CHAPTER 3

CAUSES AND SOURCES OF WATER POLLUTION

3.1 INTRODUCTION

Water pollution is caused by a number of substances including sediment, nutrients, bacteria, oxygen-demanding wastes, metals, color and toxic substances. *Sources* of these pollution-causing substances are divided into broad categories called *point* sources and *nonpoint* sources. Point sources are typically piped discharges from wastewater treatment plants and large urban and industrial stormwater systems. Nonpoint sources can include stormwater runoff from urban areas, forestry, mining, agricultural lands and others. **Section 3.2** identifies and describes the major causes of pollution in the Chowan River basin. **Sections 3.3** and **3.4** describe point and nonpoint source pollution in the basin, respectively.

3.2 CAUSES OF POLLUTION

Causes of pollution refers to the substances which enter surface waters from point and nonpoint sources and result in water quality degradation and impairment. The major causes of water quality impairment include biochemical oxygen demand (BOD), sediment, nutrients, toxicants (such as heavy metals, dioxin, chlorine, pH and ammonia) and fecal coliform bacteria. Table 3.1 provides a general overview of causes of impairment and the activities that typically lead to their introduction into surface waters. Each of these causes is discussed in the following sections.

Table 3.1 Causes and Sources of Water Pollution

Cause of Impairment	Potential Source of Pollution
Sediment	Construction and mining sites, disturbed land areas, streambank erosion and alterations, cultivated farmland
Nutrients	Fertilizer on agricultural, residential, commercial and recreational lawns, animal wastes, effluent from aquaculture facilities, leaky sewers and septic tanks, atmospheric deposition, municipal wastewater
Toxic and Synthetic Chemicals	Pesticide applications, disinfectants (chlorine), automobile fluids, accidental spills, illegal dumping, urban stormwater runoff, industrial effluent
Oxygen-Consuming Substances	Wastewater effluent, organic matter, leaking sewers and septic tanks, animal waste
Fecal Coliform Bacteria	Failing septic tanks, animal waste, runoff from livestock operations, wildlife, improperly disinfected wastewater effluent
Road Salt	Applications to snow and ice
Oil and Grease	Leaky automobiles, industrial areas, illegal dumping
Thermal Impacts	Heated landscape areas, runoff from impervious areas, tree removal along streams, wet detention ponds

3.2.1 Nutrients

The term *nutrients* in this document refers to two major plant nutrients, phosphorus and nitrogen. These are common components of fertilizers, animal and human wastes, vegetation, aquaculture facilities and some industrial processes. Nutrients in surface waters come from both point and nonpoint sources. Nutrients are beneficial to aquatic life in small amounts. However, in overabundance and under favorable conditions, they can stimulate the occurrence of algal blooms and excessive plant growth in quiet waters such as ponds, lakes, reservoirs, creeks, rivers and estuaries.

Nutrients in the Chowan River Basin

Nutrients have been and continue to be a significant issue in the Chowan River basin. In fact, the Chowan basin was the first waterbody in the state to receive the supplemental Nutrient Sensitive Waters (NSW) classification because of water quality problems associated with nutrient enrichment. Extensive resources have been targeted toward investigating nutrients in the Chowan River. This section will present a summary of water quality investigations that have occurred over the years and an estimation of current nutrient loads in the basin.

Historical Review of Water Quality Studies in the Chowan River

The Chowan River was the first coastal river in North Carolina recognized to experience problems with eutrophication. Early reports (NC-DNRCD, 1982) indicated that major nuisance algal blooms occurred in 1972 and 1978 in the lower portion of the Chowan River. In addition to algal blooms, the occurrence of fish kills and catches of fish infected with red sore disease also implicated water quality problems.

Nuisance algal growths or algal blooms occur when factors limiting algal growth increase in concentration or value. One important factor is the concentration of nutrients such as nitrogen or phosphorus. During the early 1970's a discharge of large quantities of nitrogen, an algal nutrient, was attributed to a fertilizer plant in Tunis, NC. Howells (1990) indicates that this facility may have been discharging as much as 4,000 pounds of nitrogen per day. The discharge was stopped by state action in 1972 and no severe algal blooms developed in the river during the next few years. However, in 1976, small pulse blooms appeared. These blooms were thought to be the result of high nitrogen laden water seeping from storage ponds at a fertilizer plant into the river.

The deterioration of water quality led to specialized multidisciplinary studies and the development of water quality management programs to address the problem. One of the first management programs was established in 1973. This program, known as the Chowan River Project, stimulated some of the first formal studies of the river.

One of the earliest studies was a one-dimensional deterministic flow model of the Chowan River (Daniel, 1977). This model provided daily average discharges for nine sites along the Chowan river for the period April 1974 to March 1976. The study, however, described the flow of water in the Chowan. Both lunar tides and wind tides are present within the Chowan River system. Although lunar tides are small (ca. 1 foot) and are buffered by the Outer Banks, during periods of low flow these tides may exert an influence as far upstream as six miles north of Franklin VA on the Blackwater River. Wind tides are more common and important in the hydrodynamics of the river. These tides can be as much as four feet. Saltwater intrusion into the estuary occurs infrequently.

Subsequent studies focused on nutrients and algal growth. Nitrogen was clearly implicated as a cause of the blooms and was the focus of a study conducted by Stanly and Hobbie (1977). The objectives of this study were to determine: 1) how significant recycling of nitrogen is for algal growth in the river, and 2) what factors limit algal growth in the Chowan during different seasons of the year. The study concluded that the release of nitrogen from decomposing organic matter in the sediments provided much of the nitrogen needed to sustain algal growth in the summer. During the summer, dissolved inorganic nitrogen concentrations were often undetectable. River flow was found to exert a strong negative influence on algal biomass during the winter when flow rates are high. Nitrogen limited algal growth only during the summer.

A study of the response of phytoplankton to water quality was conducted between 1974 and 1977 (Witherspoon, et al., 1979). This study found three periods of relatively high algal growth: 1) a short-lived, late-winter peak, 2) a midspring peak, and 3) a summer peak that was sustained through September to early October.

Data showed that the river could be divided into two biotic sections. The upper river usually contained concentrations of nutrients sufficient to support algal biomass. However, river flow rates usually were high enough to prevent high phytoplankton growth. The algae in this upper section were primarily composed of motile unicellular and colonial species. The lower river had more stagnant flows that provided conditions for nutrient and algal interactions. Blue-green algae were dominant in the lower section.

One of the specific conclusions of this study (Witherspoon, et al., 1979) stated that "low nutrient levels coupled with high algal biomass during the mid-summer indicated that when environmental conditions are favorable algal growth quickly depletes nitrogen and phosphorus; yet, algal growth during this season continues. Nutrient recycling, nitrogen fixation, physiological utilization or organic nitrogen and/or phosphorus in high concentration in the river or a combination of all three processes may be providing these essential nutrients during that period."

Amein and Galler (1979) developed a mathematical model to predict concentrations of dissolved oxygen, biochemical oxygen demand, various species of nitrogen and algal biomass. Phosphorus was not included in the study since, at this time, phosphorus was not identified as a limiting nutrient. The model showed that increases in nitrogen concentrations due to low flow cause algal concentrations to increase in the summer.

In response to nuisance algal blooms and fish kills in North Carolina's waters, the North Carolina Environmental Management Commission established the Nutrient Sensitive Water (NSW) supplemental classification on May 10, 1979 as a legal basis for controlling the discharge of nutrients (nitrogen and phosphorus) into surface waters (Howells, 1990). Nutrient Sensitive Waters were defined as waters subject to excessive growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs. This classification was applied to the Chowan River and took effect in September 1979. This enabled nutrient limits to be included in the NPDES permits of wastewater treatment plants discharging in the watershed (1 ppm total phosphorus and 3 ppm nitrogen).

Studies conducted during the early 1980's expanded on the findings of earlier studies. Phosphorus was first identified as a limiting nutrient in the algal assay studies conducted by Sauer and Kuenzler (1981). Both nitrogen and phosphorus simultaneously limited total algal growth in most experiments, but phosphorus was found to be the more critical limiting nutrient for <u>Anabaena</u> and <u>Aphanizomenon</u>, the nitrogen fixing blue-green species that dominated algal blooms in the lower river.

Paerl (1982) confirmed that both nitrogen and phosphorus were important nutrients that contributed to the blue-green algal blooms. In particular, high nitrogen inputs during the spring were identified as creating a potential for spring algal (non blue-green) blooms. Oxygen from bottom water was depleted when the organic matter from these blooms decomposed. The anaerobic conditions then would release phosphorus that stimulated the growth of blue-green algae during the summer.

Kuenzler, et al. (1982) addressed phytoplankton uptake and sediment release of nitrogen and phosphorus. Ratios of nitrogen to phosphorus in the water as nutrients and as seston (living and nonliving suspended matter), and ratios at which nitrogen and phosphorus are taken from the water by seston indicated that both nutrients may limit algal growth at different times and places in the river. However, this study concluded that phosphorus most likely was the more important limiting nutrient.

Kuenzler, et al. (1982) found that nitrogen and phosphorus were abundant in the sediments, but the rates of exchanges to the overlying water were too low to be the basic cause of the eutrophic condition of the water column. However, efflux rates were determined only once during the summer, and phosphorus efflux rates from the sediments could increase greatly during periods when the bottom water becomes anoxic.

Additional information on nutrient recycling was provided by Lauritsen and Mozley (1983). They showed that the Asian clam (Corbicula fluminea) was able to rapidly recycle nutrients important for phytoplankton growth. Excretion rates of these nutrients were significantly higher than sediment flux rates in parts of the river where this species was abundant.

The studies conducted by Sauer and Kuenzler (1981), Paerl (1982), and Kuenzler, et al. (1982) concluded that controls of nitrogen and phosphorus inputs were necessary to reduce the frequency and magnitude of algal blooms. Witherspoon and Pearce (1982) provided quantitative estimates of the needed reductions in nutrients to achieve particular chlorophyll *a* concentrations or biomass (wet weight) reductions. For example, to achieve a chlorophyll *a* concentration of 40 µg/l, nitrate, ammonium and orthophosphate would need to be reduced by 48%, 23% and 27% respectively.

Specifically, Witherspoon and Pearce (1982) recommended that: 1) reductions in nitrogen and phosphorus be done simultaneously, and 2) the ratio between nitrogen and phosphorus should promote competition for each nutrient by a diverse number of algal species. This could ensure that no one species would gain dominance and would promote conditions favorable to a balanced algal community.

In 1982 the North Carolina Department of Natural Resources and Community Development (NC DNRCD) developed the Chowan/Albemarle Action Plan (NC DNRCD, 1982a) and the Chowan River Water Quality Management Plan (NC DNRCD, 1982b). These plans addressed the water quality problems in the area with a particular focus on the problems in the Chowan River.

The Chowan River Water Quality Management Plan (NC DNRCD, 1982b) provided management goals and a strategy to meet those goals. Goals included nutrient reductions of 30 to 40 percent for phosphorus and 15 to 25 percent reduction in nitrogen. These reductions were hoped to achieve a reduction in chlorophyll *a* concentrations with peak levels not to exceed 40 µg/l. To meet these goals, a combination of point and nonpoint control measures were required. In order to achieve nitrogen and phosphorus reductions in the range of the target levels control measures also needed to be implemented in Virginia. Approximately 76% of the drainage basin is in Virginia.

Craig and Kuenzler (1983) examined changes in land use since 1950 and trends in fertilizer usage for the entire Chowan watershed. Specifically they noted that farm acreage decreased but yields for all major crops increased due to mechanization and increases in fertilizer usage. The usage of fertilizer in North Carolina was significantly higher than fertilizer usage in Virginia. Approximately 67% of the farmland in North Carolina was drained compared to 6% in Virginia by 1983. They also found a 30% decrease in oak-gum-cypress forested wetlands in the North Carolina portion of the Chowan basin within the period 1964-1974.

Mass balance models were developed for agricultural land, upland forest and wetland forest (Craig and Kuenzler 1983). These models suggested that agriculture, forest and wetlands and point sources contributed 62%, 21% and 7% respectively of the annual nitrogen inputs to the Chowan basin. The respective annual phosphorus inputs were estimated to be 72%, 22% and 6%. Swamp forests were estimated to remove 83% of the total nitrogen and 51% of the total phosphorus from streams passing through these wetlands.

A three year study was conducted in the Chowan River Basin to measure water quality changes resulting from the implementation of best management practices (BMPs) to reduce agricultural nonpoint sources (Humenik, et al., 1982). An important conclusion of this study was the need for educational and technical assistance on soil testing for farmers in the Chowan basin. No producers were found to be adjusting commercial fertilizer application rates to account for the nutrient value of animal waste that was being applied.

In 1985 the North Carolina Agricultural Cost Share Program (NCACSP) was implemented in the Chowan River watershed. The purpose of the NCACSP was to assist agricultural landowners in reducing nutrient, sediment and pesticide runoff through the application of best management practices (BMPs).

An update to the 1982 management plan (NC DNRCD, 1982b) was written in 1990 (NC DEHNR, 1990) and is the most recent synopsis and assessment of the nutrient reduction strategies implemented since the 1982 management plan. The update concluded that North Carolina achieved its goal of 20 percent reduction for nitrogen and reduced its phosphorus load by 29 percent (goal of 35%). These reductions were largely due to the elimination of municipal wastewater discharges, the departure of one industrial source (the Tunis fertilizer plant), and the implementation of agricultural BMPs. Calculations for point source dischargers were based on actual data collected from wastewater treatment facilities in 1989. Calculations for nonpoint source dischargers were based on assumptions, such as removal efficiency.

This update (NC DEHNR, 1990) noted that Virginia was assessing its progress on implementing its Nutrient Control Plan. Nutrient data from water quality monitoring stations near the Virginia/North Carolina boundary were used to evaluate nutrient loads from Virginia. The report (NC DEHNR, 1990) concludes "while the data are limited and somewhat variable, no significant reductions in nutrients could be ascertained by analyzing years of similar flow."

Between 1988 and 1992 the North Carolina Division of Water Quality participated in the Albemarle-Pamlico Estuarine Study (APES). The study involved various federal and state agencies with one goal of obtaining comprehensive water quality data for the area. The Chowan River is part of this estuarine system. Data for 14 stations within the watershed (primarily NC watershed) are summarized in NC-DEHNR 1992a and 1992b.

Nutrient data show high median total nitrogen concentrations for stations located on the Blackwater River near Wyanoke, VA and Ahoskie Creek near Ahoskie, NC. The greatest concentration of total nitrogen, ammonia nitrogen, total phosphorus and orthophosphate occurred at the monitoring station near Wyanoke, VA. This station is near to and downstream of the discharge canal from Union Camp. This facility stores waste in a settling pond and then releases wastewater during the early part of winter when flow is generally the greatest. High nutrients levels occur as waste is being released from the settling pond, generally in January. Data also show that the highest median concentrations of total nitrogen and nitrite-nitrate nitrogen are found in Ahoskie Creek near Ahoskie. Chapter 4 presents a detailed review of flow, chlorophyll *a* and phytoplankton data for selected stations on the Chowan River. Results indicate that there are no chlorophyll *a* concentrations exceeding 25 µg/l which was one of the target levels specified in the 1982 Chowan River Water Quality Management Plan.

Nutrient Comparisons from 1982 to 1989 and 1996

As mentioned in the above literature review, in September, 1990 the Water Quality Section released a report titled the "Chowan River Water Quality Management Plan - 1990 Update". The document's purpose was to update the results of the management strategy for the Chowan River which was originally developed in 1982. Data showing nutrient reductions for point and nonpoint sources in North Carolina through 1989 are presented in the 1990 update. In summary, the data show a substantial reduction in Total Phosphorus and Total Nitrogen loads from 1982 to 1989. Total loads were calculated yearly for phosphorus and nitrogen for all point sources. Phosphorus loads for point sources in 1982 were 55,556 pounds per year and in 1989 were 1,323 pounds per year showing a 98% reduction. Nitrogen loads for point sources in 1982 were 612,880 pounds per year and in 1989 were 39,680 pounds per year showing a 94% reduction.

More current nutrient loads from 1996 discharge monitoring reports in the Chowan River have shown a slight increase in phosphorus and nitrogen loads from the 1989 data due to increases in wasteflow for a few of the remaining point sources. However, even with these increases in recent years, the point source contribution to nutrient load for the entire basin remains less than 1% (except for subbasin 030103 where United Piece Dye Works is located). Please refer to Table 3.2 for the estimated contribution of nutrient loading from point sources.

Estimated Nutrient Loads in the Chowan River Basin

In the interest of characterizing the relative contributions of nutrients to the Chowan River Basin from different sources within the entire watershed, an updated nutrient budget was developed for the total basin. Phosphorus and nitrogen loading estimates were calculated and summarized for each of the four Chowan subbasins. Table 3.2 summarizes the loading estimates and relative contributions within each subbasin according to the land uses/areas and point source discharges. Point source loads represent the annual loads from permitted dischargers in the basin under current conditions (calendar year 1996). Nonpoint source loads represent the net export of nutrients from areas of varying land use or land cover within each subbasin. The nonpoint source loads were calculated using an export coefficient model utilizing land cover information derived from 1988 Landsat (satellite image) data and nutrient export estimates derived from previous studies in central and eastern North Carolina. Atmospheric loadings from areas of open water were also calculated using export coefficients. The specific methodology utilized is discussed in further detail in Appendix VII.

It is important to note that these loading estimates do not take into account any contribution from the Virginia portion of the basin which comprises approximately 76% of the land area. (DWQ has endeavored to obtain this information from the Virginia Department of Environmental Quality, but this information was not made available in time for inclusion in this analysis). It is also important to note that this method of calculating nutrient loads does not estimate the amount of a nutrient delivered to a certain point in the river. For instance, if a pound of nitrogen is put in the headwaters of Ahoskie Creek the entire pound will not be carried down to the estuarine portion of the river. Rather, some portion of that pound will be broken down and/or utilized by the natural system as it is being transported. Interpretation of the satellite data also introduces some uncertainty into the export coefficient approach. For example, most large areas of open land such as golf courses and school yards are grouped into the agricultural land cover category. By the same token, cotton fields are often lumped into the Scrub Land category which is grouped in with forests in terms of the export coefficient that is applied yielding a lower estimate of nutrients delivered than would be appropriate.

TABLE 3.2
NUTRIENT LOADS FOR FOUR SUBBASINS IN THE CHOWAN RIVER BASIN

	PHOSPHORUS		NITROGEN		AREA
	LB/YR	% of Load	LB/YR	% of Load	%
Subbasin 03 01 01 (320,845 ac)					
DEVELOPED LAND	157	<1%	1,107	<1%	<1%
AGRICULTURE	84,365	74%	837,895	62%	30%
FOREST/WETLAND	26,248	23%	454,971	34%	68%
POINT SOURCE	72	<1%	265	<1%	
ATMOSPHERIC DEPOSITION	3,265	3%	62,268	5%	2%
Total	114,107	100%	1,356,506	100%	100%
Subbasin 03 01 02 (245,701 ac)					
DEVELOPED LAND	507	<1%	3,583	<1%	<1%
AGRICULTURE	92,712	84%	920,794	75%	43%
FOREST/WETLAND	16,606	15%	287,835	24%	56%
POINT SOURCE	177	<1%	1,048	<1%	
ATMOSPHERIC DEPOSITION	524	<1%	9,998	1%	<1%
Total	110,526	99%	1,223,258	100%	100%
Subbasin 03 01 03 (74,783 ac)					
DEVELOPED LAND	235	1%	1,657	<1%	<1%
AGRICULTURE	29,279	66%	290,797	53%	45%
FOREST/WETLAND	3,126	7%	54,186	10%	35%
POINT SOURCE	2,677	6%	38,752	7%	
ATMOSPHERIC DEPOSITION	8,741	20%	166,674	30%	20%
Total	44,058	100%	552,066	100%	100%
Subbasin 03 01 04 (111,998 ac)					
DEVELOPED LAND	678	1%	4,791	1%	1%
AGRICULTURE	35,984	64%	357,387	50%	37%
FOREST/WETLAND	5,464	10%	94,715	13%	41%
POINT SOURCE	0	0%	0	0%	
ATMOSPHERIC DEPOSITION	13,785	25%	262,863	37%	21%
Total	55,911	100%	719,756	100%	100%

Point source estimates based on annual loads, 1996.
Nonpoint source estimates developed from 1988 Landsat data.

As shown in Figures 3.1 and 3.2, as with past estimates of nutrient loads to the basin, the current nutrient budget indicates that loading to the North Carolina portion of the basin is dominated by contributions from agriculture. However the magnitude and proportion of the agricultural contribution may be overestimated by this method because it does not account for specific land management practices on a localized basis. As a result, reductions obtained from the use of agricultural BMPs, such as no-till farming or flow control structures, are not reflected in the load estimates. Even with such reductions taken into account, agriculture would remain the dominant source of nitrogen and phosphorus in the Chowan River basin due to the prevalence of agricultural land area in the watershed.

Due to the elimination of several municipal wastewater discharges in favor of spray irrigation systems the portion of the nutrient load from point sources has declined steadily over the past 10-15 years to the current estimate of about 1% of the total load for nitrogen or phosphorus. Of the 2,900 lbs/yr TP (total phosphorus) and 40,000 lbs/yr TN (total nitrogen) contributed by point sources, the discharge from United Piece Dye Works (UPDW) contributes 2,300 and 37,000 lbs/yr of the TP and TN, respectively, or roughly 80-90% of the point source load. UPDW is currently allowed a variance from the total nitrogen limit that would be imposed by the Chowan NSW strategy on the basis that most of the nitrogen in the discharge is not in a form that is biologically available to the natural system. Further discussion of the UPDW discharge is presented in Chapter 6.

Figures 3.3 and 3.4 illustrate the estimated nutrient loads per unit area for each of the four subbasins. The largest phosphorus and nitrogen loads proportional to land area come from subbasin 030103, largely due to the fact that it has the highest percentage of agricultural land (45%) and the smallest overall land area. The area proportional contribution of subbasin 030103 is also increased by a substantial area of open water, 20% of the land area, which results in a significant contribution of nutrients from atmospheric deposition. Atmospheric deposition is also a factor in the relatively high loading per unit area in subbasin 030104. Subbasin 030101 has by far the largest overall land area and as a result is estimated to produce the largest total nutrient loads, but due to a high proportion of forest/wetland area (23%), subbasin 030101 produces the lowest loading per unit area.

3.2.2 Toxic Substances

A toxicant is defined in the North Carolina Administrative Code (Regulation 15A NCAC 2B. 0202(36)) 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 or other adverse health effects".

Toxic substances frequently encountered in water quality management include chlorine, ammonia, organics (hydrocarbons and pesticides) heavy metals and pH. These materials are toxic to different organisms in varying amounts, and the effects may be evident immediately or may only be manifested after long-term exposure or accumulation in living tissue.

North Carolina has adopted standards and *action levels* for several toxic substances. These are contained in 15A NCAC 2B .0200. Usually, limits are not assigned for parameters which have action levels 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. This process of determining action levels exists because these toxic substances are generally not bioaccumulative and have variable toxicity to aquatic life because of chemical form, solubility, stream characteristics

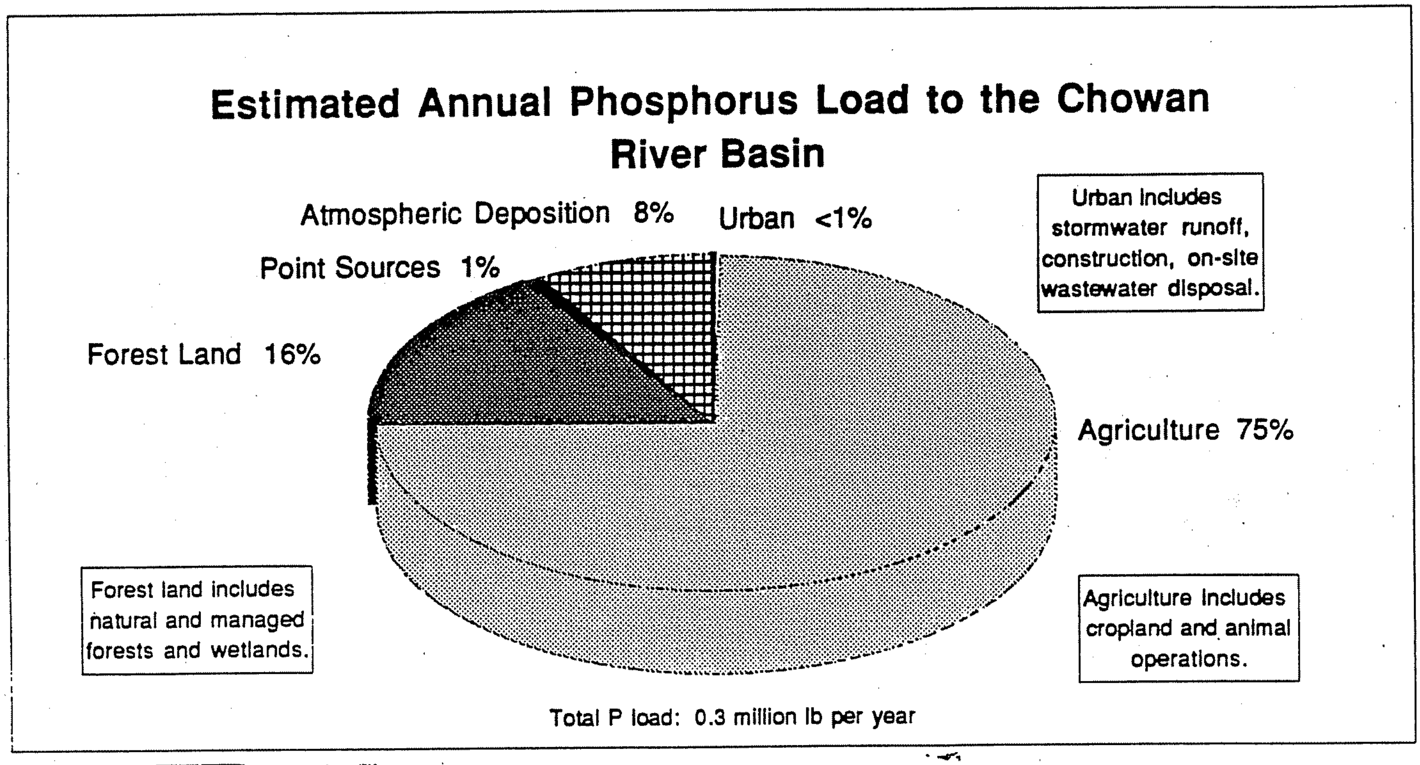

Figure 3.1. Estimated annual phosphorus load to the Chowan River basin.

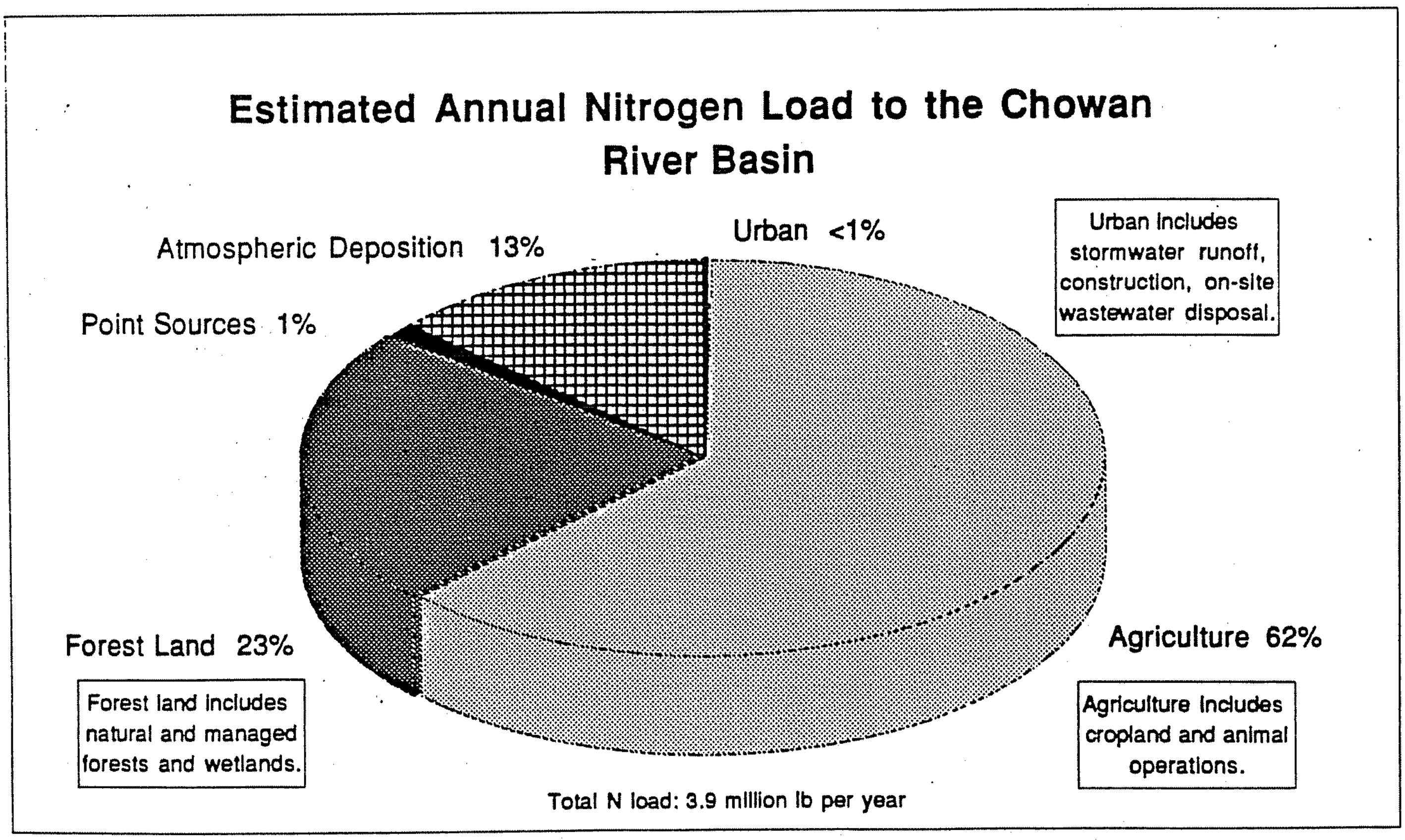

Figure 3.2. Estimated annual nitrogen load to the Chowan River basin.

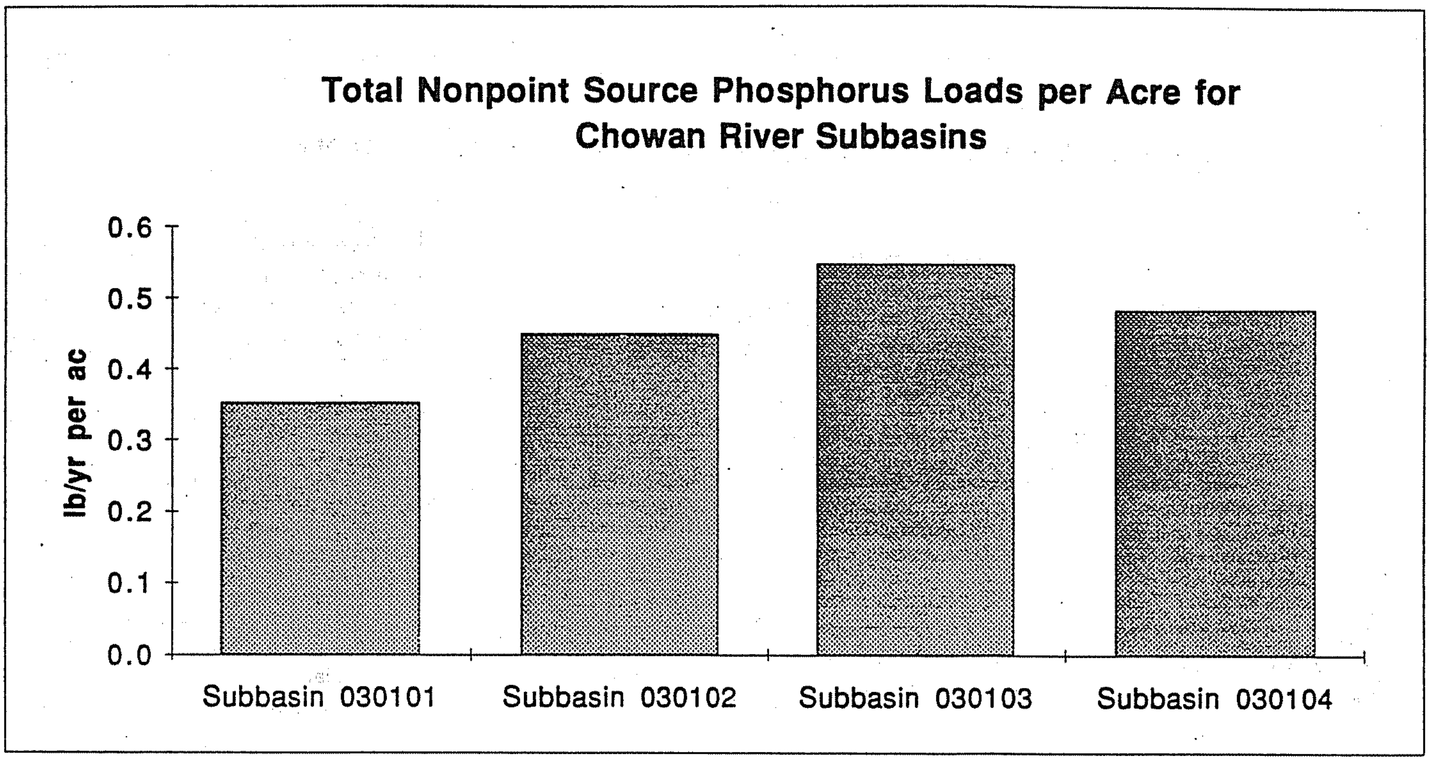

Figure 3.3. Total nonpoint source phosphorus loads per acre for Chowan River subbasins.

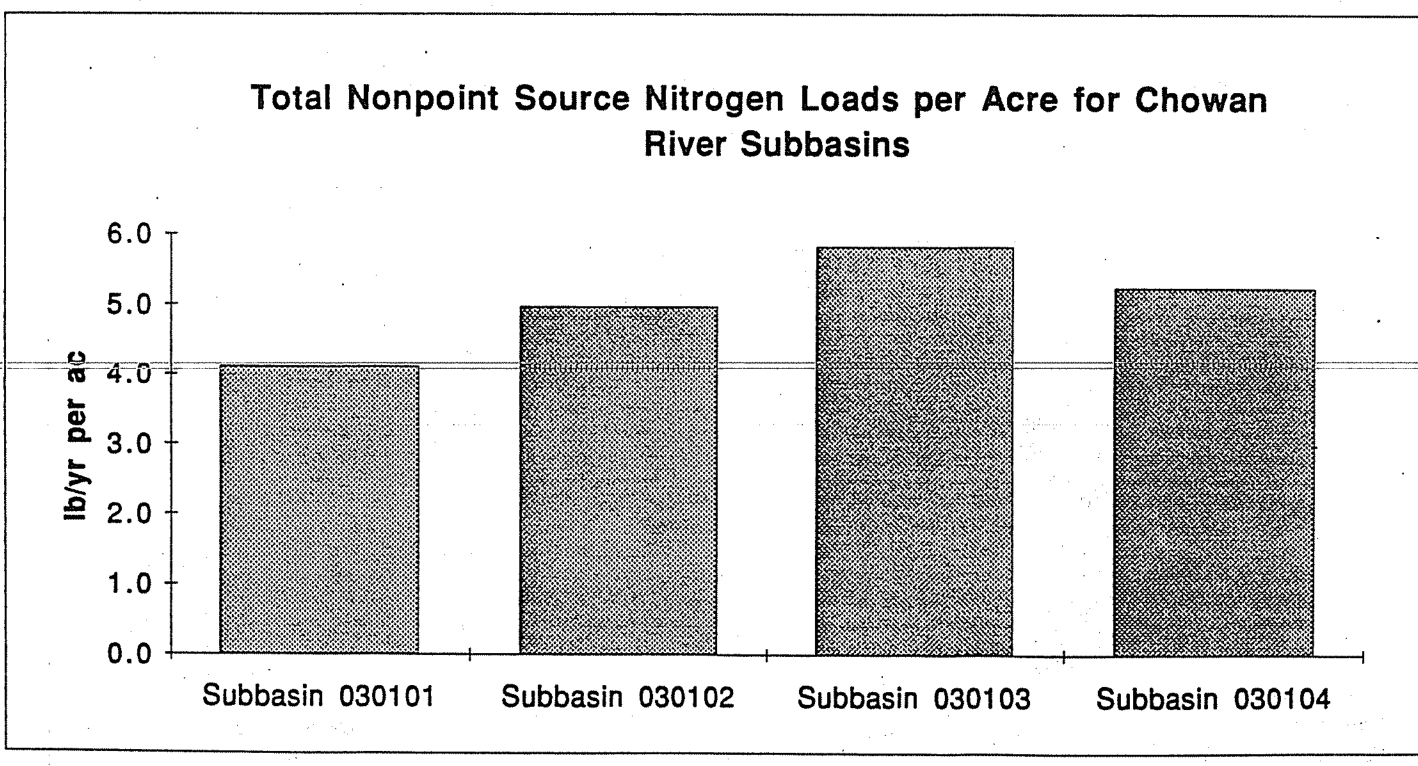

Figure 3.4. Total nonpoint source nitrogen loads per acre for Chowan River subbasins.

and/or associated waste characteristics. Water quality based limits may also be assigned to a given NPDES permit if data indicate that a substance is present for which there is a federal criterion but no water quality standard.

Whole effluent toxicity (WET) testing is required on a quarterly basis for major NPDES dischargers (≥ 1 MGD) and any discharger containing complex (industrial) wastewater. This test shows whether the effluent from a treatment plant is toxic, but it does not identify the specific cause of toxicity. If the effluent is found to be toxic, further testing is done to determine the specific cause. This follow-up testing is called a toxicity reduction evaluation (TRE). WET testing is discussed in Sections 4.2.4 and 5.2.5 of Chapters 4 and 5 respectively. Other testing, or monitoring, 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. These monitoring programs are discussed in Chapter 4.

Each of the substances below can be toxic in sufficient quantity or concentration.

Dioxin

Dioxin contamination is found throughout the world. Dioxins and similar contaminants such as furans and polychlorinated benzenes (PCB) are present as trace impurities in some commercial products. Dioxin is generated through processes such as:

- Production of chlorinated phenols and their derivatives (i.e. herbicides),
- High temperature combustion processes (i.e. incinerators), and
- Chemical bleaching of pulp (in the production of paper).

Dioxins are not intentionally generated, but are unwanted by-products in the production of other items. These contaminants occur everywhere in the environment from sediment and living organisms to consumer products such as bleached paper products. Due to recent research and tighter standards, production of dioxins has been greatly reduced.

Dioxin is chemically stable and bioaccumulates in animal tissues. This means that organisms higher up in the food chain tend to have greater concentrations of the chemical. The biological effects on humans that have been associated with dioxin include, but are not limited to:

- death (high doses),
- chloracne (similar to skin rash) from direct contact to skin,
- carcinogenicity (cancer),
- wasting syndrome,
- thymus atrophy, and
- reproductive impairment including fetal toxicity and testicular atrophy.

Dioxin is very hydrophobic (does not mix with water) and, as a result, it binds tightly with sediment, food particles and organic matter in the water column, leaving extremely low concentrations dissolved in water. When these particles are taken into an aquatic organism such as fish, the dioxin tends to accumulate in the organism's lipids (fats). Due to dioxin's low rate of breakdown, organisms exposed to continuous sources of dioxin tend to bioaccumulate dioxin. That fact is why larger fish such as bowfin and bass tend to have higher levels of dioxin in their bodies than fish which eat lower in the food chain (algae or plants) and higher in the water column.

Dioxin in the Chowan River Basin

The Chowan River from the Virginia Border to the Albemarle Sound (at Highway 17 bridge) remains under a fish consumption advisory for all fish except herring, shellfish and shad (including roe). The advisory has been in place since August 1990 and currently recommends that the general population consume no more than two meals of any fish except those noted above in one month and that children and pregnant or nursing women consume no fish except those noted above. The Albemarle Sound is under a separate (although identical) consumption advisory. DWQ basin boundaries are drawn such that a portion of the upper Albemarle Sound is considered a part of the Chowan River Basin. Figure 3.6 shows the location of the Chowan River and Albemarle Sound fish consumption advisory areas as they occur in the Chowan River basin.

In the mid 1980's, paper mills which employ chlorine bleaching were recognized by the US EPA as contributors to dioxin detected in fish caught downstream of paper mills. The Union Camp Fine Paper mill in Franklin, Virginia is believed to contribute to the dioxin contamination of fish in the Chowan River. However, the Albemarle sound and the lower portion of the Chowan River experience tidal action and it is possible that the fish in this area have been impacted by other discharges of dioxin into waters that flow into the upper end of the sound. The Union Camp facility discharges effluent into the Blackwater River (which joins with the Nottoway River to form the Chowan River) daily during the months of November or December through March. Total annual discharge varies from 10 to 12 billion gallons with the daily discharges being adjusted to prevent adverse impacts to the river system. Union Camp has been performing voluntary fish tissue dioxin monitoring in Virginia and North Carolina waters since 1989, shortly after the discover of dioxin in fish downstream of paper mills that employ chlorine bleaching. The voluntary monitoring became a Virginia VPDES Permit requirement for Virginia waters in 1994. Union Camp continues to perform voluntary fish tissue monitoring in North Carolina. In 1990, the company voluntarily instituted process operating measures aimed at controlling the generation of dioxin. They further reduced the dioxin generation in 1992 by completing construction of the first commercial application of their patented C-Free™ bleaching technology to replace two older conventional chlorine bleach lines. These efforts resulted in a reduction of dioxin content in the effluent to a non-detectable level by 1992.

Union Camp's monitoring data demonstrates the significant reductions in fish tissue dioxin levels achieved as a result of their efforts (see Figure 3.5). Dioxin levels (as TEQ) in gamefish species (largemouth bass and bluegill sunfish) collected from Virginia and North Carolina waters have largely been below the 3 ppt (as TEQ) NC action level since 1989. TEQ is a toxicity equivalency factor and is a measure of how toxic a particular form of dioxin is relative to 2,3,7,8 TCDD (tetrachlorodibenzo-p-dioxin). Channel catfish dioxin levels have decreased to below the 3 ppt NC action level at all stations except at Chowan Marker 9, the Highway 17 bridge and at Marker 2. It should be noted that the Albemarle Sound and the lower portion of the Chowan River experience tidal action as evidenced by elevated salinity levels (see Figure 4-20). Therefore, it is possible that the fish in that area have been impacted other discharges of dioxin into waters which flow into the upper end of the sound.

pH

Changes in pH to surface waters is primarily through point source discharges, although pH levels can be naturally low in areas of the coastal plain, including the Chowan River basin. As the pH of a water decreases, metals are more bioavailable within the water column and are therefore more toxic to the aquatic organisms. As the pH increases, metals are precipitated out of the water column and less toxic to aquatic organisms. If a surface water has had chronic introductions of metals and the pH gradually or dramatically decreases, the metals in the substrate will become more soluble and be readily available in the water column. While lower pH values may not be toxic to the aquatic organisms, the lower values can have chronic effects on the community structure of macroinvertebrates, fish, and phytoplankton. Macroinvertebrates will show a shift from tolerant species to intolerant species and have less community diversity.

The NC standard for pH in surface waters is 6.0 to 9.0 for most waters. The supplemental 'swamp' (Sw) classification is applied to waters that have naturally acidic waters and allows for lower pH levels.

1992-1996 CATFISH FILLET DIOXIN AND TEQ LEVELS WINTON

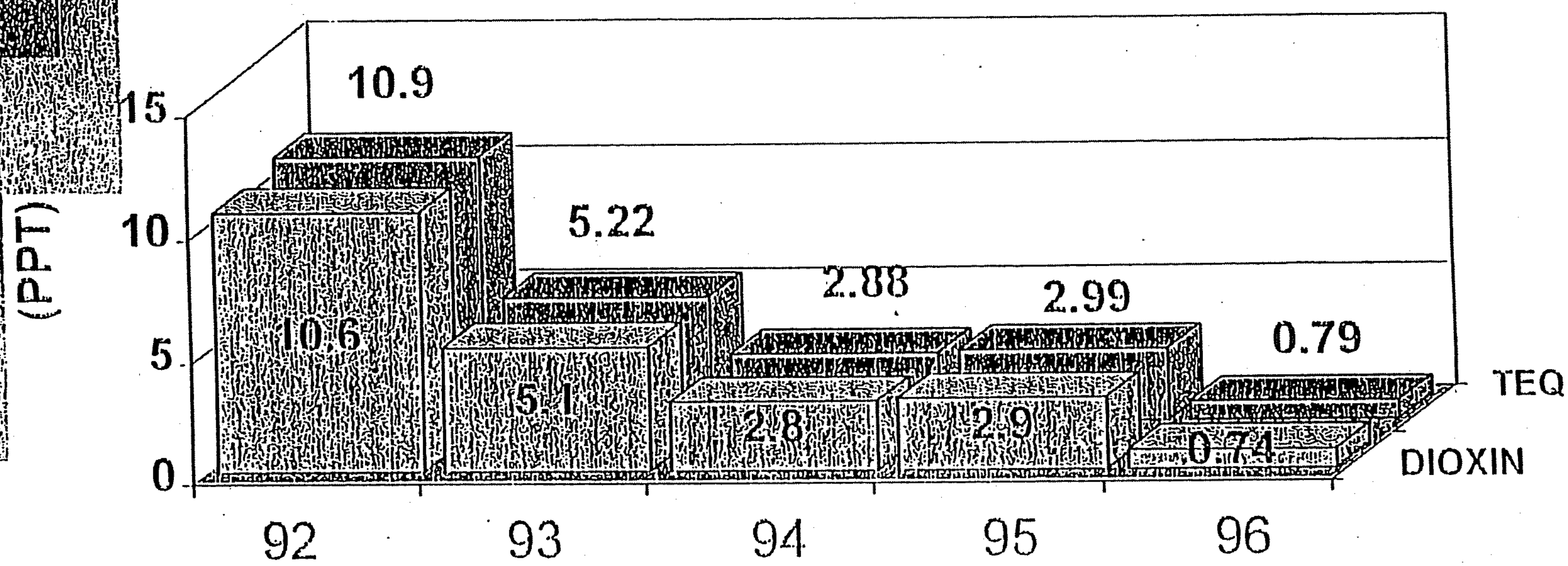

Figure 3.5. Levels of Dioxin and TEQ (ppt) in catfish fillets at Winton, NC; 1992 - 1996.

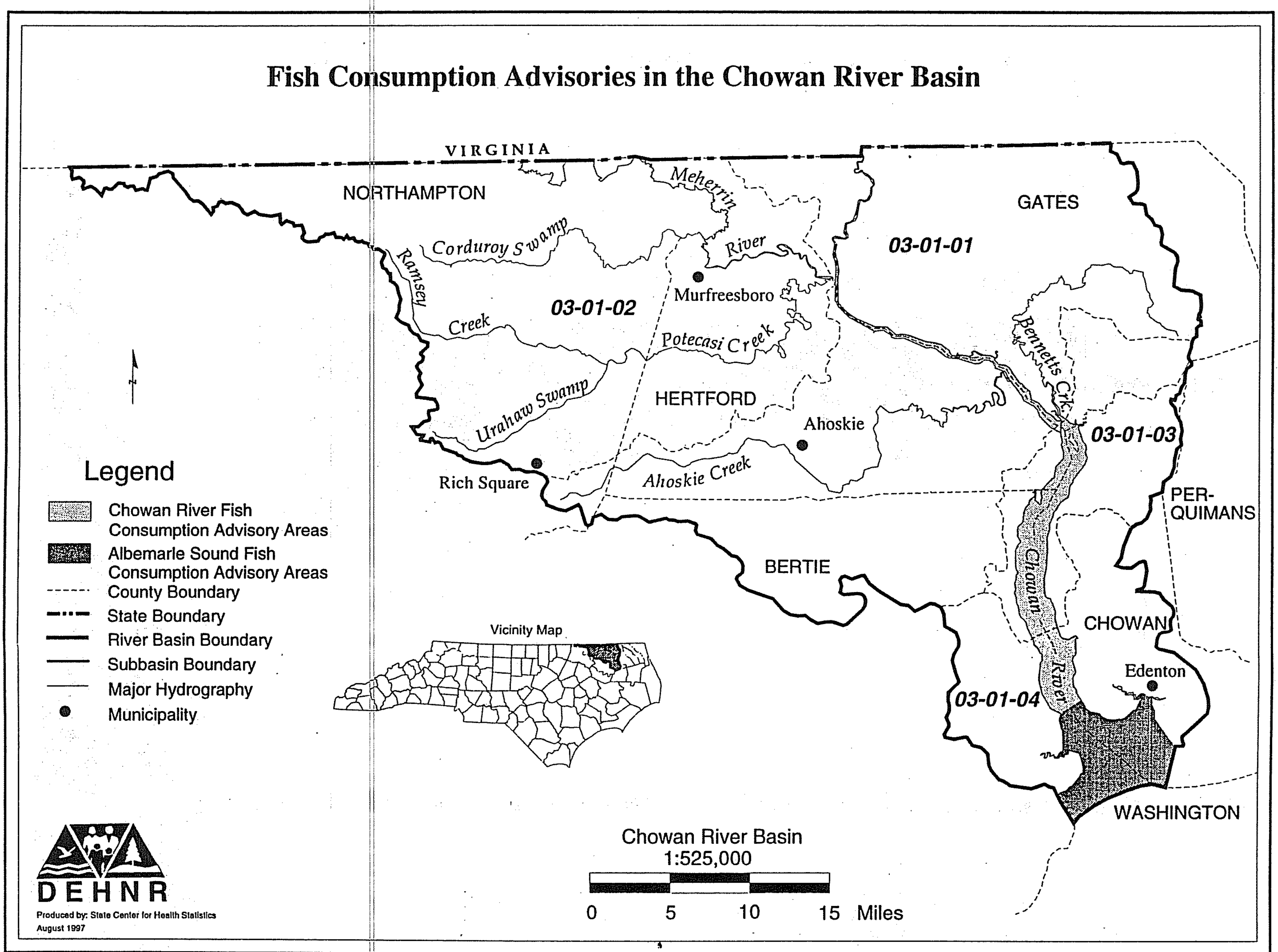

Figure 3.6. Location of area of Dioxin Fish Consumption Advisory in the Chowan River Basin

pH in the Chowan Basin

No waters in the Chowan are supplementally classified as swamp waters, but there are clearly areas that exhibit characteristics of swamps, including low pH levels. Many of the small tributary creeks, including Potecasi Creek and the Chowan River near Colerain, have exhibited pH levels below the standard of 6 SU (standard units).

Metals

Municipal and industrial dischargers and urban runoff are the main sources of metals contamination in surface water. North Carolina has stream standards for many heavy metals, but the most common ones in municipal permits are cadmium, chromium, copper, nickel, lead, mercury, silver and zinc. Standards are listed in Appendix I. Each of these, with the exception of silver, is also monitored through the ambient network along with aluminum and arsenic. Point source discharges of metals are controlled through the NPDES permit process. Mass balance models are employed to determine allowable concentrations for a permit limit. Municipalities with significant industrial users discharging wastes to their treatment facilities limit the heavy metals from these industries through a *pretreatment program*. Source reduction and wastewater recycling at WWTPs also reduces the amount of metals being discharged to a stream. Nonpoint sources of pollution are controlled through best management practices.

In North Carolina, as well as many other areas of the country, mercury contamination in fish is causing the need to post widespread fish consumption advisories. The source of the mercury, which is found all along the east coast from Maine to Florida, is unclear. There is suspicion that it is entering surface waters through atmospheric sources, and there are studies underway to determine whether or not this is the case.

Metals in the Chowan Basin

Instances of elevated levels of mercury found in fish in the Chowan River basin have been sporadic. However, on June 12, 1997, a statewide consumption advisory on bowfin was issued due to unsafe mercury levels. The advisory recommends that the general population consume no more than 2 meals of the fish per month, and child-bearing women and children consume no fish.

Along the Chowan River, an abandoned fertilizer plant is now a hazardous waste site because of chromium contamination. Groundwater in the area is contaminated with low concentrations of chromium. However, even though concentrations are low, there is enough contaminated water to exceed the threshold for RCRA designation which is based on pounds of contaminant. DWQs primary concern with this site is the high nitrogen levels in the groundwater and its proximity to the nutrient-enriched Chowan River.

Chlorine

Chlorine is a commonly used disinfectant at NPDES discharge facilities which have a domestic (i.e., human) waste component. These discharges are a major source of chlorine in the State's surface waters. Chlorine dissipates fairly rapidly once it enters the water, but its toxic effects can have a significant impact on sensitive aquatic life such as trout and mussels. At this time, no standard exists for chlorine in waters supplementally classified as trout waters and an action level has been established for all other waters. A standard for all waters may be adopted in the future. In the meantime, all new and expanding dischargers are required to dechlorinate their effluent if chlorine is used for disinfection. If a chlorine standard is developed for North Carolina, chlorine limits may be assigned to all dischargers in the State that use chlorine for disinfection.

Ammonia (NH_3)

Point source dischargers are one of the major sources of ammonia. In addition, decaying organisms which may come from nonpoint source runoff and bacterial decomposition of animal waste also contribute to the level of ammonia in a waterbody. At this time, there is no numeric standard for ammonia in North Carolina. However, DWQ has developed an interim set of instream criteria of 1.0 mg/l in the summer (April - October) and 1.8 mg/l in the winter (November - March). These interim criteria are under review, and the State may adopt a standard in the near future.

3.2.3 Oxygen-Consuming Wastes

Oxygen-consuming wastes include decomposing organic matter or chemicals which reduce dissolved oxygen in the water column through chemical reactions or biological activity. Raw domestic wastewater contains high concentrations of oxygen-consuming wastes that need to be removed from the wastewater before it can be discharged into a waterway. Maintaining a sufficient level of dissolved oxygen in the water is critical to most forms of aquatic life.

The concentration of dissolved oxygen (DO) in a water body is one indicator of the general health of an aquatic ecosystem. Dissolved oxygen concentrations are affected by a number of factors. Higher dissolved oxygen is produced by turbulent actions, such as waves, rapids and water falls, which mix air and water. Lower water temperatures also generally allows for retention of higher dissolved oxygen concentrations. Therefore, the cool swift-flowing streams of the mountains are generally high in dissolved oxygen. Low dissolved oxygen levels tend to occur more often in warmer, slow-moving waters. In general, the lowest dissolved oxygen concentrations occur during the warmest summer months and particularly during low flow periods. Water depth is also a factor. In deep slow-moving waters, such as reservoirs or estuaries, dissolved oxygen concentrations may be very high near the surface due to wind action and plant (algae) photosynthesis but may be entirely depleted (anoxic) at the bottom.

Sources of dissolved oxygen depletion include wastewater treatment plant effluent, the decomposition of organic matter (such as leaves, dead plants and animals) and organic waste matter that is washed or discharged into the water. Sewage from human and household wastes is high in organic waste matter. Bacterial decomposition can rapidly deplete dissolved oxygen levels unless these wastes are adequately treated at a wastewater treatment plant. In addition, some chemicals may react with and bind up dissolved oxygen. Industrial discharges with oxygen consuming wasteflow may be resilient instream and continue to use oxygen for a long distance downstream.

Oxygen-Consuming Waste in the Chowan River Basin

In the Chowan River basin, Potecasi Creek is considered impaired and one of the problem parameters identified is dissolved oxygen. From 1990-1995, 42% of the 67 samples taken from Potecasi Creek violated the minimum DO requirement of 4 mg/l. Agriculture and channelization are the activities suspected to be contributing to the impairment.

In addition, 2 sites on the Blackwater River and 1 site on the Chowan River showed violations of the dissolved oxygen criteria greater than 10% of the time. Some violations may be due to natural swamp conditions.

Flow and BOD Changes from 1987 to 1996

Wasteflow and BOD data from the discharge monitoring reports (DMR) for 1987 and 1996 were evaluated for point source trends in the basin. The estimated wasteflow increased from 268 million gallons per year in 1987 to 416 million gallons per year in 1996 (36% increase). Estimated BOD loads also increased from 34,548 pounds per year in 1987 to 70,141 pounds per year in 1996 (51% increase). Average daily loads for BOD were pulled from the DMRs, multiplied by 365 and added together to get the annual point source loadings for BOD. The increases in flow and BOD loading to the system are primaily due to increased wastefow from the Colrain WWTP and United Piece Dye Works facilities. No new surface water discharges have come into the basin since 1987.

3.2.4 Sedimentation

Sedimentation is the most widespread cause of nonpoint source pollution in the state and results from land-disturbing activities including agriculture, building and highway construction, uncontrolled urban runoff which erodes streambanks, mining and timber harvesting. Unpaved roads and driveways on steep slopes are also significant sources of sediment. Sedimentation is often divided into two categories: *suspended load* and *bed load*. Suspended load is composed of small particles that remain in suspension in the water. Bed load is composed of larger particles that slide or roll along the stream bottom. Suspension of load types depends on water velocity and stream characteristics. Biologists are primarily concerned with the *concentration* of the suspended sediments and the *degree of sedimentation* on the streambed (Waters 1995).

The concentration of suspended sediments affects the availability of light for photosynthesis, as well as the ability of aquatic animals to see their prey. Several researchers have reported reduced feeding and growth rates by fish in waters with high suspended solids. In some cases it was noted that young fish left those stream segments with turbid conditions. Suspended sediments can clog the gills of fish and reduce their respiratory abilities. These forms of stress may reduce the tolerance level of fish to disease, toxicants and chronic turbid conditions. Suspended solids are reported as Total Suspended Solids or as Turbidity. They are measured in parts per million or milligrams per liter (Waters 1995).

The degree of sedimentation affects both the habitat of aquatic macroinvertebrates and the quality and amount of fish spawning and rearing habitat. Degree of sedimentation can be estimated by observing the amount of streambed covered, the depth of sedimentation, and the percent saturation of interstitial space or embeddedness. Eggs and fry in interstitial spaces may be suffocated by the sediments thereby reducing reproductive success (Waters 1995).

The impact of sedimentation on fish populations depends on both concentration and degree of sedimentation, but impact severity can also be affected by the duration (or dose) of sedimentation. Suspended sediments may occur at high concentrations for short periods of time, or at low concentrations for extended periods of time. The greatest impacts to fish populations will be seen at high concentrations for extended time periods. The use of a dose-response matrix in combination with field investigations can help predict the impact of suspended sediments on various life stages of fish populations (Newcombe 1996).

Sedimentation impacts streams in several other ways. Eroded sediments may gradually fill lakes and navigable waters and may increase drinking water treatment costs. Sediment also serves as a carrier for other pollutants including nutrients (especially phosphorus), toxic metals, pesticides, and road salts.

Statistics compiled by the US Department of Agriculture, Natural Resource Conservation Service (formerly known as the Soil Conservation Service) indicate a statewide decline in erosion from 1982 to 1992 (USDA, NRCS, 1992) as shown in Table 3.3.

Table 3.3. Overall Erosion Trends in North Carolina

	1982	1987	1992
Area (1,000 acres)	33,708.2	33,708.2	33,708.2
Gross Erosion (1,000 tons/yr)	46,039.5	43,264.6	36,512.9
Erosion Rate (Tons/Yr/Ac)	1.1	1.4	1.3

The NRCS statistics also indicate a statewide reduction per acre on cropland erosion using the Universal Soil Loss Equation (Table 3.4).

Table 3.4. USLE Erosion on Cultivated Cropland in North Carolina

	1982	1987	1992
Cropland Area (1,000 acres)	6,318.7	5956.8	5538.0
Gross Erosion (1,000 tons/yr)	40,921.4	37475.3	30,908.3
Erosion Rate (Tons/Yr/Ac)	6.5	6.3	5.6

As can be seen in Table 3.5, compared to other areas of the state, erosion in the eastern North Carolina (tidewater area, Atlantic coast flatwoods, southern coastal plain) is much lower than in mountain areas where slopes are greater.

Table 3.5. North Carolina Erosion on Major Land Resource Areas (MLRA) (in tons/acre/year)

	1982	1987	1992
Blue Ridge Mountains	12.7	20.8	18.3
Southern Piedmont	12.3	12.0	10.5
Carolina and Georgia Sand Hills	6.0	5.6	5.1
Southern Coastal Plain	3.9	3.9	4.0
Atlantic Coast Flatwoods	3.2	3.1	3.2
Tidewater Area	1.4	1.5	1.6

Streambank erosion is a natural process, but one that is accelerated by human activities. Streambank erosion results from two processes: high flows and bank failures. Growth is associated with an increase in impervious surfaces, resulting in higher volumes and rates of flow into receiving streams. Bank failures can occur due to these high flows, or from heavy use of streambanks for cattle or vehicle crossings. Loss of buffer strips along streambanks can greatly contribute to bank erosion. The use of structural techniques such as: bank sloping, use of tree roots for stabilization, buffer strips, and fencing cattle out of streams can greatly reduce streambank erosion. Average annual soil loss has been shown to be decreased by 40% after cattle were fenced away from streams. This decrease resulted in nearly a 60% reduction in average sediment concentration during stormflow events (Owens, et al 1996). Stormwater management measures for urban development areas can also lessen the potential for streambank erosion.

Most sediment-related impacts are associated with nonpoint source pollution. Recommendations aimed at addressing sedimentation are listed in Chapter 6 and programs are briefly described under nonpoint source pollution controls in Chapter 5. Nonpoint sources are considered to be in compliance with the turbidity standard if approved best management practices (BMPs) have been implemented.

Sedimentation and Erosion in the Chowan River Basin

Although sedimentation has not been identified as a source of impairment for water bodies in the Chowan River basin, that does not mean that there are no localized impacts from sediment runoff. Sedimentation is more difficult to identify in coastal plain areas because of the waters' naturally sandy substrate.

3.2.5 Fecal Coliform Bacteria

Fecal coliform bacteria are typically associated with the intestinal tract of warm-blooded animals. These bacteria are widely used as an indicator of the potential presence of pathogenic, or disease-causing, bacteria and viruses. Common potential sources of fecal coliform bacteria include leaking or failing septic systems, leaking sewer lines or pump station overflows, runoff from livestock operations and wildlife, and improperly disinfected wastewater effluent.

Fecal coliform bacteria are widely used as indicators of the potential presence of waterborne pathogenic organisms (which cause such diseases as typhoid fever, dysentery, and cholera). Fecal coliform bacteria in treatment plant effluent are controlled through disinfection methods including chlorination (sometimes followed by dechlorination), ozonation or ultraviolet light radiation.

Fecal Coliform Bacteria in the Chowan River Basin

Fecal coliform bacteria have not been identified as a problem parameter for any impaired waters in the Chowan basin. However, DWQ will continue to monitor bacterial concentrations at ambient locations in the basin to measure any changes that may occur.

3.3 POINT SOURCES OF POLLUTION (Including Non-discharging Land-Application Facilities)

3.3.1 Defining Point Sources

Point sources refers to discharges that enter surface waters through a pipe, ditch or other well-defined point of discharge. The term applies to wastewater and stormwater discharges from a variety of sources. Wastewater point source discharges include municipal (city and county) and industrial wastewater treatment plants and small domestic wastewater treatment systems that may serve schools, commercial offices, residential subdivisions and individual homes. Stormwater point source discharges include stormwater collection systems for medium and large municipalities which serve populations greater than 100,000 and stormwater discharges associated with industrial activity as defined in the Code of Federal Regulations [40 CFR 122.26(a)(14)]. The primary pollutants associated with point source discharges are oxygen-demanding wastes, nutrients, sediment, color and toxic substances including chlorine, ammonia and metals.

Point source dischargers in North Carolina must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the state. Discharge permits are issued under the NPDES program which is delegated to North Carolina by the US Environmental Protection Agency (EPA). See Chapter 5 for a description of the NPDES program and permitting strategies.

Although not technically a "point" source of pollution, some treatment facilities apply their waste to the land as opposed to discharging it to surface waters. These facilities are also required to obtain a non-discharge permit from the state for these operations. They are described in more detail in subsection 3.3.4.

3.3.2 Point Source Discharges in the Chowan River Basin

There are 58 permitted NPDES wastewater dischargers in the Chowan River basin. Only one facility (United Piece Dye Works) is considered a "major" facility. These are facilities that are either large (> 1 MGD (million gallons per day)) or industrial discharges that have toxic material in its discharge (this latter category is determined to be major on a discretionary basis). There are 14 dischargers covered under individual permits, 30 covered under general stormwater permits and 14 covered under other general permits. Figure 3.7 shows the location of permitted facilities in the basin (not including stormwater permits which are discussed below). Permit renewals are conducted at five year intervals. Permits for the Chowan River basin are scheduled to be renewed in January of 1998.

Total permitted flow for all facilities is 1.68 million gallons per day (MGD). The average actual flow from all facilities is 1.11 MGD. Table 3.7 provides the total and average discharge for each category of permitted facility. Definitions and examples of the various categories can be found in Table 3.6.

3.3.3 Stormwater Point Source Discharges in the Chowan River Basin

Excluding construction general permits, there are 28 general permits and 2 individual stormwater permits issued within the river basin. Activities covered under the general stormwater permits include: construction; mining/borrow pits; metal waste recycling and manufacture of metal products and equipment; manufacture of timber products; apparel, printing, paper, leather, and rubber products manufacturing; vehicle maintenance, transportation, and postal service activities, public warehousing and petroleum bulk stations and terminals; used automobile parts and scrap yards; ready mixed concrete production; manufacture of asphalt paving mixtures and blocks; production of textile mill products; ship and boat building/repairing and marinas. Activities covered under individual permits include resin manufacturers. There are currently no municipalities in the Chowan River basin that are subject to NPDES stormwater permitting.

The primary source of concern from industrial facilities is the contamination of stormwater from contact with exposed materials. In addition, poor site management can lead to significant contributions of sediment and other pollutants which have a detrimental effect on the water quality in receiving streams. There have been no reported water quality concerns associated with permitted stormwater dischargers in this basin.

Table 3.6. Definitions of Categories of NPDES Permits

CATEGORY	DEFINITION	EXAMPLES
Major vs. Minor discharges (NCOO Facilities)	For publicly owned treatment works, any facility discharging over 1 MGD is defined as a Major discharge. For industrial facilities, the EPA provides evaluation criteria including daily discharge, toxic pollutant potential, public health impact and water quality factors. Any facilities which do not meet the criteria for Major status are defined as Minor discharges.	United Piece Dye Works is the only major permitted facility in the Chowan River basin.
100% Domestic	A system which treats wastewater containing household-type wastes (bathrooms, sinks, washers, etc.).	Housing subdivision WWTPs, schools, Mobile Home Parks,
Municipal	A system which serves a municipality of any size.	NC0020630 - Colerain WWTP
Process Industrial	Water used in an industrial process which must be treated prior to discharge.	Perry-Wynns Fish Company
Nonprocess Industrial	Wastewater which requires no treatment prior to discharging[1].	NCG500046 - R.J. Reynolds Tobacco Co. (Non-contact cooling water and cooling tower blowdown)
Stormwater Facilities[2]	Discharges of runoff from rainfall or snow melt. NPDES permits are required for "stormwater discharges associated with industrial activity" and from municipal stormwater systems for towns over 100,000 in population.	"Stormwater discharges associated with industrial activity" include most types of manufacturing plants. Light manufacturing is subject only if they process or store materials outdoors. Landfills, mines, junkyards, steam electric plants, transportation terminals and any construction activity which disturbs 5 acres or more during construction.

1: Non-contact cooling water may contain biocides; however, the biocides must be approved by our Aquatic Survey and Toxicology Unit. The approval process verifies that the chemicals involved have no detrimental effect on the stream when discharged with the non-contact cooling water.

2: Stormwater facilities are covered by General Permits NCG010000 through NCG190000. Facilities which do not fit the categories of these permits are covered under individual stormwater permits NCS000000.

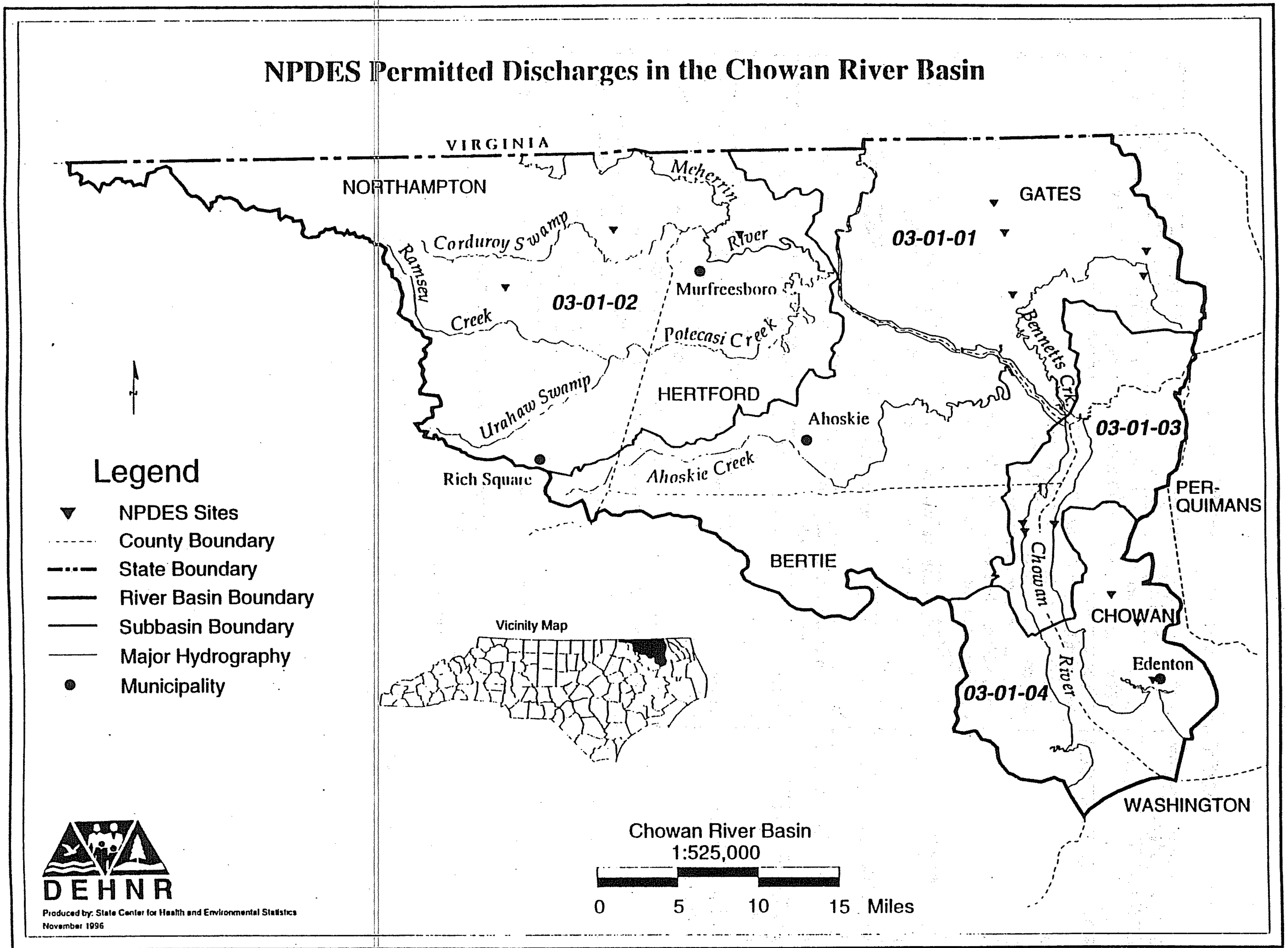

Figure 3.7. Location of NPDES Permitted Wastewater Discharges in the Chowan River Basin

Table 3.7. Summary of Major/Minor NPDES Dischargers and Permitted and Actual Flows by Subbasin for the Chowan River Basin

FACILITY CATEGORIES	SUBBASIN 01	02	03	04	TOTALS
NC00 Individual Facilities	5	3	3	3	14
Stormwater Facilities	15	5	2	8	30
NCG General Permit Facilities	6	6	1	1	14
Total Facilities	26	14	6	12	**58**
Total Permitted Flow (MGD)	0.02	0.04	1.60	0.02	**1.68**
# of Facilities Reporting	4	2	3	1	**10**
Total Avg. Flow (MGD)	0.01	0.01	1.07	0.02	**1.11**
***Major Discharges**	0	0	1	0	**1**
Total Permitted Flow (MGD)	0	0	1.5	0	**1.5**
# of Facilities Reporting	0	0	1	0	**1**
Total Avg. Flow (MGD)	0.00	0.00	0.97	0.00	**0.97**
***Minor Discharges**	5	3	2	3	**13**
Total Permitted Flow (MGD)	0.02	0.04	0.10	0.02	**0.18**
# of Facilities Reporting	4	2	2	1	**9**
Total Avg. Flow (MGD)	0.01	0.01	0.10	0.02	**0.14**
100% Domestic Wastewater	4	2	0	0	**6**
Total Permitted Flow (MGD)	0.02	0.04	0.00	0.00	**0.06**
# of Facilities Reporting	4	2	0	0	**6**
Total Avg. Flow (MGD)	0.01	0.01	0.00	0.00	**0.02**
Municipal Facilities	0	0	1	0	**1**
Total Permitted Flow (MGD)	0	0	0.08	0	**0.08**
# of Facilities Reporting	0	0	1	0	**1**
Total Avg. Flow (MGD)	0.00	0.00	0.09	0.00	**0.09**
Major Process Industrial	0	0	1	0	**1**
Total Permitted Flow (MGD)	0	0	1.5	0	**1.5**
# of Facilities Reporting	0	0	1	0	**1**
Total Avg. Flow (MGD)	0.00	0.00	0.97	0.00	**0.97**
Minor Process Industrial	0	0	0	1	**1**
Total Permitted Flow (MGD)	0	0	0	0.00	**0.00**
# of Facilities Reporting	0	0	0	1	**1**
Total Avg. Flow (MGD)	0.00	0.00	0.00	0.02	**0.02**
Nonprocess Industrial	0	0	1	0	**1**
Total Permitted Flow (MGD)	0	0	0.02	0.02	**0.04**
# of Facilities Reporting	0	0	1	0	**1**
Total Avg. Flow (MGD)	0.00	0.00	0.03	0.00	**0.03**

*** NC00 Individual permit facilities**

3.3.4 Non-discharging (Land-application) Wastewater Treatment Facilities

The Division of Water Quality also issues permits for the construction and operation of wastewater treatment systems that utilize non-discharging disposal systems. The following are examples of systems that are regulated and permitted:

- wastewater collection systems
- groundwater remediation facilities
- spray irrigation disposal systems
- reuse of reclaimed water disposal systems,
- land application and surface disposal of residuals,
- animal waste management systems.

DWQs review and permitting of these systems insures construction and operation of these facilities will be completed in accordance with the non-discharge regulations (15A NCAC 2H .0200) and the North Carolina General Statutes. Included in this review are details into the assurance that the facility will not discharge when operated. Senate Bill 1217 which was passed by the 1996 NC General Assembly, requires DWQ to permit animal waste facilities over a certain size. All regulated facilities are currently deemed permitted but will be required to receive coverage under animal waste general permits over the next five years.

In the Chowan basin, there are 17 permitted non-discharge facilities (not including regulated animal operations). These facilities are comprised primarily of industrial spray irrigation and municipal waste spray irrigation systems.

3.4 NONPOINT SOURCES OF POLLUTION

Nonpoint source (NPS) pollution refers to runoff that enters surface waters through stormwater, snowmelt or atmospheric deposition (e.g., acid rain). There are many types of land use activities that can serve as sources of nonpoint source pollution including land development, construction, mining operations, timber harvesting, crop production, animal feeding lots, failing septic systems, landfills, roads and parking lots. As noted earlier, stormwater from large urban areas (>100,000 people) and from certain industrial sites is technically considered a point source since NPDES permits are required for piped discharges of stormwater from these areas. However, a discussion of urban runoff will be included in this section.

Sediment and nutrients are major pollution-causing substances associated with nonpoint source 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, nonpoint pollution sources are diffuse in nature and occur at random time intervals depending on rainfall events. Below is a brief description of major areas of nonpoint sources of pollution in the Chowan River Basin.

3.4.1 Agriculture

There are a number of activities associated with agriculture that can serve as sources of water pollution. Land clearing and plowing make soils susceptible to erosion, which can then cause stream sedimentation. Pesticides and fertilizers (including chemical fertilizers and animal wastes) can be washed from fields, nursery farms or improperly designed storage or disposal sites. Construction of drainage ditches on poorly drained soils enhances the movement of soluble nutrients into groundwater.

Concentrated animal operations can be a significant source of nutrients, biochemical oxygen demand and fecal coliform bacteria if wastes are not properly managed (see Section 5.3.1 of Chapter 5 for discussion of animal waste rules). Impacts can result from over-application of wastes to fields, from leaking lagoons and from unpermitted flows of lagoon liquids to surface waters from improper waste lagoon management. Also there are potential concerns associated with nitrate-nitrogen movement through the soil from poorly constructed lagoons and from wastes applied to the soil surface.

Sediment production and transport is greatest from row crops and cultivated fields (Waters 1995; Lenat et al. 1979). Contour plowing, terracing, grassed waterways, conservation tillage, and no-till practices are several common methods used by most farmers to minimize soil loss. Maintaining a vegetated buffer between fields and streams is another excellent way to minimize soil loss to streams. Implementing Nondischarge Rule for Animal Waste Management System decreases the introduction of nutrients and fecal coliform bacteria from animal waste.

In the Chowan River basin, agriculture is thought to be the primary source of impairment. The Wiccacon River, Ahoskie Creek, Potecasi Creek and Cutawhiskie Swamp are all partially supporting their uses due to agriculture and channelization. Chapter 5 discusses agricultural nonpoint source control programs. A list of BMPs for addressing agricultural runoff is presented in Appendix V.

3.4.2 Urban/Residential

It is commonly known that urban streams are often degraded or impaired streams. Some potential impacts of stormwater runoff include:

- Polluted water: Numerous pollutants may be present in urban stormwater, including sediment, nutrients, bacteria, oxygen demanding substances, oil and grease, trace metals, road salt, and toxic/synthetic chemicals. These pollutants can impair aquatic life, reduce recreational value and threaten public health if drinking water sources and fish tissue become contaminated.
- Flooding: Flooding damages public and private property, including infrastructure. It can also threaten public safety.
- Eroded streambanks: Sediment clogs waterways and fills lakes and reservoirs. It can also smother the plants and animals in waterbodies and destroy the habitat necessary for reproduction of fish and aquatic animals. The erosion of streambanks causes loss of valuable property as stream width grows.
- Economic impacts: The economy can be impacted from a loss of recreation-related business and an increase in drinking water treatment costs.

Runoff from urbanized areas, as a rule, is more localized but can often be more severe than agricultural runoff. Any type of land-disturbing activity such as land clearing or excavation can result in soil loss and cause sedimentation into the waters in the watershed. The rate and volume of runoff in urban areas is much greater due both to the high concentration of impervious surface areas and to storm drainage systems that rapidly transport stormwater to nearby surface waters. This increase in volume and rate of runoff can result in streambank erosion and sedimentation in surface waters.

These drainage systems, including curb and guttered roadways, also allow urban pollutants to reach surface waters quickly and with little or no filtering. Pollutants include lawn care products such as pesticides and fertilizers; automobile-related pollutants such as fuel, lubricants, abraded tire and brake linings; lawn and household wastes (often dumped in storm sewers); road salts, and fecal coliform bacteria (from animals and failing septic systems). The diversity of these pollutants makes it very challenging to attribute water quality degradation to any one pollutant.

Replacement of natural vegetation with pavement, removal of streamside buffers and managed lawns reduce the ability of the watershed to filter pollutants before they enter the stream. The chronic introduction of these pollutants and increased flow and velocity into a stream results in degraded waters. Many urban streams are rated as biologically poor.

The population density map presented in Chapter 2 is an indicator of where urban development and potential urban stream impacts are likely to occur. Between 1982 and 1992, the most significant land use change in the basin was seen in the urban/built-up category with a 59% increase. Although population growth in the basin has been and is projected to be moderate, it will be important to properly manage the growth that will likely occur in the larger municipal areas. Management strategies for addressing urban runoff are presented in Chapter 6. A list of BMPs for addressing urban runoff is presented in Appendix V.

3.4.3 Construction

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 in a basin. Construction of single family homes in rural areas can also be a source of sedimentation when homes are placed in or near stream corridors. This latter form of development can be seen throughout the Chowan River basin.

As a pollution source, construction activities are typically temporary, but the impacts can be severe and long lasting (see discussion in sediment section above). Construction activities tend to be concentrated in the more rapidly developing areas of the basin. However, road construction is widespread and often involves stream crossings in remote or undeveloped areas of the basin. In addition, resort development in relatively undeveloped areas can be devastating to previously unimpacted streams.

Construction-related sedimentation is addressed through the Sedimentation Pollution Control Act (see Section 5.5.3 in Chapter 5). A list of BMPs for controlling erosion and sedimentation is presented in Appendix V.

3.4.4 Timber Harvesting

Undisturbed forested areas are an ideal land cover for water quality protection. They stabilize the soil, filter rainfall runoff and produce minimal loadings of organic matter to waterways. In addition, forested stream buffers can filter impurities from runoff from adjoining nonforested areas.

Improper forest management practices can adversely impact water quality in a number of ways. Without proper BMPs, large clearcutting operations can change the hydrology of an area and significantly increase the rate and flow of stormwater runoff. This results in both downstream flooding and stream bank erosion. Clearcutting, when compared to selective cutting, can cause a much higher rate of erosion (Waters 1995). Some experts have concluded that sedimentation from timber harvesting is more related to raods and skid trails than it is to the method of harvest (Stone, et. al., 1978).

Careless harvesting and road and stream crossing construction can transport sedimentation to downstream waters. Streams with sedimentation may require many years to restore. Removing riparian vegetation along stream banks can cause water temperature to rise, destabilize the shoreline and minimize or eliminate the runoff protection benefits of the buffer. Sedimentation due to forestry practices is most often associated with the construction and use of logging roads, particularly when roads are built near streams (Waters 1995). Density and length of logging roads can be major factors in the amount of sedimentation produced.

Timber harvesting is an important industry in the Chowan River basin and is sometimes done at the onset of clearing for site development and agricultural activities. However, it is critical that all efforts be made to minimize sediment loss and runoff so as to protect other natural resources in this basin. These resources include anadromous and resident fish spawning areas and habitat, recreational uses and aesthetics. This is especially important in light of a trend toward increased logging in North Carolina and in the southeast United States, in general.

The NC Division of Forest Resources (DFR) is implementing various measures for protecting water quality statewide. These measures began with the creation of voluntary *Forest Practices Guidelies Related to Water Quality* (FPGs). These measures were voluntarily applied best management practices, which had no enforcement power by any agency. In 1989, the Sedimentation Pollution Control Act (SPCA) was amended to require compliance with nine performance standards in order to remain exempt from the SPCA's permitting requirements. These nine standards are the FPGs whose complinace is accomplished throught the use of BMPs. The *Forestry Best Practices Manual* was published in September, 1989 to guide forestry operations in protecting water quality. The manual and the FPGs are available from the DFR office at no charge.

FPG/BMP inspections are carried out continuously by DFR field personnel in the course of their normal duties. Examinations of 3,318 sites in FY 1995-96 revealed an initial compliance rate of 94%. Two systematic surveys by a DFR staff hydrologist in 1995 and 1996 examined 196 and 223 sites respectively. Compliance with FPGs and BMPs was found to be 92% and 95% for the two years, respectively. A summary of activities and past accomplishments in the Chowan River basin is reported in Chapter 5.

Section 5.6.3 describes several programs that are aimed at either encouraging or requiring utilization of forest best management practices at the state and federal level. A list of forest FPGs is presented in Appendix V.

3.4.5 Mining

Mining is a common activity in the Piedmont and Coastal Plain regions and can produce high localized levels of stream sedimentation. Sediment may be washed from mining sites or it may enter streams from the wash water used to rinse some mined products. In addition, abandoned gold mined lands are suspected of being the sources of mercury in stream waters because of its historic use for the amalgamation of gold. Mining has not been identified as a source of pollution in the Chowan basin. A list of BMPs to address mining is presented in Appendix V.

3.4.6 Onsite Wastewater Disposal

Septic systems contain all of the wastewater from a household or business. The septic tank removes some wastes, but the soil drainfield provides further absorption and treatment. Septic tanks can be a safe and effective method for treating wastewater if they are sized, sited, and maintained properly. However, if the tank or drainfield malfunction or are improperly placed, constructed or maintained, nearby wells and surface waters may become contaminated.

Some of the potential problems from malfunctioning septic system include:

- Polluted groundwater: Pollutants in sewage include bacteria, nutrients, toxic substances, and oxygen-consuming wastes. Nearby wells can become contaminated by septic tanks.
- Polluted surface water: Often, groundwater carries the pollutants mentioned above into surface waters, where they can cause serious harm to aquatic ecosystems. Septic tanks can also leak into surface waters both through or over the soil.
- Risks to human health: Septic system malfunctions can endanger human health when they contaminate nearby wells, drinking water supplies, and fishing and swimming areas.

Pollutants associated with onsite wastewater disposal may also be discharged directly to surface waters through *straight pipes* (i.e., illegal direct pipe connections between the septic system and surface waters). These types of discharges, if unable to be eliminated, must be permitted under the NPDES program and be capable of meeting effluent limitations specified to protect the receiving stream water quality, including disinfection.

Onsite wastewater disposal is most prevalent in rural portions of the basin and at the fringes of urban areas. Fecal coliform contamination from failing septic systems is of particular concern in waters used for swimming, water supply and other related activities (Chapter 4). Regulatory programs and BMPs pertaining to onsite wastewater disposal are presented in Appendix V.

3.4.7 Solid Waste Disposal

Solid wastes (usually disposed of in landfills) may include household wastes, commercial or industrial wastes, refuse or demolition waste, infectious wastes or hazardous wastes. Improper disposal of these types of wastes can serve as a source of a wide array of pollutants. The major water quality concern associated with modern solid waste facilities is controlling the leachate and stabilizing the soils used for covering many disposal facilities. Properly designed, constructed and operated facilities should not significantly effect water quality.

Groundwater and surface water monitoring is required at all permitted Municipal Solid Waste Sites (MSW) and all Construction and Demolition landfills. Monitoring efforts have been required since July 1989. All MSW landfills must have a liner system in place by January 1, 1998. All existing unlined landfills must close at this same time.

Section 5.3.5 briefly summarizes state, local and federal solid waste recycling programs.

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