APPENDIX II

DWQ Water Quality Monitoring Programs:

- Benthic Macroinvertebrate Sampling
- Fisheries Studies
- Lakes Assessment
- Effluent Toxicity Testing

A - II.1 BENTHIC MACROINVERTEBRATES

Freshwaters

Benthic macroinvertebrates, or benthos, are organisms that live in and on the bottom substrates of rivers and streams. These organisms are primarily aquatic insect larvae in freshwater systems, and polychaetes, crustacea, and mollusks in estuarine systems. The use of benthos data has proven to be a reliable monitoring tool, as benthic macroinvertebrates are sensitive to subtle changes in water quality. The benthic community also integrates the effects of a wide array of potential pollutant mixtures. Criteria have been developed for freshwater to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups Ephemeroptera, Plecoptera, and Trichoptera (EPT S). Higher taxa richness values are associated with better water quality. Likewise, ratings can be assigned with a Biotic Index. This index summarizes tolerance data for all taxa in each collection. The two rankings are given equal weight in final site classification for qualitative samples. Taxa richness alone is used to assign bioclassifications for EPT samples. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is poorly assessed by a taxa richness analysis. Different criteria have been developed for different ecoregions (mountains, piedmont, and coastal) within North Carolina. Criteria are being developed for estuarine benthos samples, but at the present time estuarine samples cannot be given a water quality evaluation.

<u>Classification Criteria by Ecoregion*</u>

A. EPT taxa richness values

	10-sample Qualitative Samples			4-sample EPT Samples		
	Mountains	Piedmont	Coastal	Mountains	Piedmont	Coastal
Excellent	>41	>31	>27	>35	>27	>23
Good	32-41	24-31	21-27	28-35	21-27	18-23
Good-Fair	22-31	16-23	14-20	19-27	14-20	12-17
Fair	12-21	8-15	7-13	11-18	7-13	6-11
Poor	0-11	0-7	0-6	0-10	0-6	0-5

B. Biotic Index Values (Range = 0-10)

	Mountains	Piedmont	Coastal
Excellent	<4.05	<5.19	<5.47
Good	4.06-4.88	5.19-5.78	5.47-6.05
Good-Fair	4.89-5.74	5.79-6.48	6.06-6.72
Fair	5.75-7.00	6.49-7.48	6.73-7.73
Poor	>7.00	>7.48	>7.73

*These criteria apply to flowing water systems only. Biotic index criteria are only used for full-scale (10-sample) qualitative samples.

Saltwaters

The effort to develop a method to assess water quality based on estuarine macroinvertebrates started in North Carolina in late 1990. By 1992, several standard methods of sampling and data analysis had been tested and found to be inadequate for North Carolina waters. In 1993, it was demonstrated that an Estuarine Biotic Index designed for Florida could also be used in North Carolina to accurately rank sites of varying water quality. It was also shown that sampling by epibenthic trawl was more effective at ranking sites than infaunal sampling with a petite ponar. Even so, using the Florida Estuarine Biotic Index (FEBI) on ponar-collected data was found to yield accurate results more often than not and more consistently than any other metric tested. It was also found that another Florida sampling technique, a semi-quantitative timed sweep, yielded results comparable to our historical samples, so a change in methods would not necessarily nullify previous estuarine work. Sampling for long term databases after December 1993 used the semi-quantitative sweep.

In 1994, further use of this semi-quantitative sweep method and FEBI suggested that they might also be useful at low salinities. A separate test in 1994 suggested that the FEBI was the only one of 17 metrics to accurately rank variably impacted sites for each of three sampling methods (petite ponar, epibenthic trawl, semi-quantitative sweep). Additionally, it was found that for semi-quantitative sweeps, the metrics Total taxa (S) and Amphipoda and Caridian shrimp (A+) taxa could also correctly rank the sites. In an early attempt at biocriteria development, it appeared that in high salinity waters, Total taxa (S), Biotic Index (BI), and Amphipoda and Caridian shrimp (A+) were most useful for delineating the highest quality areas.

These observations were confirmed with additional sampling during which it was also found that the metrics % Crustacean taxa and % Spionid and Capitellid polychaete taxa correctly ranked petite ponar samples 75% of the time. The FEBI was modified to create the North Carolina Estuarine Biotic Index (EBI) which more closely reflects taxa and tolerances in North Carolina.

A - II.2 FISHERIES

Fish Communtiy Structure Assessment
The North Carolina Index of Biotic Integrity (NCIBI) is a modification of the Index of Biotic Integrity (Karr, 1981; Karr et al., 1986). The method was developed for assessing a stream's biological integrity by examining the structure and health of its fish community. The scores derived from this index are a measure of the ecological health of the waterbody and may not necessarily directly correlate to water quality. A stream with excellent water quality, but poor to fair habitat would not rate excellent in this index; however, a stream which rates excellent on the NCIBI would be expected to have excellent water quality. The NCIBI is not applicable to high elevation trout streams, lakes, or estuaries.

The Index incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition. The NCIBI summarizes the effects of all classes of factors influencing aquatic faunal communities (water quality, energy source, habitat quality, flow regime, and biotic interactions). The assessment of biological integrity using the NCIBI is provided by the cumulative assessment of 12 parameters, or metrics. While any change in a fish community can be caused by many factors, certain aspects of the community are generally more responsive to specific influences. Species composition measurements reflect habitat quality effects. Information on trophic composition reflects the effect of biotic interactions and energy supply. Fish abundance and condition information indicates additional water quality effects. It should be noted, however, that these responses may overlap. For example, a change in fish abundance may be due to decreased energy supply or a decline in habitat quality, not necessarily a change in water quality.

NCIBI scores and integrity classes are presented in Tables A-II.1 and A-II.2.

Table A-II.1 <u>NCIBI Scores and Integrity Classes</u>

Excellent	58-60
Good-Excellent	53-57
Good	48-52
Fair-Good	45-47
Fair	40-44
Poor-Fair	35-39
Poor	28-34
Very Poor - Poor	23-27
Very Poor	12-22
No Fish	

Classes listed above, but not below, have attributes of two classes.

Table A-II.2 **NCIBI Integrity Classes and attributes of those classes** (modified from Karr et al., 1986)

Integrity Class	Attributes
Excellent	Comparable to the best situations without human disturbance; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of size classes; balanced trophic structure.
Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; trophic structure shows some signs of stress.
Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure.
Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; diseased fish often present.
Very poor	Few fish present, mostly introduced or tolerant forms, disease fin damage and other anomalies regular
No fish	Repeated sampling finds no fish.

Streams with larger watersheds or drainage areas are expected to support more fish species and a larger number of fish.

Fish TIssue

Since fish spend their entire lives in the aquatic environment, they incorporate chemicals from this environment into their body tissues. Contamination of aquatic resources, including freshwater, estuarine, and marine fish and shellfish species, have been documented for heavy metals, pesticides, and other complex organic compounds. Once these contaminants reach surface waters, they may be available for bioaccumulation either directly or through aquatic food webs and may accumulate in fish and shellfish tissues. Results from fish tissue monitoring can serve as an important indicator of further contamination of sediments and surface water.

Fish tissue analysis results are used as indicators for human health concerns, fish and wildlife health concerns, and the presence and concentrations of various chemicals in the ecosystem.

In evaluating fish tissue analysis results, several different types of criteria are used. Human health concerns related to fish consumption are screened by comparing results with Federal Food and Drug Administration (FDA) action levels, U. S. Environmental Protection Agency (EPA) recommended screening values, and criteria adopted by the North Carolina Division of Epidemiology.

The FDA levels were developed to protect humans from the chronic effects of toxic substances consumed in foodstuffs and thus employ a "safe level" approach to fish tissue consumption. A list of fish tissue analytes accompanied by their FDA criteria are presented below. At present, the FDA has only developed metals criteria for mercury. Individual parameters which appear to be of potential human health concern are evaluated by the North Carolina Division of Epidemiology by request of the Water Quality Section.

Food and Drug Administration (FDA) Action Levels

Metals

Mercury	1.0 ppm		

Organics

Aldrin	0.3 ppm	o,p DDD	5.0 ppm
Dieldrin	0.3 ppm	p,p DDD	5.0 ppm
Endrin	0.3 ppm	o,p DDE	5.0 ppm
Methoxychlor	None	p,p DDE	5.0 ppm
Alpha BHC	None	o,p DDT	5.0 ppm
Gamma BHC	None	p,p DDT	5.0 ppm
PCB-1254	2.0 ppm	cis-chlordane	0.3 ppm
Endosulfan I	None	trans-chlordane	0.3 ppm
Endosulfan II	None	Hexachlorobenzene	None

In the guidance document, Fish Sampling and Analysis: Volume 1 (EPA823-R-93-002), the EPA has recommended screening values for target analytes which are formulated from a risk assessment procedure. EPA screening values are the concentrations of analytes in edible fish tissue that are of potential public health concern. The DEM compares fish tissue results with EPA screening values to evaluate the need for further intensive site specific monitoring. A list of target analytes and EPA recommended screening values for the general adult population is presented below.

The North Carolina Division of Epidemiology has adopted a selenium limit of 5 ppm for issuing fish consumption advisories. Total DDT includes the sum of all its isomers and metabolites (i.e. p,p DDT, o,p DDT, DDE, and DDD). Total chlordane includes the sum of cis-and trans- isomers as well as nonachlor and oxychlordane. Although the EPA has suggested a screening value of 7.0 x 10-7 ppm for dioxins, the State of North Carolina currently uses a value of 3.0 ppt in issuing fish consumption advisories.

Environmental Protection Agency (EPA) Screening Values

Metals

Cadmium	10.0 ppm
Mercury	0.6 ppm
Selenium	50.0 ppm

Organics

Chlorpyrifos	30.0 ppm
Total chlordane	0.08 ppm
Total DDT	0.3 ppm
Dieldrin	0.007 ppm
Dioxins	7.0×10^{-7} ppm
Endosulfan (I and II)	20.0 ppm
Endrin	3.0 ppm
Heptachlor epoxide	0.01 ppm
Hexachlorobenzene	0.07 ppm
Lindane	0.08 ppm
Mirex	2.0 ppm
Total PCB's	0.01 ppm
Toxaphene	0.1 ppm

Results of fish tissue analyses for the Chowan River Basin have been presented in Chapter 4.

A - II.3 LAKES ASSESSMENT PROGRAM

Lakes are valued for the multitide of benefits they provide to the public, including recreational boating, fishing, drinking water, and aesthetic enjoyment. The North Carolina Lake Assessment Program seeks to protect these waters through monitoring, pollution prevention and control, and restoration activities. Assessments have been made at all publicly accessible lakes, lakes which supply domestic drinking water, and lakes (public or private) where water quality problems have been observed. Data are used to determine the trophic state (a relative measure of nutrient enrichment and productivity) of each lake, and whether the designated uses of the lake have been threatened or impaired by pollution.

Tables presented in each subbasin summarize data used to determine the trophic state and use support status of each lake. These determinations are based on information from the most recent summertime sampling (date listed). The most recent North Carolina Trophic State Index (NCTSI) value is shown followed by the descriptive trophic state classification (O=oligotrophic, M=mesotrophic, E=eutrophic, H=hypereutrophic, D=dystrophic).

Numerical indices are often used to evaluate the trophic state of lakes. An index was developed specifically for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NCDNRCD, 1982). The North Carolina Trophic State Index (NCTSI) is based on total phosphorus (TP in mg/l), total organic nitrogen (TON in mg/l), Secchi depth (SD in inches), and chlorophyll-a (CHL in µg/l). Lakewide means for these parameters are manipulated to produce a NCTSI score for each lake using the following equations:

$$\text{TON score} = \frac{\text{Log(TON)} + (0.45)}{0.24} \times 0.90$$

$$\text{TP score} = \frac{\text{Log(TP)} + (1.55)}{0.35} \times 0.92$$

$$\text{SD score} = \frac{\text{Log(SD)} - (1.73)}{0.35} \times -0.82$$

$$\text{CHL score} = \frac{\text{Log(CHL)} - (1.00)}{0.43} \times 0.83$$

$$\text{NCTSI} = \text{TON score} + \text{TP score} + \text{SD score} + \text{CHL score}$$

In general, NCTSI scores relate to trophic classifications as follows: less than -2.0 is oligotrophic, -2.0 to 0.0 is mesotrophic, 0.0 to 5.0 is eutrophic, and greater than 5.0 is hypereutrophic. When scores border between classes, best professional judgment is used to assign an appropriate classification. NCTSI scores may be skewed by highly colored water typical of dystrophic lakes. Some variation in the trophic state of a lake between years is not unusual due to the potential variability of data collections which usually involve sampling on a single day during the growing season. This survey methodology does not adequately evaluate changes which might occur throughout the year between lake samplings. More intensive (monthly) monitoring is required to identify lake specific variability. However, monitoring a lake once per growing season does provide a relatively valuable assessment of water quality conditions on a large number of lakes.

Lakes are classified for their "best usage" and are subject to the state's water quality standards. Primary classifications are C (suited for aquatic life propagation/protection and secondary recreation such as wading), B (primary recreation, such as swimming, and all class C uses), and WS-I through WS-V(water supply source ranging from highest watershed protection level I to lowest watershed protection V, and all class C uses). Lakes with a CA designation represent water supplies with watersheds that are considered to be Critical Areas (i.e., an area within 1/2 mile and draining to water supplies from the normal pool elevation of reservoirs, or within 1/2 mile and draining to a river intake). Supplemental classifications in the New Fear River basin may include SW (slow moving Swamp Waters where certain water quality standards may not be applicable), NSW (Nutrient Sensitive Waters subject to excessive algal or other plant growth where nutrient controls are required), HQW (High Quality Waters which are rated excellent based on biological and physical/chemical characteristics), and ORW (Outstanding Resource Waters which are unique and special waters of exceptional state or national recreational or ecological value). A complete listing of these water classifications and standards can be found in Title 15 North Carolina Administrative Code, Chapter 2B, Section .0100 and .0200.

The summary tables presented within the body of this document list lakewide averages of total phosphorus (TP in mg/l), total organic nitrogen (TON in mg/l), chlorophyll *a* (CHLA in µg/l), and Secchi depth, followed by surface water classification. Causes of use impairment are explained below each table. Algal Growth Potential Tests (AGPT) have not been conducted on these lakes. Merchants Millpond in Subbasin 030501 is the only lake which has been monitored in the Chowan River Basin as part of the Lakes Assessment Program. This lake was sampled most recently in 1995 and is discussed in detail in Chapter 4.

A-II.4 AQUATIC TOXICITY MONITORING

Acute and/or chronic toxicity tests are used to determine toxicity of discharges to sensitive aquatic species (usually fathead minnows or the water flea, Ceriodaphnia dubia). Results of these tests have been shown by several researchers to be predictive of discharge effects on receiving stream populations. Many facilities are required to monitor whole effluent toxicity by their NPDES permit or by administrative letter. Other facilities may be tested by DEM's Aquatic Toxicology Laboratory. The Aquatic Survey andToxicology Unit maintains a compliance summary for all facilities required to perform tests and provides a monthly update of this information to regional offices and DEM administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.