

Section 2

Data Sources and Methods

This chapter discusses major sources of information and provides an overview of the methods used to develop the watershed assessment. An introduction to the sub-watershed functional analysis is also presented.

2.1 Overview

The watershed assessment draws on three primary data sources and several supplemental sources of information. The primary data sources include the following:

- Water quality monitoring conducted by the NCDWQ, including fish community, benthic community, chemical and toxicity monitoring.
- A GIS (Geographic Information System) data base and spreadsheet pollutant model developed by the TVA as part of an IPSI analysis conducted for the planning area.
- A field assessment of stream habitat and physical condition coordinated by Equinox and conducted jointly by Equinox and NCDWQ staff.

Each of these primary sources is described in more detail below. Additionally, a number of secondary data sources were used. These included:

- Other available GIS data;
- Field observations made by Equinox and NCDWQ staff during windshield surveys and watershed reconnaissance;
- Investigations by NCDWQ into specific water quality problems. These included both site investigations and review of agency records.
- A survey of crayfish and mussel taxa of natural heritage interest conducted by the NCWRC in August 2006.

These secondary sources will not be described further here, but will be discussed later in the report as appropriate.

2.2 NCDWQ Water Quality Monitoring

NCDWQ conducted a multi-faceted monitoring effort in support of the NCEEP's local watershed planning in the Peachtree-Martin's Creek area. This effort is fully described in a NCDWQ summary report entitled *Peachtree-Martins Creek Water Quality Study* (NCDWQ, 2007), and in a variety of supporting documents. Because of the diversity of approaches used, monitoring methods are difficult to summarize succinctly. The paragraphs below present an overview of the methods used. Additional pertinent details are presented in the course of this document when specific monitoring results are discussed. Maps and tables showing monitoring locations are located in Section 4. Applicable NCDWQ documents are included as Appendix E (available as a separate volume of this report) and should be consulted for further information.

2.2.1 Benthic Macroinvertebrate Community Sampling

Benthic community sampling was conducted by two NCDWQ sampling teams. The NCDWQ Watershed Assessment Team (WAT) sampled 14 sites in January and February 2006 (NCDWQ 2006h and NCEEP 2007), and the Biological Assessment Unit (BAU) sampled 12 sites in March 2006 (NCDWQ 2006a). Sites were located on both Peachtree and Martins Creeks, as well as on smaller streams throughout the planning area.

The BAU and WAT samples were collected using different NCDWQ-approved methods. The WAT used the "EPT" method, a sampling approach focusing on three major insect groups-- mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). The BAU used more comprehensive methods (Qual 4 and standard qualitative sampling), which sampled all aquatic macroinvertebrates. See NCDWQ 2006d and 2007 for additional details.

Two primary indicators or metrics are commonly derived from macroinvertebrate community data: 1) the diversity of a more sensitive subset of the invertebrate fauna is evaluated using EPT taxa richness; and 2) the pollution tolerance of those organisms present is evaluated using a biotic index (BI). *Generally, the higher the EPT number, the healthier the benthic community.* A low BI indicates a community dominated by taxa that are relatively sensitive to pollution and other disturbances (*intolerant*). A high BI indicates greater dominance by organisms that are pollution and disturbance insensitive (*tolerant*). *Thus, the lower the BI number, the healthier the benthic community.* The BI can be calculated based on all taxonomic groups, or based only upon EPT taxa (EPT BI).

Biotic index values (BI or EPT BI) are combined with EPT taxa richness ratings to produce a final bioclassification (Excellent, Good, Good-Fair, Fair, and Poor). Final bioclassifications are used to determine if a stream is impaired. Streams with bioclassifications of Excellent, Good, and Good-Fair are all considered to be supporting their designated uses. Those with Fair and Poor ratings are considered impaired and are typically added to the State's 303(d) list.

Several other indicators are sometimes derived from these data. These include abundance (the total number of individual organisms collected) and the number or percentage of intolerant organisms (taxa considered to be sensitive, or intolerant to, pollution).

Streams with a drainage area of 3 square miles or more receive a formal rating (bioclassification). Smaller streams are generally not rated, though conclusions regarding likely overall condition and major stressors can often be drawn. A small stream is rated as Not Impaired (NI) if it meets the criteria for a Good-Fair or higher rating using the standard qualitative criteria. If this stream would not be Good-Fair or higher using standard qualitative criteria, it is listed as Not Rated (NR).

2.2.2 Fish Community Sampling

The fish community was monitored at four locations in March 2006, two sites on Martins Creek and one each on Peachtree Creek and Slow Creek (NCDWQ, 2006b). Sampling was carried out using NCDWQ standard methods, and the fish communities rated with the NC Index of Biotic Integrity (NCIBI) protocols (NCDWQ, 2006b and 2007). NCIBI scores are determined by considering a number of individual metric scores, including number of species, number of fish, number of minnow species, number of darter species, number of rock bass, smallmouth bass, and trout species, number of intolerant species, percentage of insectivores, percentage of

omnivores and herbivores, percentage of tolerants, and percentage of species with multiple age groups. NCIBI scores are translated into bioclassifications as for benthic macroinvertebrate communities (Excellent, Good, Good-Fair, Fair, and Poor). As with benthic data, streams with bioclassifications of Excellent, Good, and Good-Fair are all considered to be supporting their designated uses.

2.2.3 Aquatic Habitat Assessment

NCDWQ conducted a habitat assessment for each reach at which fish or benthic community sampling was conducted. NCDWQ's standard habitat assessment protocol for mountain and piedmont streams was used (NCDWQ, 2007). This protocol rates the overall aquatic habitat of a reach by adding the scores of a series of habitat factors relevant to fish and/or macroinvertebrates (Table 2.1). Total scores may range from zero (worst) to 100 (best).

Table 2.1 Metrics Included in NCDWQ Habitat Assessment Protocol

Habitat Metric	Maximum Possible Score	Low Score Interpretation	High Score Interpretation
Channel modification	5	straight channelized reach	natural channel with frequent bends
In-stream microhabitat variety and area	20	few habitat types with limited aerial coverage	diverse habitat types with extensive aerial coverage
Bottom substrate type and embeddedness	15	homogeneous substrate, high embeddedness	mixed large substrate with low embeddedness
Pool variety and frequency	10	pools infrequent, similar in size	pools frequent, sizes diverse
Riffle frequency and size	16	riffles infrequent, small relative to stream size	riffles frequent, large relative to stream size
Bank stability and vegetation	14	banks eroding, poorly vegetated	banks stable, well-vegetated
Light penetration/canopy coverage	10	no shading	stream well shaded, with some limited light penetration
Riparian zone width and integrity	10	wooded riparian zone is narrow, with frequent breaks	wooded riparian zone is wide, breaks rare

2.2.4 Chemical Monitoring

NCDWQ conducted chemical monitoring activities at 33 sites throughout the planning area. Sites were selected for a variety of reasons, including synoptic sub-watershed monitoring, exploratory investigations and the evaluation of various site specific concerns. Most sampling was carried out during baseflow conditions, which was defined as a period of at least 48 hours without precipitation. However, some sampling took place during storm events, on the day following precipitation or occasionally when prior precipitation was unknown.

Parameters varied by site, but common parameters included:

- Dissolved oxygen;
- pH;
- Specific conductance;
- Fecal coliform bacteria;

- Total Kjeldahl nitrogen (TKN);
- Ammonia nitrogen (NH₃);
- Nitrite (NO₂) + nitrate (NO₃) nitrogen;
- Total phosphorus;
- Suspended residue (total suspended solids, or TSS); and
- Turbidity.

Particular attention was focused on the monitoring of nutrients and fecal coliform bacteria. Metals were also sampled as part of the toxicity monitoring, as discussed below. Monitoring at many sites included only one or two sampling events, and few sites were sampled more than four times. Samples were collected following the protocols specified in the NCDWQ Intensive Survey Unit's standard operating procedure. Laboratory analyses were conducted by the NCDWQ Laboratory Section. See Appendix E for additional details.

2.2.5 Toxicity Monitoring

Two approaches were used at six locations to evaluate whether toxic conditions existed (NCDWQ, 2006g). The first approach, **toxicity screening**, involved comparing concentrations of specific pollutants to established thresholds of concentrations known to be toxic. The pollutants evaluated included ten metals: aluminum, arsenic, cadmium, chromium, copper, iron, lead, nickel, silver and zinc. The benchmarks used are from the USEPA's National Ambient Water Quality Criteria (NAWQC).

The second approach used **toxicological assays** to evaluate the response of various aquatic organisms to the samples collected. The approach used a panel of toxicity assays employing multiple organisms and endpoints for both water and sediment samples. Assays include organisms representing various functional levels of the freshwater ecosystem. Organisms included bacteria, algae, crustaceans and other organisms (see Appendix E).

2.3 Integrated Pollutant Source Identification

NCEEP contracted with TVA to conduct an Integrated Pollutant Source Identification (IPSI) analysis of a portion of the Hiwassee River basin, including the project area. The IPSI analysis involved the development of a geographic database, derived largely from the interpretation of recent aerial photographs, providing information on features related to potential watershed pollution sources. Aerial photography was flown in March 2005, and the final IPSI products were delivered in June 2006. Data most relevant to the current planning effort include: land use/land cover, channelized streams, streambank erosion sites, eroding road ditches, livestock operations, and a classification of the type and condition of riparian area vegetation.

The IPSI also includes a nonpoint source (NPS) loading model which uses Microsoft Excel to estimate annual pollutant loads based upon the data in the nonpoint source inventory. Loads for each sub-watershed are estimated for total phosphorus (TP), total nitrogen (TN), five-day biochemical oxygen demand (BOD₅) and total suspended solids (TSS). Elements of the model were subsequently modified by Equinox to improve the utility of TSS load estimates.

The IPSI data base and models are described in a report by TVA (TVA, 2006). Appendix A discusses selected features of the IPSI particularly relevant to the current watershed assessment.

2.4 Phase 2 Field Survey

In August and September 2006 teams of Equinox and NCDWQ staff conducted field assessments of 62 stream sites. The purpose of the field assessment was to supplement existing NCDWQ stream habitat data and to assess channel physical condition, including factors such as bank erosion, incision, and sediment impacts. Field sites were selected to be representative of sub-watershed conditions in order to allow meaningful conclusions to be drawn regarding individual sub-watersheds.

Data were collected for the following indicators:

- Overall aquatic habitat (and component metrics), using the NCDWQ habitat protocol for piedmont and mountain streams;
- Riffle pebble count (measure of substrate size), using the standard Equinox protocol;
- Bank erosion hazard index (BEHI), using the standard Equinox protocol;
- Bank height ratio using the approach outlined by Rosgen (2001); and
- Riffle embeddedness (measure of sediment deposition), using the standard Equinox protocol.

Assessments at each site were conducted on reaches 100 yards in length, although some protocols were applied to specific portions of the target reach. NCDWQ personnel measured temperature, conductivity, dissolved oxygen and pH at most sites. Assessment site locations are shown in Figure 4.3 and are discussed in Appendix B along with additional information on site selection and field methods.

2.5 Sub-Watershed Functional Analysis

The assessment of ecological function at the watershed and sub-watershed scale is an important component of the NCEEP's approach to local watershed planning. This section presents background material on the sub-watershed functional assessment, including a description of the general approach used and the selection of indicators. The scoring of indicators is discussed in Section 7, where the results of the analysis are presented.

2.5.1 Background and General Approach

Through guidance from its Watershed Needs Assessment Team, NCEEP currently seeks to evaluate watershed function in three broad areas (WNAT, 2003):

- 1) *Hydrology*, which includes functional elements relating to the storage and discharge of surface and ground water;
- 2) *Habitat and biological communities*, which includes both aquatic and terrestrial physical habitat as well as plant and animal distribution and abundance; and
- 3) *Water quality*, which includes elemental and thermal processes.

Specific functions recommended by the WNAT for consideration in a watershed assessment are defined in Table 2.2.

Table 2.2 Watershed Function Categories Defined by the Watershed Needs Assessment Team

Water Quality	Hydrology	Habitat-Biological Communities
<p>Elemental Cycling and Spiraling: Abiotic and biotic processes that convert elements from one form to another within a watershed.</p>	<p>Subsurface Water Storage: Availability of water storage beneath the surface.</p>	<p>Maintain Characteristic Plant Distribution and Abundance: The emphasis is on the dynamics, structure, species composition and physical characteristics of the plant community (upland, wetland and aquatic).</p>
<p>Removal and Transport: Of nutrients, contaminants, sediment and/or other elements or compounds.</p>	<p>Moderation of Groundwater Flow or Discharge: Capacity of a watershed to moderate rate of groundwater flow or discharge from upgradient sources.</p>	<p>Maintain Characteristic Animal Distribution and Abundance: The emphasis is on the dynamics, spatial distribution and species composition of the animal communities (terrestrial, semi-aquatic, aquatic).</p>
<p>Retention: Of nutrients, contaminants, sediment and/or other elements or compounds.</p>	<p>Surface Water Flow or Discharge: Capacity of a watershed to moderate surface water flow and energy from upgradient sources.</p>	<p>Physical Habitat Characteristics: Maintain interspersed, connectivity, temporal dynamics and spatial structure of the physical habitat.</p>
<p>Thermal Regulation: Absorption, storage and dissipation of thermal energy.</p>	<p>Dynamic Surface Water Storage: Capacity of a watershed to detain moving water from overbank flow for a short duration when flow is out of the channel; associated with moving water from overbank flow and/or upland surface water inputs by overland flow or tributaries.</p>	
	<p>Long Term Surface Water Storage: The capacity of a watershed to temporarily store (retain) surface water for long durations; associated with standing water not moving over the surface. Water sources maybe overbank flow, overland flow and/or channelized flow from uplands or direct precipitation.</p>	

Source: WNAT, 2003

Consistent with these objectives, Equinox assessed ecological function at the sub-watershed level for the Peachtree-Martins Creek planning area, applying the approach outlined below.

1. A suite of indicators was selected for each of the three broad functional areas.
2. Sub-watersheds were scored on each indicator, with scores ranging from 1 (Poor condition) to 4 (Excellent condition).
3. Component indicator scores were averaged for each of the three functional areas, producing a hydrology, habitat/biological community and water quality functional score for each sub-watershed.
4. A total score for each sub-watershed was then calculated by averaging the three functional area scores.

2.5.2 Selection of Indicators

Most of the functional elements enumerated by the WNAT are difficult to measure directly, especially within the time frame and resource constraints of a planning project. The measures feasible for use in the Peachtree-Martins Creek planning effort are generally either indicators of

condition believed to be associated with ecological function, or indicators of stressors likely to impact function. Indicators measured do not necessarily fit the specific functions listed by the WNAT.

The indicators selected are summarized in Table 2.3 and discussed below.

Table 2.3 Summary of Watershed Function Indicators for Peachtree-Martins Creek Planning Area

Functional Area	Indicator	Measure and Data Source
Hydrology	Forest Area Extent	% sub-watershed forested (GIS analysis of IPSI data)
	Impervious Cover	% sub-watershed impervious area (GIS analysis of IPSI data)
	Extent of Stream Channelization	% of streams channelized (GIS analysis of IPSI data)
	Streambank Stability	Mean BEHI score (Equinox field survey)
Habitat and Biological Communities	Overall Aquatic Habitat Quality	Mean total habitat score, NCDWQ stream habitat protocol (field surveys)
	Benthic Macroinvertebrate Community Integrity	EPT Biotic Index (NCDWQ monitoring)
	Microhabitat Diversity and Abundance	Mean microhabitat score, NCDWQ stream habitat protocol (Equinox field survey)
	Riffle Embeddedness	Median riffle embeddedness (Equinox field survey)
	Pool Frequency and Variety	Median pool habitat score, NCDWQ stream habitat protocol (field surveys)
Water Quality	Specific Conductance	Mean specific conductance (NCDWQ field measurement)
	Riparian Area Condition	Percent of stream length rated adequate on both banks (GIS analysis of IPSI data)
	Total Suspended Solids Load	IPSI NPS model estimates (tons/yr/sq mi)
	Benthic Macroinvertebrate Community Integrity	EPT Biotic Index (NCDWQ monitoring)
	Nutrient Concentration	Nitrite-Nitrate concentration (NCDWQ monitoring data)

Indicators of Hydrologic Function

- *Forest Area Extent.* In areas such as the eastern United States, where forest is the natural vegetative cover, the retention of forested areas is critical to watershed hydrologic function (Booth et al, 2002). Forest cover helps maintain natural infiltration and transport processes. The extent of forest area in each sub-watershed was calculated from the IPSI database.
- *Impervious Cover.* The extent of impervious cover is a second factor that is widely acknowledged to have a substantial impact on watershed hydrologic function, as well as on other ecological factors (Center for Watershed Protection, 2003). The impervious cover percentage calculated by TVA for the IPSI was used.
- *Extent of Stream Channelization.* Direct channel modification through straightening, realignment or dredging can significantly impact drainage hydrology, as well as stream habitat and other factors. Channel modification is probably more widespread in the eastern part of NC than in the mountains. In some coastal plain drainages virtually the entire drainage network has been channelized (Mason et al, 1990). Channel

modification is carried out less frequently on higher gradient streams, limiting the maximum level of channel modification likely in most mountain drainages. The measure used here is the percentage of sub-watershed stream length classified as channelized by the IPSI.

- *Streambank Stability.* Bank instability is an indicator of changing stream morphology and often indicates that changes in watershed hydrology have occurred. High bank erosion rates also indicate the likelihood of higher than normal sediment loading, which will affect water quality and habitat functions. The BEHI (Bank Erosion Hazard Index) developed by Rosgen (1996) was used as a measure of bank stability.
- *Other Potential Measures.* The extent of forested riparian areas (areas rated as Adequate in the IPSI dataset) was considered, but it was decided that this was more appropriate as a water quality indicator. Channel incision was also considered as a hydrologic indicator. Incision can limit access of waters to floodplain areas and has an important impact on stream hydrology. The qualitative nature of the incision data available, however, does not lend itself to the rating approach used here (Appendix B). An examination of the available incision data indicates that it largely supports the conclusions of the other hydrologic indicators that hydrologic impacts are only low to moderate in most sub-watersheds.

Indicators of Habitat and Biological Communities.

- *Overall Aquatic Habitat Quality.* Stream physical habitat is a critical indicator of ecological condition. The NCDWQ habitat protocol for piedmont and mountain streams, administered by both NCDWQ and Equinox at numerous sites, was used for this metric. This protocol provides an overall rating of aquatic habitat condition for fish and macroinvertebrates.
- *Benthic Macroinvertebrate Community Integrity.* The integrity of aquatic communities provides a direct measure of the status of biological communities and is a critical component of watershed function. The EPT Biotic Index calculated from NCDWQ monitoring is used here. This measure captures one component of community integrity. A taxa richness indicator, such as total richness or EPT richness is arguably preferable but such a measure could not be used for several reasons. Collection method varied by site, so total richness was not consistently measured. The use of EPT richness was explored, but no way could be developed to scale this indicator appropriately. Since many sites sampled by WAT were small, adjusting for expected decreased richness with declining stream size was essential. Macroinvertebrate community data are available for 16 of the 19 sub-watersheds.
- *Microhabitat Diversity and Abundance.* This indicator refers to the diversity and abundance of stream microhabitat types—rocks, macrophytes, sticks and leaf packs, snags and logs, and undercut banks or root mats—and is one of the most critical components of aquatic habitat quality. Information on microhabitat is available from the NCDWQ habitat protocol used by Equinox during the stream field assessment. This measure was calculated using the method developed previously by Equinox for the Bald Creek Local Watershed Plan (Equinox, 2006b). The metric was derived by summing scores for each of five habitat types potentially present. Each type is given a score of 0 if it is absent from a survey reach, 1 if it is rare, 2 if it is common and 3 if it is abundant. These values are summed to obtain a total maximum score of 15 for each reach.
- *Riffle Embeddedness.* Riffle embeddedness is an indicator of the quality of one important element of stream habitat, and provides information on the extent of sediment impacts. Riffle embeddedness measurements made during the field assessments were used to develop this metric.

- *Pool Frequency and Variety.* Pool frequency and variety is another important indicator of aquatic habitat quality. Homogenous and infrequent pools are noted by NCDWQ and Equinox as one of the more significant limiting habitat factors for fish. The pool score from the NCDWQ habitat protocol was used.
- *Other Potential Measures.* The use of NCDWQ fish community data was considered, but data were available for only four sites. Median substrate particle size from the pebble count data recently collected by Equinox was also evaluated when these data were analyzed. While the pebble count data are useful for descriptive purposes, even in unimpacted systems decreases in particle size will generally be expected in a downstream direction. No approach could be readily devised to adjust for this expected variability.

Indicators of Water Quality Function

- *Specific Conductance.* Specific conductance is a general indicator of the overall level of pollution in a stream, though it is recognized that all types of pollutants do not impact conductance. The higher the conductance level relative to background levels (which are dependent on watershed geology), the higher the level of pollution. Specific conductance measurements were made during the recently completed stream survey, and are also available from both the chemical monitoring and biological community monitoring conducted by NCDWQ.
- *Riparian Area Condition.* The integrity of riparian areas is important to the maintenance of water quality, and substantially impacts hydrology and aquatic habitat as well. Using the IPSI data on riparian zone condition, the proportion of perennial and intermittent stream length classified as having adequate riparian vegetation on both banks was calculated.
- *Total Suspended Solids (TSS) Load.* Sediment is one of the major water quality concerns in the planning area. The estimated TSS load from the IPSI NPS model provides a surrogate for overall sediment loading. TSS does not account for coarser material moving as bedload.
- *Benthic Macroinvertebrate Community Integrity.* The extent to which benthic communities are comprised of sensitive taxa intolerant of pollution vs. more pollution tolerant taxa provides a synoptic measure of water quality condition. Either the EPT Biotic Index (essentially a weighted average of pollution tolerance) or a measure based on the percentage of intolerant taxa could be used. The EPT BI, which is the more widely used measure in NC, was selected.
- *Nutrient Concentration.* Excess nutrients can be important stressors to aquatic systems. Nitrite-nitrate concentrations are used as an indicator of the nutrient status of area streams. Baseflow data are available for 14 sub-watersheds and are used here. Storm data are limited both in terms of the number of sites and the number of samples collected per site. Other nutrient parameters (ammonia, total Kjeldahl nitrogen and total phosphorus) tend to have values in the study area at or near detection limits and would thus provide little discrimination between sub-watersheds.
- *Other Potential Measures.* In-stream concentration data for other water quality parameters are available (e.g. fecal coliform), but for fewer sub-watersheds than the nitrogen data discussed above. Estimates of total phosphorus and total nitrogen loads are available from the IPSI NPS model. However given uncertainties associated with the model load estimates, it was decided to limit use of the load data to TSS, which is probably the most important parameter for the planning area. In-stream nitrogen concentration data is used to capture nutrient impacts.

Individual indicators, including scoring for the functional analysis, are discussed further in Section 7.

2.5.3 Data Limitations

Many indicators used to evaluate sub-watershed function are derived by using data from specific sites to generalize to sub-watershed scale conditions. There are uncertainties associated with this process that should be recognized. These uncertainties are particularly applicable to the habitat-biological community metrics used here, since all metrics in this functional area rely on site-specific data.

Indicators derived from the stream field surveys are based on data collected at one to six sites per sub-watershed. While sites were selected in a manner intended represent to sub-watershed conditions (Appendix B), there is no way to verify that the sites selected truly represent the variability in conditions present within each sub-watershed. Indicators based on NCDWQ chemical data (e.g., nutrient concentration) are also based on limited sampling - four or fewer observations at a single site in most sub-watersheds. How accurately these samples represent typical sub-watershed conditions cannot be readily determined. Benthic community indicators for sub-watersheds are often based on a single site. While benthic communities integrate water quality over time and space, community integrity is influenced by local habitat at the site sampled, which may not be typical of overall aquatic habitat in a particular stream. IPSI GIS and pollutant load data (Appendix A) are based on sub-watershed scale data. Generalizing from these sources is not an issue, though they are subject to errors of photo-interpretation and model estimation.