

## 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.

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.



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

#### 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 stormwater discharger permitting regulations and programs is to prevent pollution from entering the waters of the state 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](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](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](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 bacteriological 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 contaminants 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 strategies, 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.

## REFERENCES

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