loading in the estuary.
Agriculture Nitrogen Loading Reduction	15A NCAC 2B .0236	August 1998	Specifies that all persons engaging in agricultural operations must collectively achieve and maintain the 30 percent N reduction goal.
BMP Cost-Effectiveness Rate (BMPc)	15A NCAC 2B .0237	April 1997	Establishes the BMPc, which is the cost to achieve reduction of one kilogram of total N through the use of BMPs.
Agriculture Nitrogen Reduction Strategy	15A NCAC 2B .0238	September 2001	Explains the requirements that apply to all persons who engage in agricultural activities; establishes the formation of a Basin Oversight Committee (BOC) and local advisory committees.
Nutrient Management	15A NCAC 2B .0239	August 1998	Identifies persons responsible for obtaining training certificates for nutrient management (i.e., persons who apply fertilizers, develop nutrient management plans, etc.).
Nutrient Offset Payments	15A NCAC 2B .0240	August 1998	Establishes that an offset payment can be made if nutrient management controls are not meeting the N reduction goal.
Riparian Buffer Mitigation	15A NCAC 2B .0241	August 2000	Defines the requirements for delegating implementation and enforcement of the buffer protection program (.0233).
Mitigation Program	15A NCAC 2B .0242	August 2000	Defines the mitigation requirements that apply to the existing riparian buffer protection program (.0233).

1 In September 2004, DWQ updated the stormwater nutrient removal efficiencies for stormwater BMPs under the Rule .0258. The memo can be found on the DWQ website (http://h2o.enr.state.nc.us/nps/documents/BMPNutrientRemovalEfficiencies_001.pdf). The DWQ Stormwater Manual can alls be found on the DWQ Web site (http://h2o.enr.state.nc.us/su/Manuals_Factsheets.htm).

11.3 MONITORING NUTRIENTS

11.3.1 EVALUATING ALGAE AND AQUATIC PLANTS

The Algal and Aquatic Plan (A&AP) Assessment Program in the Environmental Sciences Section (ESS) of DWQ provides support to the Ambient Monitoring Program, Lakes Assessment Program and regional office staff in the analysis of algal and aquatic plant assemblages. The major focus is phytoplankton. Phytoplankton are defined as the suspended microscopic plants found in the water column capable of performing photosynthesis. The A&AP Assessment Program:

- Documents problematic algal growths.
- Identifies problematic taxa and their distribution.
- Investigates possible causes of fish kills.
- Investigates taste and odor problems in drinking water supplies.
- Provide habitat characterization for bioassessment evaluations.

The program performs two types of evaluations – episodic and routine. Episodic evaluations make up the majority of the analysis performed. Samples are collected in response to specific events such as fish kills, algal blooms and nuisance aquatic plant and algal growths. Routine evaluations are targeted studies of specific watersheds through the Ambient Monitoring Program or the Intensive Survey Unit. Routine evaluations assess changes in algal assemblages over time and often focus on estuarine systems where frequent algal blooms and fish kills have occurred due to nutrient enrichment. More information on the A&AP Assessment Program can be found on the DWQ ESS Web site (http://h2o.enr.state.nc.us/esb/algal.html).

The NC State University through the College of Agriculture and Life Sciences has an Aquatic Plant Management Web site (www.weedscience.ncsu.edu/aquaticweeds/factsheets.html). Several "fact sheets" related to aquatic plants and aquatic weed management can be found here. In addition, the DENR Division of Water Resources (DWR) also has an Aquatic Weed Control Program. Information about this program can be found on the DWR Web site (www.ncwater.org/Education_and_Technical_Assistance/Aquatic_Weed_Control/).

11.3.2 MONITORING LAKES AND RESERVOIRS

Lakes and reservoirs are valued for the multiple benefits they provide to the public, including recreational boating, fishing, drinking water and aesthetic enjoyment. The Lake Assessment Program (http://h2o.enr.state.nc.us/esb/isu.html) seeks to protect these waters through monitoring, pollution prevention and control, restoration and public education activities. Assessments have been made at many publicly accessible lakes, lakes that supply domestic drinking water and lakes (public or private) where water quality problems have been observed. Data are used to determine the trophic state of each lake (a relative measure of nutrient enrichment and productivity) and whether the designated uses of the lake have been threatened or impacted by pollution.

Lakes are classified for a variety of uses. All lakes monitored as part of North Carolina's Ambient Lakes Monitoring Program carry the Class C (aquatic life) classification, and most are classified for swimming (Class B) and/or water supply (Class WS-I, WS-II, WS-III, WS-IV or WS-V). The surface water quality numeric standard specifically associated with recreation is fecal coliform bacteria (Chapter 10). For water supplies, however, there are numeric and narrative standards. There are 29 numeric standards (i.e., pH, dissolved oxygen, metals, nitrite, etc.) based on human consumption of water and fish. Narrative standards include aesthetics such as odor and untreated wastes. There are other numeric standards that also apply to lakes for the protection of aquatic life and human health. These standards also apply to all other waters of the state and are listed under the Class C rules.

One of the major problems associated with lakes and reservoirs is increasing eutrophication related to nutrient inputs. Several water quality parameters help to describe the level of eutrophication. Since nutrient impacts are not always reflected in the parameters sampled through the Ambient Lakes Monitoring Program, a more holistic, or weight of evidence approach, is necessary. For instance, some lakes have taste and odor problems associated with particular algal species, yet these lakes do not have chlorophyll *a* concentrations above the 40 µg/l numeric standard often enough to impair the lake based on the chlorophyll *a* standard. In addition, each reservoir possesses unique traits (i.e., watershed area, volume, depth, retention time, etc.) that dramatically influence its water quality, but that cannot be evaluated through water quality standard comparisons. In such waterbodies, aquatic life may be impaired even though a particular indicator is below the water quality standard. Where exceedances of surface water quality standards are not sufficient to evaluate a lake or reservoir, the weight of evidence approach can take into consideration indicators and parameters not identified in the water quality standards to allow a more sound and robust determination of water quality.

The weight of evidence approach uses the following sources of information to determine the eutrophication (nutrient enrichment) level as a means of assessing lake use support in the aquatic life category:

- Quantitative water quality parameters including physical and chemical parameters (i.e., dissolved oxygen, chlorophyll *a*, pH, etc.)
- Reported algal blooms and/or fish kills
- Watershed characteristics including lake size, volume, retention time, volume loss, etc.
- Third party reports related to taste and odor complaints, hydrocarbon sheens, colors or other aesthetic and safety considerations reported by citizens, water treatment plant operators, state agencies, etc.

More information on the Lakes Assessment Program can be found on the DWQ Environmental Sciences Section Web site (http://h2o.enr.state.nc.us/esb/isu.html).

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Chapter 12 – Protecting Water Quality

The future of our rivers, streams, wetlands and estuaries are closely linked to land use decisions made on both a public and private scale. Most areas within a watershed are privately owned and it is the private landowner who can best protect our waters through conservation and various land use management options. This chapter explores various options for protecting water quality and includes information related to local initiatives, planning and funding opportunities.

12.1 The Importance of Local Initiatives

Local initiatives to protect water quality are essential to any community because local people make decisions that affect change in their own communities. There are a variety of limitations local initiatives can overcome including limited state government budgets and staff resources, minimal regulations for land use management, rulemaking processes and many others. Local organizations and agencies are able to combine professional expertise in a watershed, thus allowing groups to holistically understand the challenges and opportunities of different water quality efforts. Involving a wide array of people in water quality projects also brings together a wide range of knowledge and interests and encourages others to become involved and invested in these projects.

By working in coordination across jurisdictions and agency lines, more funding opportunities may be available. This will potentially allow local entities to do more work and be involved in more activities because their funding sources are diversified. The most important aspect of these local endeavors is that the more localized the project, the better the chances for success.

The collaboration of local efforts are key to water quality improvements. There are good examples of local agencies and groups using these cooperative strategies throughout the state and specific groups are discussed in each of the seventeen basinwide water quality plans. DWQ applauds the foresight and proactive response of local watershed groups and local governments to address any number of water quality problems.

12.2 Growth Management and Land Use Planning

Growth management can be defined as the application of strategies and practices that help achieve sustainable urban development and redevelopment in harmony with the conservation of environmental qualities and features. In other words, growth management is the effective and equitable management of growth and change in human habitats. Growth management tools range from on-the-ground best management practices (BMPs) such as modifying parking areas to reduce impervious surfaces, to establishing regional wastewater and/or stormwater authorities.

12.2.1 Comprehensive Watershed Protection Strategies

In order for land use planning to effectively protect watersheds in the long-term, tools and strategies must be applied at several scales. Effective implementation will require commitment ranging from the individual citizen to the state government. A comprehensive watershed protection plan should act on the following elements.

Basin Scale (Implemented by Town, County, and State Governments)

- Characterize the watersheds within a basin as developed or undeveloped, identifying the watersheds that are currently less than and more than10 percent impervious.

- Focus new construction projects to the already developed watersheds first. Then assign any construction that cannot be accommodated in developed watersheds to a limited number of undeveloped watersheds. The watersheds to be developed should be determined by their ecological importance and by other regional growth considerations, such as the value of terrestrial ecosystems, the economic development potential as determined by proximity to roads and rail lines, and the disposition of landowners in the area toward land preservation and development.

- Adopt policies that maintain impervious surfaces in undeveloped watersheds at less than ten percent. These can include private conservation easements, purchase of development rights, infrastructure planning, urban service boundaries, rural zoning (20-200 acres per unit, depending on the area) and urban growth boundaries.

- Ensure that local governments develop land use plans to provide adequate land for future development within developed or developing watersheds.

Neighborhood Scale (Implemented by Town and County Governments)

- Allow residential densities that support mass transit (i.e., buses, trains, etc.), reduce vehicle trips per household and minimize land consumption. The minimum density for new development should be seven to ten net units per acre.

- Require block densities that support walking and reduce the length of vehicle trips. Cities that support walking and transit often have more than 100 blocks per square mile.

- Connect the street network by requiring subdivision road systems to link to adjacent subdivisions.

- Integrate houses with stores, civic buildings, neighborhood recreational facilities and other daily or weekly destinations.

- Incorporate pedestrian and bike facilities (greenways) into new development and ensure these systems provide for inter-neighborhood travel.

- Encourage and require other design features and public facilities that accommodate and support walking by creating neighborhoods with a pleasing scale and appearance. (i.e., short front-yard setbacks, neighborhood parks, alleys and architectural and material quality)

<u>Site Scale (Implemented by Individual Property Owners, Developers Town and County Governments)</u>

- Require application of the most effective structural stormwater practices, especially focusing on hot spots such as high-volume streets, gas stations and parking lots.

- Establish buffers and setbacks that are appropriate for the area to be developed – more extensive in undeveloped watersheds than in developed watersheds. In developed watersheds, buffers and setbacks should be reconciled to other urban design needs (such as density) and a connected street network.

- Educate homeowners about their responsibility in watershed management, such as buffer and yard maintenance, proper disposal of oil and other toxic materials, and the impacts of excessive automobile use (Beach, 2002).

12.2.2 Reducing Impacts from Existing Urbanization

Below is a summary of management actions recommended for local authorities, followed by discussions on large watershed management issues. These actions are necessary to address current sources of impairment and to prevent future degradation in all streams. The intent of these recommendations is to describe the types of actions necessary to improve stream conditions, not to specify particular administrative or institutional mechanisms for implementing remedial practices. Those types of decisions must be made at the local level.

Because of uncertainties regarding how individual remedial actions cumulatively impact stream conditions and how aquatic organisms will respond to improvements, the intensity of management effort necessary to bring about a particular degree of biological improvement cannot be established in advance. The types of actions needed to improve biological conditions can be identified, but the mix of activities that will be necessary – and the extent of improvement that will be attainable – will only become apparent over time as an adaptive management approach is implemented. Management actions are suggested below to address individual problems, but many of these actions are interrelated.

- **Feasible and cost-effective stormwater retrofit projects should be implemented throughout the watershed to mitigate the hydrologic effects of development** (i.e., increased stormwater volumes and increased frequency and duration of erosive and scouring flows). This should be viewed as a long-term process.

    - Over the short term, currently feasible retrofit projects should be identified and implemented.
    - In the long term, additional retrofit opportunities should be implemented in conjunction with infrastructure improvements and redevelopment of existing developed areas.
    - Grant funds for these retrofit projects may be available from EPA initiatives, such as EPA Section 319 funds, or the North Carolina Clean Water Management Trust Fund (CWMTF).

- **A watershed scale strategy to address toxic inputs should be developed and implemented, including a variety of source reduction and stormwater treatment methods.** As an initial framework for planning toxicity reduction efforts, the following general approach is proposed:

  - Implementation of available BMP opportunities for control of stormwater volume and velocities. As recommended above to improve aquatic habitat potential, these BMPs will also remove toxics from stormwater.
  - Development of a stormwater and dry weather sampling strategy in order to facilitate the targeting of pollutant removal and source reduction practices.
  - Implementation of stormwater treatment BMPs, aimed primarily at pollutant removal, at appropriate locations.
  - Development and implementation of a broad set of source reduction activities focused on: reducing non-storm inputs of toxics; reducing pollutants available for runoff during storms; and managing water to reduce storm runoff.

- **Stream channel restoration activities should be implemented in target areas, in conjunction with stormwater retrofit BMPs, in order to improve aquatic habitat.** Before beginning stream channel restoration, a geomorphologic survey should be conducted to determine the best areas for stream channel restoration. Additionally, it would be advantageous to implement retrofit BMPs before embarking on stream channel restoration, as restoration is best designed for flows driven by reduced stormwater runoff. Costs of approximately $200 per foot of channel should be anticipated (Haupt, et *al*., 2002 and Weinkam, 2001). Grant funds for these retrofit projects may be available from federal sources, such as EPA Section 319 funds, or state sources including North Carolina Clean Water Management Trust Fund.

- Actions recommended above (i.e., stormwater quantity and quality retrofit BMPs) are likely to reduce nutrient/organic loading, and to some extent, its impacts. Activities recommended to address this loading include the identification and elimination of illicit discharges; education of homeowners, commercial applicators, and others regarding proper fertilizer use; street sweeping; catch basin clean-out practices; and the installation of additional BMPs targeting biological oxygen demand (BOD) and nutrient removal at appropriate sites.

- Prevention of further channel erosion and habitat degradation will require effective post-construction stormwater management for all new development in the study area.

- Effective enforcement of sediment and erosion control regulations will be essential to the prevention of additional sediment inputs from construction activities. Development of improved erosion and sediment control practices may also be beneficial.

- Watershed education programs should be implemented and continued by local governments with the goal of reducing current stream damage and preventing future degradation. At a minimum, the program should include elements to address the following issues:

- Redirecting downspouts to pervious areas rather than routing these flows to driveways or gutters;
- Protecting existing woody riparian areas on all streams;
- Replanting native riparian vegetation on stream channels where such vegetation is absent; and
- Reducing and properly managing pesticide and fertilizer use.

12.2.3 Reducing Impacts from Future Urbanization

Proactive planning efforts at the local level are needed to ensure that development is done in a manner that maintains water quality. These planning efforts can find a balance between water quality protection, natural resource management and economic growth. Growth management requires planning for the needs of future population increases, as well as developing and enforcing environmental protection measures. These actions are critical to water quality management and the quality of life for residents across the state.

Streams in areas adjacent to high growth areas are at a high risk of loosing healthy aquatic communities. These biological communities are important to maintaining the ecological integrity of the state. Unimpacted streams are important sources of benthic macroinvertebrates and fish for reestablishment of biological communities in nearby streams that are recovering from past impacts or are being restored.

To prevent future water quality degradation, local governments should:

- Identify waters that are threatened by development.
- Protect existing riparian habitat along streams.
- Implement stormwater BMPs during and after development.
- Develop land use plans that minimize disturbance in sensitive areas of watersheds.
- Minimize impervious surfaces including roads and parking lots.
- Develop public outreach programs to educate citizens about stormwater runoff.

Planning Recommendations for New Developments

- Minimize number and width of residential streets.
- Minimize size of parking areas (angled parking & narrower slots).
- Place sidewalks on only one side of residential streets.
- Minimize culvert pipe and hardened stormwater conveyances.
- Vegetate road right-of-ways, parking lot islands and highway dividers to increase infiltration.
- Plant and protect natural buffer zones along streams and tributaries.

Action needs be taken at the local level to plan for new development in urban and rural areas and on inland, soundside and barrier islands. For more detailed information regarding recommendations for new development found in the text box (above), refer to the US Environmental Protection Agency's (EPA) Watershed Academy Web site www.epa.gov/owow/watershed/wacademy/acad2000/protection, the Center for Watershed Protection Web site www.cwp.org, and the Low Impact Development Center Web site www.lowimpactdevelopment.org. Additional information regarding environmental stewardship for coastal homeowners is available at www.soil.ncsu.edu/assist/coastindex.html. Further public education is also needed throughout the state in order for citizens to understand the value of urban planning and stormwater management. For an example of local community planning effort to reduce stormwater runoff, visit www.charmeck.org/Home.htm.

12.2.4 PREVENTING STREAMBANK EROSION

Streambank erosion can be caused by a number of factors, some of which may be difficult to identify. For example, erosion may be caused by a lack of streambank vegetation that holds soil in place. Erosion may also result from complex changes in urban runoff patterns, poor logging or farming practices or other activities within the watershed.

Because the stabilization of a streambank can be an expensive and time-consuming process that may require several attempts, the specific cause and nature of a problem should be investigated and understood before any action is taken to restore a degraded stream channel or riparian area.

The following techniques can help control sediment loading and protect instream water quality:

- Avoid the disturbance of streams and riparian zones.
- Protect existing riparian forest buffers and restore vegetation that has been cleared from the riparian zone.
- Use BMPs for sediment control. A variety of agricultural BMPs effectively controls sediment including conservation tillage/residue management, filter strips, field borders and cover crops.
- Maintain natural channels, or if modification is unavoidable, design channels based on the stability and behavior of natural stream channels. Channel designs based on natural stability principles will be less susceptible to erosion, remain more stable and provide more habitat than traditional engineered channel designs.
- Maintain predevelopment peak flows, flow velocities and flow timing to the extent possible using stormwater management techniques and appropriate BMPs.
- Use BMPs such as riser basins, diversion ditches, rock dams, check dams and buffers for construction activities.

12.2.5 Using Riparian Buffers to Protect Stream Quality and Integrity

A stream and its riparian area function as one. The condition of a riparian area plays a pivotal role in the integrity of a stream channel and instream water quality. While any type of streamside vegetation is desirable, forests provide the greatest amount of benefit and the highest potential for meeting both water quality and habitat restoration objectives. Riparian forest buffers are managed to protect water quality through the control of nonpoint source pollution and the maintenance of the stream environment.

Riparian forest buffer systems are typically comprised of an area of trees, usually accompanied by shrubs and other vegetation, adjacent to a waterbody and managed as three integrated streamside zones that are designed to intercept surface runoff and subsurface flow.

A sound scientific foundation exists to support the sediment reduction, nutrient reduction and ecological values and functions of riparian forest buffers. The use of riparian buffers as a management tool should be promoted.

Riparian/Forested Buffers Specifically Designed and Managed To:

- Maintain the integrity of stream channels and shorelines by protecting them from erosion.
- Reduce the impact of upland sources of pollution by trapping, filtering and converting sediments, nutrient and other chemicals.
- Provide wildlife habitat for birds and other species dependant on the streams and woods for food, shelter and raising young.
- Provide shade, which stabilizes water temperatures, keeping water livable for fish and other aquatic species.
- Provide woody debris and organic matter to the bacteria, fungi and other species forming the basis of the aquatic food chain.

12.2.6 Implementing Effective Education Programs

North Carolina's natural resources are under stress and could be lost in the absence of a widespread awareness of their existence, their significance and their value. Government officials, business leaders and private citizens must better understand the complexity of the natural ecosystems that support our quality of life and make this state an appealing place to live, work and visit.

These natural resources are not isolated from each other or from the people. Each element is part of the ecosystem, interrelated and interconnected. When one part of the system is affected, other parts feel the impact. Sound development decisions require an understanding of these interconnections, as well as of the life-support roles played by natural resources.

The cause and effect relationship between human behavior and the environment and the economics of that relationship must be well understood by decision makers - including individuals, business, industry, government and elected officials - to instill a conservation ethic and a sense of stewardship into the choices facing the state. Such stewardship of land, water, air and biological resources is required to continue to enjoy the existing quality of life and to ensure future improvements.

Environmental quality ultimately depends upon the understanding and support of individual and corporate citizens who come to embrace standards and practices that discourage pollution while they prize high quality air, water and soil. This relationship between knowledge of the environment and support for its protection form a basis of public policy development. While the need for education to improve our understanding of ecology and environment is accepted as important, the practice of environmental education may take many forms. DWQ encourages implementation of educational programs tailored to specific audiences that invoke the following principles:

- **Respect and care for the community of life.**
  All things are connected. When something affects one part of the environment, other parts feel the impact. The more we understand and respect our own community, the better we will understand this interconnectedness and our responsibilities to the global community of life.

- **Improve the quality of human life.**
  The aim of development is to improve the overall quality of human life. Development must enable all people to realize their potential and lead lives of dignity and fulfillment. This kind of development requires a healthy and robust supporting ecosystem.

- **Conserve North Carolina's vitality and diversity.**

  Renewable natural resources are the base of all economies. Soil, water, air, timber, medicines, plants, fish, wildlife and domesticated species -- all come from natural systems and can be maintained through conservation.

  Life support systems are the ecological processes that shape climate, cleanse air and water, regulate water flow, recycle essential elements, create and regenerate soil and keep our environment fit for life. We must prevent pollution and degradation of these ecosystems as well as the natural plant and wildlife habitats they provide.

  Biological diversity includes the total array of species, genetic varieties, habitats and ecosystems on Earth. It contributes to our quality of life, including a healthy economy. It is a foundation of the Earth's biosphere, buffering us from the inevitable changes in the environment.

- **Change personal understanding and practice.**
  Society must promote values that build and support its ability to continuously improve the quality of living for its citizens. This requires maintaining the quality and integrity of our natural environment. Knowledge, awareness and decision-making skills must be taught through formal and non-formal education to promote problem solving and constructive action to nurture the life-giving qualities of our ecosystem.

- **Enable communities to care for their own environment.**
  Living within the limits set by the environment depends on the beliefs and commitment of individuals, but it is through communities that people share concerns and promote practices that can nourish rather than cripple their natural life-support systems.

- **Provide a state and local knowledge base for integrating development and conservation.**
  Economic policy can be an effective instrument for sustaining ecosystems and natural resources. Every economy depends on the environment as a source of life support and raw materials. The knowledge base for each city, county and the state must be strengthened, and information on environmental matters made more accessible. The state's adult and student populations must understand certain ecological and civics concepts, and North Carolina's place within those concepts.

12.2.7 The Role of Homeowners and Landowners

The following are ten simple steps individuals can do today to protect water quality.

- To decrease polluted runoff from paved surfaces, households can develop alternatives to areas traditionally covered by impervious surfaces. Porous pavement materials are available for driveways and sidewalks, and native vegetation and mulch can replace high maintenance grass lawns.
- Homeowners can use fertilizers sparingly and sweep driveways, sidewalks, and roads instead of using a hose.
- Instead of disposing of yard waste, use the materials to start a compost pile.
- Learn to use Integrated Pest Management (IPM) in the garden and on the lawn to reduce dependence on harmful pesticides.
- Pick up waste pet waste and dispose of it properly.
- Use, store, and dispose of chemicals properly.
- Drivers should check their cars for leaks and recycle their motor oil and antifreeze when these fluids are changed.
- Drivers can also avoid impacts from car wash runoff (e.g., detergents, grime, etc.) by using car wash facilities that do not generate runoff.
- Households served by septic systems should have them professionally inspected and pumped every 3 to 5 years. They should also practice water conservation measures to extend the life of their septic systems.
- Support local government watershed planning efforts and ordinance development.

12.3 LOCAL WATER SUPPLY PLANNING

The North Carolina General Assembly mandated a local and state water supply planning process in 1989 to ensure that communities have an adequate supply of potable water for future needs. Under this statute, all units of local government that provide, or plan to provide, public water supply service are required to prepare a Local Water Supply Plan (LWSP) and to update that plan at least every five years. The information presented in a LWSP is an assessment of a water system's present and future water needs and its ability to meet those needs. By looking at current and future needs, local governments will be better able to manage water supplies and better prepared to plan for water supply system improvements. Local governments must have an adopted current LWSP on file with the NC Division of Water Resources (DWR) to qualify for certain grants and loans available for water supply systems in North Carolina. More information about local water supply planning can be found on the DWR Web site (www.ncwater.org).

Benefits to Local Water Supply Planning

- Provides comprehensive look at water supply needs, water usage, and water availability.
- Reduces the potential for water conflicts and water shortages. Early identification of these issues will allow more time for resolution.

12.4 SOURCE WATER ASSESSMENT OF PUBLIC WATER SUPPLIES

The Federal Safe Drinking Water Act (SDWA) Amendments of 1996 emphasize pollution prevention as an important strategy for the protection of ground and surface water resources. This new focus promotes the prevention of drinking water contamination as a cost-effective means to provide reliable, long-term and safe drinking water sources for public water supply (PWS) systems. In order to determine the susceptibility of public water supply sources to contamination, the amendments also required that all states establish a Source Water Assessment Program (SWAP). Specifically, Section 1453 of the SDWA Amendments require that states develop and implement a SWAP to:

- Delineate source water assessment areas;
- Inventory potential contaminants in these areas; and
- Determine the susceptibility of each public water supply to contamination.

In North Carolina, the agency responsible for SWAP is the Public Water Supply (PWS) Section of the NCDENR Division of Environmental Health (DEH). The PWS Section received approval from the EPA for their SWAP Plan in November 1999. The SWAP Plan, entitled *North Carolina's Source Water Assessment Program Plan*, fully describes the methods and procedures used to delineate and assess the susceptibility of more than 9,000 wells and approximately 207 surface water intakes, and it builds upon existing protection programs for ground and surface water resources. These include the state's Wellhead Protection Program and the Water Supply Watershed Protection Program.

Wellhead Protection (WHP) Program: North Carolinians withdraw more than 88 million gallons of groundwater per day from more than 9,000 water supply wells across the state. In 1986, Congress passed Amendments to the SDWA requiring states to develop wellhead protection programs that reduce the threat to the quality of groundwater used for drinking water by identifying and managing recharge areas to specific wells or wellfields.

Defining a wellhead protection area (WHPA) is one of the most critical components of wellhead protection. A WHPA is defined as "the surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." The SWAP uses the methods described in the state's approved WHP Program to delineate source water assessment areas for all public water supply wells (http://www.deh.enr.state.nc.us/pws/swap).

Water Supply Watershed Protection (WSWP) Program: DWQ is responsible for managing the standards and classifications of all water supply watersheds. In 1992, the WSWP Rules were adopted by the NC Environmental Management Commission (EMC) and require all local governments that have land use jurisdiction within water supply watersheds adopt and implement water supply watershed protection ordinances, maps and management plans. SWAP uses the established water supply watershed boundaries and methods established by the WSWP program as a basis to delineate source water assessment areas for all public water surface water intakes (www.ncwaterquality.org/wswp/index.html).

12.4.1 Susceptibility Determination – North Carolina's Overall Approach

The SWAP Plan contains a detailed description of the methods used to assess the susceptibility of each PWS intake in North Carolina. The following is a brief summary of the susceptibility determination approach.

Overall Susceptibility Rating: The overall susceptibility determination rates the potential for a drinking water source to become contaminated. The overall susceptibility rating for each PWS intake is based on two key components: a contaminant rating and an inherent vulnerability rating. For a PWS to be determined "susceptible", a potential contaminant source must be present and the existing conditions of the PWS intake location must be such that a water supply could become contaminated. The determination of susceptibility for each PWS intake is based on combining the results of the inherent vulnerability rating and the contaminant rating for each intake. Once combined, a PWS is given a susceptibility rating of higher, moderate or lower (H, M or L).

Inherent Vulnerability Rating: Inherent vulnerability refers to the physical characteristics and existing conditions of the watershed or aquifer. The inherent vulnerability rating of groundwater intakes is determined based on an evaluation of aquifer characteristics, unsaturated zone characteristics and well integrity and construction characteristics. The inherent vulnerability rating of surface water intakes is determined based on an evaluation of the watershed classification (WSWP Rules), intake location, raw water quality data (i.e., turbidity and total coliform) and watershed characteristics (i.e., average annual precipitation, land slope, land use, land cover, groundwater contribution).

Contaminant Rating: The contaminant rating is based on an evaluation of the density of potential contaminant sources (PCSs), their relative risk potential to cause contamination, and their proximity to the water supply intake within the delineated assessment area.

Inventory of Potential Contaminant Sources (PCSs): In order to inventory PCSs, the SWAP conducted a review of relevant, available sources of existing data at federal, state and local levels. The SWAP selected sixteen statewide databases that were attainable and contained usable geographic information related to PCSs.

12.4.2 Source Water Protection

The PWS Section believes that the information from the source water assessments will become the basis for future initiatives and priorities for public drinking water source water protection (SWP) activities. The PWS Section encourages all PWS system owners to implement efforts to manage identified sources of contamination and to reduce or eliminate the potential threat to drinking water supplies through locally implemented programs

To encourage and support local SWP, the state offers PWS system owners assistance with local SWP as well as materials such as:

- Fact sheets outlining sources of funding and other resources for local SWP efforts.
- Success stories describing local SWP efforts in North Carolina.
- Guidance about how to incorporate SWAP and SWP information in Consumer Confidence Reports (CCRs).

Information related to SWP can be found at http://www.deh.enr.state.nc.us/pws/swap.

12.4.3 Public Water Supply Susceptibility Determinations

In April 2004, the PWS Section completed source water assessments for all drinking water sources and generated reports for the PWS systems using these sources. A second round of assessments were completed in April 2005. The results of the assessments can be viewed in two different ways, either through the interactive ArcIMS mapping tool or compiled in a written report for each PWS system. To access the ArcIMS mapping tool, simply click on the "NC SWAP Info" icon on the PWS Web site (http://www.deh.enr.state.nc.us/pws/swap). To view a report, select the PWS System of interest by clicking on the "SWAP Reports" icon.

12.5 Reclassification of Surface Waters

The classification of surface water may be changed after a request is submitted to the DWQ Classifications and Standards Unit. DWQ reviews each request for reclassification and conducts an assessment of the surface water to determine if the reclassification is appropriate. If it is determined that a reclassification is justified, the request must proceed through the state rule-making process. To initiate a reclassification, the *Application to Request Reclassification of NC Surface Waters* must be completed and submitted to DWQ's Classifications and Standards Unit. For more information on requests for reclassification and contact information, visit http://h2o.enr.state.nc.us/csu/swcfaq.html#ClassChanges. More information about DWQ's classifications and water quality standards can be found in Chapter 2.

12.6 Federal and State Initiatives

12.6.1 Federal Clean Water Act – Section 319 Program

Section 319 of the Clean Water Act provides grant money for nonpoint source demonstration and restoration projects. Through annual base funding, there is approximately $1 million available for demonstration and education projects across the state. An additional $2 million is available annually through incremental funds for restoration projects. All projects must provide nonfederal matching funds of at least 40 percent of the project's total costs. Information on the North Carolina Section 319 Grant Program application process is available online http://h2o.enr.state.nc.us/nps/application_process.htm. Descriptions of projects and general Section 319 Program information are available on the DWQ Web site http://h2o.enr.state.nc.us/nps/Section_319_Grant_Program.htm. For more information on program initiatives refer to Chapter 6.

12.6.2 North Carolina Ecosystem Enhancement Program (NCEEP)

The North Carolina Ecosystem Enhancement Program (NCEEP) is responsible for providing ecologically effective compensatory mitigation in advance of permitted impacts associated with road projects and other development activities. The fundamental mission of the program is to restore, enhance and protect key watershed functions in the seventeen river basins across the state. This is accomplished through the implementation of wetlands, stream and riparian buffer projects within selected local watersheds. The vital watershed functions that NCEEP seeks to restore and protect include water quality, floodwater conveyance and storage, fisheries and wildlife habitat.

The NCEEP is not a grant program but can implement its restoration projects cooperatively with other state or federal programs such as the Section 319 Program. Combining NCEEP-funded restoration or preservation projects with 319 or other local watershed initiatives (i.e., those funded through the Clean Water Management Trust Fund or local/regional Land Trusts) increases the potential to improve the water quality, hydrologic and habitat functions within selected watersheds.

The selection of optimal sites for NCEEP mitigation projects is founded on a basinwide and local watershed planning approach, which results, respectively, in the development of *River Basin Restoration Priorities* and *Local Watershed Plans*. In developing *River Basin Restoration Priorities (RBRP*, the NCEEP identifies local watersheds (14-digit hydrologic units) with the greatest need and opportunity for restoration, enhancement or preservation projects. These high-priority watersheds are called "targeted local watersheds" (*TLW*s). Targeted local watersheds are identified, in part, using information compiled by DWQ's programmatic activities (i.e., *Basinwide Assessment Reports* and *Basinwide Water Quality Plans*). Local factors considered in the selection of *TLW*s include: water quality impairment, habitat degradation, the presence of critical habitat or significant natural heritage areas, the presence of water supply watersheds or other high-quality waters, the status of riparian buffers, estimates of impervious cover, existing or planned transportation projects, and the opportunity for local government partnerships. Recommendations from local resource agency professionals and the presence of existing or planned watershed projects are given significant weight in the selection of *TLW*s. In essence, targeted local watersheds represent those areas within a river basin where NCEEP resources can be focused for maximum benefit to local watershed functions.

The *Local Watershed Plans (LWP*s*)* are usually located within targeted local watersheds identified in the *RBRPs*. Through the local watershed planning process, NCEEP conducts watershed characterization and field assessment tasks to identify critical stressors in local watersheds. The NCEEP planners and their consultants coordinate with local resource professionals and local governments to identify optimal watershed projects and management strategies to address the major functional stressors identified in that watershed. The *LWP*s prioritize restoration/enhancement projects, preservation sites and BMP projects that will provide water quality improvement, habitat protection and other environmental benefits to the local watershed. More information about watershed planning through NCEEP can be found on the NCEEP Web site (www.nceep.net).

12.6.3 North Carolina's Clean Water Management Trust Fund (CWMTF)

The CWMTF offers approximately $40 million annually in grants for projects within the broadly focused areas of restoring and protecting state surface waters and establishing a network of riparian buffers and greenways. For more information on the CWMTF or these grants, call (252) 830-3222 or visit the website at www.cwmtf.net.

12.6.4 Community Conservation Assistance Program (CCAP)

The landscape of North Carolina is changing and Soil and Water Conservation Districts (SWCD) have voiced concern about a void in program areas to address the growing threat of nonpoint source pollution issues on non-agricultural lands. In the summer of 2005, a survey was distributed to all districts to inventory their level of interest and BMP needs on urban, suburban and rural lands. Many districts completed surveys about their needs for a community assistance program and requested over $6.5 million for local projects. In July 2006, the legislature unanimously passed House Bill 2129, creating the Community Conservation Assistance Program (CCAP).

CCAP will focus its efforts on stormwater retrofits to existing land uses. It will not be used to assist in new development sites to meet state and federal stormwater mandates. Districts have the technical expertise to install stormwater BMPs and a successful history of promoting voluntary conservation practices. The program will give the districts the structure and financial assistance to carry out this mission. CCAP will encourage local governments, individual landowners and businesses to incorporate stormwater BMPs within their landscape. The economic incentive, 75 percent of average installation costs, will encourage voluntary conservation to be installed.

A workgroup is developing recommendations for the standards and specifications of CCAP BMPs. This group is also charged with defining the average cost of each practice. Practices that have been approved by the Technical Review Committee (TRC) and the Soil and Water

Conservation Commission (SWCC) include: impervious surface conversion, permeable pavement, grassed swale, critical area planting, bioretention areas, backyard rain gardens, stormwater wetlands, backyard wetlands, diversion, riparian buffer, stream restoration, stream stabilization, cisterns/rain barrels and pet waste receptacles.

The NCDENR Division of Soil and Water Conservation (DSWC) was awarded two grants that will fund CCAP implementation in eighteen counties across the state. The DSWC received a grant from the CWMTF in the sum of $557,000 and an award from Section 319 program for $277,425. Since this is a grant-funded program, only districts that participated in the surveys will receive an allocation. The maximum amount of assistance per practice is limited to $50,000. It is the goal of the DSWC to seek additional funding sources, including recurring state appropriations, to offer this program statewide in the future.

12.6.5 Clean Water Bonds – NC Rural Center

Outdated wastewater collection systems, some more than 70 years old, allow millions of gallons of untreated or partially treated wastewater to spill into the state's rivers and streams. The NC Rural Economic Development Center, Inc. (Rural Center) has taken the lead role in designing public policy initiatives to assist rural communities in developing and expanding local water and sewer infrastructure. The Rural Center is a private, nonprofit organization. The Rural Center's mission is to develop sound, economic strategies that improve the quality of life in North Carolina, while focusing on people with low to moderate incomes and communities with limited resources.

To support local economic growth and ensure a reliable supply of clean water, the Rural Center administers three Water and Sewer Grant Programs to help rural communities develop water and sewer systems. The *Supplemental Grants Program* enables local governments and qualified non-profit corporations to improve local water and sewer systems. Projects may address public health, environmental and/or economic development critical needs. The maximum grant amount for this program is $400,000. Rural Center funds must be used to match other project funds. The *Capacity Building Grants Program* provides funding for local governments to undertake planning efforts that support strategic investments in water and sewer facilities. Funds typically are used to prepare preliminary engineering reports, master water/sewer plans, capital investment plans, water/sewer feasibility studies, rate studies and grant applications. The maximum amount for this program is generally $40,000. The *Unsewered Communities Grants Program* provides funding for the planning and construction of new central, publicly-owned sewer systems. Qualified communities must be unserved by wastewater collection or treatment systems. Unsewered communities grants are designed to cover 90 percent of the total cost of a project but will not exceed $3 million. For each grant program, priority is given to projects from economically distressed counties of the state as determined by the NC Department of Commerce (www.nccommerce.com).

The water and sewer grant programs are made possible through appropriations from the NC General Assembly and through proceeds from the Clean Water Bonds. In 1998, North Carolina voters approved an $800 million clean water bond referendum that provided $330 million to state grants to help local governments repair and improve water supply systems and wastewater collection and treatment. The grants also address water conservation and water reuse projects. Another $300 million was made available as clean water loans.

Since the program's beginning, the Rural Center has awarded nearly 500 communities and counties more than $64 million to plan, install, expand, and improve their water and sewer systems. As a result, these communities have served new residential and business customers, created and preserved thousands of jobs, and leveraged millions of dollars in other water and sewer funds. For more information on the Water and Sewer Grants administered by the Rural Center visit www.ncruralcenter.org/grants/water.htm.

12.6.6 NC CONSTRUCTION GRANTS AND LOANS PROGRAMS

The NC Construction Grants and Loans Section provides grants and loans to local government agencies for the construction, upgrades and expansion of wastewater collection and treatment systems. As a financial resource, the section administers five major programs that assist local governments. Of these, two are federally funded programs administered by the state, the Clean Water State Revolving Fund (SRF) Program and the State and Tribal Assistance Grants (STAG). The STAG is a direct congressional appropriations for a specific "special needs" project. The High Unit Cost Grant (SRG) Program, the State Emergency Loan (SEL) Program and the State Revolving Loan (SRL) Program are state funded programs, with the latter two being below market revolving loan money.

As a technical resource, the Construction Grants and Loan (CG&L) Section, in conjunction with EPA, has initiated the Municipal Compliance Initiative Program. It is a free technical assistance program to identify wastewater treatment facilities that are declining but not yet out of compliance. A team of engineers, operations experts and managers from the section work with local officials to analyze the facility's design and operation. For more information, visit the Web site www.nccgl.net. You may also call (919)-715-6212.

12.6.7 STATE FUNDED OYSTER HATCHERIES

North Carolina Aquariums, in conjunction with the Department of Marine Fisheries (DMF), are working together to establish additional oyster hatcheries in proximity to the three state aquariums to support oyster gardening efforts and public education programs. An additional commercial-sized hatchery would be constructed to support the goals of the DMF and will have a production capacity of a billion larvae and include a nursery area for setting. The General Assembly appropriated $600,000 to the state aquariums to facilitate the hatchery program. The committee is also working to establish an education program that could potentially lead to a certification in constructing and maintaining oyster hatcheries in North Carolina.

12.6.8 CLEAN MARINA PROGRAM

The Clean Marina is a voluntary program that began in the summer of 2000. The program is designed to show that marina operators can help safeguard the environment by using management and operations techniques that go above and beyond regulatory requirements. This is a nationwide program developed by the National Marine Environmental Education Foundation, a nonprofit organization that works to clean up waterways for better recreational boating. The foundation encourages states to adapt Clean Marina principles to fit their own needs. North Carolina joins South Carolina, Florida and Maryland as states with Clean Marina programs in place.

Marina operators who choose to participate must complete an evaluation form about their use of specific best management practices. If a marina meets criteria developed by NC Marine Trades Services and the Division of Coastal Management (DCM), it will be designated as a Clean Marina. Such marinas will be eligible to fly the Clean Marina flag and use the logo in their advertising. The flags will signal to boaters that a marina cares about the cleanliness of area waterways. Marinas that do not meet the standards will be able to learn about improvements needed for Clean Marina designation. Marina owners can reapply after making the necessary changes.

For more information about the program, visit http://dcm2.enr.state.nc.us/Marinas/clean.htm, http://www.nccoastalmanagement.net/Marinas/marinas.htm or contact NC Coastal Reserve Education Office at 252-728-2170 or Coastal Management at 919-733-2293.

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Glossary

7Q10	The annual minimum 7-day consecutive low flow, which on average will be exceeded in 9 out of 10 years.
ACOE	United States Army Corps of Engineers.
B (Class B)	Class B Water Quality Classification. This classification denotes freshwaters protected for primary recreation and other uses suitable for Class C. Primary recreational activities include frequent and/or organized swimming and other human contact such as skin diving and water skiing.
basin	The watershed of a major river system. There are 17 major river basins in North Carolina.
benthic macroinvertebrates	Aquatic organisms, visible to the naked eye (macro) and lacking a backbone (invertebrate), that live in or on the bottom of rivers and streams (benthic). Examples include, but are not limited to, aquatic insect larvae, mollusks and various types of worms. Some of these organisms, especially aquatic insect larvae, are used to assess water quality. See EPT index and bioclassification for more information.
benthos	A term for bottom-dwelling aquatic organisms.
best management practices	Techniques that are determined to be currently effective, practical means of preventing or reducing pollutants from point and nonpoint sources, in order to protect water quality. BMPs include, but are not limited to: structural and nonstructural controls, operation and maintenance procedures, and other practices. Often, BMPs are applied as system of practices and not just one at a time.
bioclassification	A rating of water quality based on the outcome of benthic macroinvertebrate sampling of a stream. There are five levels: Poor, Fair, Good-Fair, Good and Excellent.
BMPs	See *best management practices*.
BOD	Biochemical Oxygen Demand. A measure of the amount of oxygen consumed by the decomposition of biological matter or chemical reactions in the water column. Most NPDES discharge permits include a limit on the amount of BOD that may be discharged.
C (Class C)	Class C Water Quality Classification. This classification denotes freshwaters protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, and others uses.
channelization	The physical alteration of streams and rivers by widening, deepening or straightening of the channel, large-scale removal of natural obstructions, and/or lining the bed or banks with rock or other resistant materials.
chlorophyll *a*	A chemical constituent in plants that gives them their green color. High levels of chlorophyll *a* in a waterbody, most often in a pond, lake or estuary, usually indicate a large amount of algae resulting from nutrient over enrichment or eutrophication.
coastal counties	Twenty counties in eastern NC subject to requirements of the Coastal Area Management Act (CAMA). They include: Beaufort, Bertie, Brunswick, Camden, Carteret, Chowan, Craven, Currituck, Dare, Gates, Hertford, Hyde, New Hanover, Onslow, Pamlico, Pasquotank, Pender, Perquimans, Tyrrell and Washington.
Coastal Plain	One of three major physiographic regions in North Carolina. Encompasses the eastern two-fifths of state east of the *fall line* (approximated by Interstate I-95).
conductivity	A measure of the ability of water to conduct an electrical current. It is dependent on the concentration of dissolved ions such as sodium, chloride, nitrates, phosphates and metals in solution.
DEH	Department of Environmental Health

degradation	The lowering of the physical, chemical or biological quality of a waterbody caused by pollution or other sources of stress.
DENR	Department of Environment and Natural Resources.
DHHS	Department of Health and Human Services.
DO	Dissolved oxygen.
drainage area	An alternate name for a watershed.
DWQ	North Carolina Division of Water Quality, an agency of DENR.
dystrophic	Naturally acidic (low pH), "black-water" lakes which are rich in organic matter. Dystrophic lakes usually have low productivity because most fish and aquatic plants are stressed by low pH water. In North Carolina, dystrophic lakes are scattered throughout the Coastal Plain and Sandhills regions and are often located in marshy areas or overlying peat deposits. NCTSI scores are not appropriate for evaluating dystrophic lakes.
EEP	Ecosystem Enhancement Program (EEP)
effluent	The treated liquid discharged from a wastewater treatment plant.
EMC	Environmental Management Commission.
EPA	United States Environmental Protection Agency.
EPT Index	This index is used to judge water quality based on the abundance and variety of three orders of pollution sensitive aquatic insect larvae: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies).
eutrophic	Elevated biological productivity related to an abundance of available nutrients. Eutrophic lakes may be so productive that the potential for water quality problems such as algal blooms, nuisance aquatic plant growth and fish kills may occur.
eutrophication	The process of physical, chemical or biological changes in a lake associated with nutrient, organic matter and silt enrichment of a waterbody. The corresponding excessive algal growth can deplete dissolved oxygen and threaten certain forms of aquatic life, cause unsightly scums on the water surface and result in taste and odor problems.
fall line	A geologic landscape feature that defines the line between the piedmont and coastal plain regions. It is most evident as the last set of small rapids or rock outcroppings that occur on rivers flowing from the piedmont to the coast.
FDA	Unites States Food and Drug Administration.
GIS	Geographic Information System. An organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information.
habitat degradation	Identified where there is a notable reduction in habitat diversity or change in habitat quality. This term includes sedimentation, bank erosion, channelization, lack of riparian vegetation, loss of pools or riffles, loss of woody habitat, and streambed scour.
headwaters	Small streams that converge to form a larger stream in a watershed.
HQW	High Quality Waters. A supplemental surface water classification.
HU	Hydrologic unit. See definition below.
Hydrilla	The genus name of an aquatic plant - often considered an aquatic weed.
hydrologic unit	A watershed area defined by a national uniform hydrologic unit system that is sponsored by the Water Resources Council. This system divides the country into 21 regions, 222 subregions, 352 accounting units and 2,149 cataloging units. A hierarchical code consisting of two digits for each of the above four levels combined to form an eight-digit hydrologic

	unit (cataloging unit). An eight-digit hydrologic unit generally covers an average of 975 square miles. There are 54 eight-digit hydrologic (or cataloging) units in North Carolina. These units have been further subdivided into eleven and fourteen-digit units.
hypereutrophic	Extremely elevated biological productivity related to excessive nutrient availability. Hypereutrophic lakes exhibit frequent algal blooms, episodes of low dissolved oxygen or periods when no oxygen is present in the water, fish kills and excessive aquatic plant growth.
Impaired	Term that applies to a water body that is not meeting the designated use criteria.
impervious	Incapable of being penetrated by water; non-porous.
lbs	Pounds. To change pounds to kilograms multiply by 0.4536.
loading	Mass rate of addition of pollutants to a waterbody (e.g., kg/yr)
macroinvertebrates	Animals large enough to be seen by the naked eye (macro) and lacking backbones (invertebrate).
macrophyte	An aquatic plant large enough to be seen by the naked eye.
mesotrophic	Moderate biological productivity related to intermediate concentrations of available nutrients. Mesotrophic lakes show little, if any, signs of water quality degradation while supporting a good diversity of aquatic life.
MGD	Million gallons per day.
mg/l	Milligrams per liter (approximately 0.00013 oz/gal).
NCIBI	North Carolina Index of Biotic Integrity. A measure of the community health of a population of fish in a given waterbody.
NH_3-N	Ammonia nitrogen.
nonpoint source	A source of water pollution generally associated with rainfall runoff or snowmelt. The quality and rate of runoff of NPS pollution is strongly dependent on the type of land cover and land use from which the rainfall runoff flows. For example, rainfall runoff from forested lands will generally contain much less pollution and runoff more slowly than runoff from urban lands.
NOV	Notices of Violation. An NOV serve to alert the permittee of permit infractions and request that whatever caused the violation be corrected immediately. Many times these will not include a fine. Depending upon the severity of the violation, the permittee may receive a Notice of Violation and Assessment of a Civil Penalty, which will include a fine.
NPDES	National Pollutant Discharge Elimination System.
NPS	Nonpoint source.
NR	Not rated. A waterbody that is not rated for use support due to insufficient data.
NSW	Nutrient Sensitive Waters. A supplemental surface water classification intended for waters needing additional nutrient management due to their being subject to excessive growth of microscopic or macroscopic vegetation. Waters classified as NSW include the Neuse, Tar-Pamlico and Chowan River basins; the New River watershed in the White Oak basin; and the watershed of B. Everett Jordan Reservoir (including the entire Haw River watershed).
NTU	Nephelometric Turbidity Units. The units used to quantify turbidity using a turbidimeter. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of the light scattered by a standard reference suspension under the same conditions.

oligotrophic	Low biological productivity related to very low concentrations of available nutrients. Oligotrophic lakes in North Carolina are generally found in the mountain region or in undisturbed (natural) watersheds and have very good water quality.
ORW	Outstanding Resource Waters. A supplemental surface water classification intended to protect unique and special resource waters having excellent water quality and being of exceptional state or national ecological or recreational significance. No new or expanded wastewater treatment plants are allowed, and there are associated stormwater runoff controls enforced by DWQ.
PCBs	Polychlorinated Biphenyls. PCBs are man-made chemicals that persist in the environment. There are a number of adverse health effect associated with exposure to PCBs.
pH	A measure of the concentration of free hydrogen ions on a scale ranging from 0 to 14. Values below 7 and approaching 0 indicate increasing acidity, whereas values above 7 and approaching 14 indicate a more basic solution.
phytoplankton	Aquatic microscopic plant life, such as algae, that are common in ponds, lakes, rivers and estuaries.
Piedmont	One of three major physiographic regions in the state. Encompasses most of central North Carolina from the Coastal Plain region (near I-95) to the eastern slope of the Blue Ridge Mountains region.
riparian zone	Vegetated corridor immediately adjacent to a stream or river. See also SMZ.
river basin	The watershed of a major river system. North Carolina is divided into 17 major river basins: Broad, Cape Fear, Catawba, Chowan, French Broad, Hiwassee, Little Tennessee, Lumber, Neuse, New, Pasquotank, Roanoke, Savannah, Tar-Pamlico, Watauga, White Oak and Yadkin River basins.
river system	The main body of a river, its tributary streams and surface water impoundments.
runoff	Rainfall that does not evaporate or infiltrate the ground, but instead flows across land and into waterbodies.
SA	Class SA Water Classification. This classification denotes saltwaters that have sufficient water quality to support commercial shellfish harvesting.
SB	Class SB Water Classification. This classification denotes saltwaters with sufficient water quality for frequent and/or organized swimming or other human contact.
SC	Class SC Water Classification. This classification denotes saltwaters with sufficient water quality to support secondary recreation and aquatic life propagation and survival.
sedimentation	The sinking and deposition of waterborne particles (e.g., eroded soil, algae and dead organisms).
SOC	Special Order by Consent. An agreement between the Environmental Management Commission and a permitted discharger found responsible for causing or contributing to surface water pollution. The SOC stipulates actions to be taken to alleviate the pollution within a defined time. The SOC typically includes relaxation of permit limits for particular parameters, while the facility completes the prescribed actions. SOCs are only issued to facilities where the cause of pollution is not operational in nature (i.e., physical changes to the wastewater treatment plant are necessary to achieve compliance).
streamside management zone (SMZ)	The area left along streams to protect streams from sediment and other pollutants, protect streambeds, and provide shade and woody debris for aquatic organisms.
subbasin	A designated subunit or subwatershed area of a major river basin. Subbasins typically encompass the watersheds of significant streams or lakes within a river basin. Every river basin is subdivided into subbasins ranging from one subbasin in the Watauga River basin to 24 subbasins in the Cape Fear River basin. There are 133 subbasins statewide. These

	subbasins are not a part of the national uniform hydrologic unit system that is sponsored by the Water Resources Council (see *hydrologic unit*).
Sw	Swamp Waters. A supplemental surface water classification denoting waters that have naturally occurring low pH, low dissolved oxygen and low velocities. These waters are common in the Coastal Plain and are often naturally discolored giving rise to their nickname of “blackwater” streams.
SWCD	Soil and Water Conservation District
TMDL	Total maximum daily load. The amount of a given pollutant that a waterbody can assimilate and maintain its uses and water quality standards.
TN	Total nitrogen.
TP	Total phosphorus.
tributary	A stream that flows into a larger stream, river or other waterbody.
trophic classification	Trophic classification is a relative description of a lake's biological productivity, which is the ability of the lake to support algal growth, fish populations and aquatic plants. The productivity of a lake is determined by a number of chemical and physical characteristics, including the availability of essential plant nutrients (nitrogen and phosphorus), algal growth and the depth of light penetration. Lakes are classified according to productivity: unproductive lakes are termed "oligotrophic"; moderately productive lakes are termed "mesotrophic"; and very productive lakes are termed "eutrophic".
TSS	Total Suspended Solids.
turbidity	An expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through a sample. All particles in the water that may scatter or absorb light are measured during this procedure. Suspended sediment, aquatic organisms and organic particles such as pieces of leaves contribute to instream turbidity.
USGS	United States Geological Survey
UT	Unnamed tributary.
watershed	The region, or land area, draining into a body of water (such as a creek, stream, river, pond, lake, bay or sound). A watershed may vary in size from several acres for a small stream or pond to thousands of square miles for a major river system. The watershed of a major river system is referred to as a basin or river basin.
WET	Whole effluent toxicity. The aggregate toxic effect of a wastewater measured directly by an aquatic toxicity test.
WS	Class WS Water Supply Water Classification. This classification denotes freshwaters used as sources of water supply. There are five WS categories. These range from WS-I, which provides the highest level of protection, to WS-V, which provides no categorical restrictions on watershed development or wastewater discharges like WS-I through WS-IV.
WTP	Water Treatment Plant
WWTP	Wastewater treatment plant.