Appendix II

Biological Water Quality Data Collected by DWQ

- **Benthic Macroinvertebrate Collections**
- **Fish Community Collections**
- **Fish Tissue Assessments**
- **Lakes Assessments**

Benthic Macroinvertebrate Sampling Methodology and Bioclassification Criteria

Benthic macroinvertebrates can be collected using two sampling procedures. DWQ's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs. The purpose of these collections is to inventory the aquatic fauna and produce an indication of relative abundance for each taxon. Organisms are classified as Rare (1-2 specimens), Common (3-9 specimens) or Abundant (≥10 specimens).

Several data analysis summaries (metrics) can be produced from standard qualitative samples to detect water quality problems. These metrics are based on the idea that unimpaired streams and rivers have many invertebrate taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index.

EPT taxa richness (EPT S) is used with DWQ criteria to assign water quality ratings (bioclassifications). "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution. Higher EPT taxa richness values usually indicate better water quality. Water quality ratings are also based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI). Both tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions.

Water quality ratings assigned with the biotic index numbers are combined with EPT taxa richness ratings to produce a final bioclassification, using criteria for mountain/piedmont/coastal plain streams. EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. If the EPT taxa richness rating and the biotic index differ by one bioclassification, the EPT abundance value is used to determine the final site rating.

Benthic macroinvertebrates can also be collected using the DWQ's EPT sampling procedure. Four composite samples are taken at each site instead of the 10 taken for the qualitative sample: 1 kick, 1 sweep, 1 leafpack and visual collections. Only intolerant EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification.

The expected EPT taxa richness values are lower in small high quality mountain streams, <4 meters in width or with a drainage area <3.5 square miles. For these small mountain streams, an adjustment to the EPT taxa richness values is made prior to applying taxa richness criteria. Both EPT taxa richness and biotic index values also can be affected by seasonal changes. DWQ criteria for assigning bioclassification are based on summer sampling (June-September). For samples collected in other seasons, EPT taxa richness can be adjusted. The biotic index values can also be seasonally adjusted for samples collected outside the summer season.

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis.

Swamp Streams

Extensive evaluation, conducted by DWQ, of swamp streams across eastern North Carolina suggests that different criteria should be used to assess the condition of water quality in these systems. Swamp streams are characterized by slower flow, lower dissolved oxygen, lower pH, and sometimes very complex braided channels and dark-colored water. DWQ has developed draft biological criteria that may be used in the future to assign bioclassifications to these streams. However, validation of the swamp criteria will require collecting data for several years from swamp stream reference sites. The criteria will remain in draft form until DWQ is better able to evaluate such things as: year-to-year variation at reference swamp sites, effects of flow interruption, variation among reference swamp sites, and the effect of small changes in pH on the benthos community. Other factors, such as whether the habitat evaluation can be improved and the role fisheries data should play in the evaluation, must also be resolved. While it may be difficult to assign use support ratings to these swamp streams, these data can be used to evaluate changes in a particular stream between dates or to evaluate effects of different land uses on water quality within a relatively uniform ecoregion.

Draft swamp stream rating criteria evaluate swamp streams based on benthic macroinvertebrate data (collected in winter), fish community data and a habitat score. Benthic data collected outside of the winter high flow period are not used to assign ratings. At least two of the above referenced data types must be collected in order to assign a rating. Each of these data types is assigned a point value of 10 (Good), 5 (Fair) or 1 (Poor), and the points are averaged to assign an overall site rating (OSR): Good-Excellent (>7.5), Fair-Good (5.0-7.5), Fair (2.0-4.9) and Poor (<2.0). Ratings for the benthic macroinvertebrate communities are based entirely on the biotic index value: Good <6.99, Fair 7.75-7.00, Poor >7.75. Deep (nonwadeable) coastal rivers with little or no visible current have different EPT criteria that are being used on a provisional basis until more data can be gathered.

Flow Measurement

Changes in the benthic macroinvertebrate community are often used to help assess between-year changes in water quality. However, some between-year changes in the macroinvertebrate community may be due largely to changes in flow. High flow years magnify the potential effects of nonpoint source runoff, leading to scour, substrate instability and reduced periphyton. Low flow years may accentuate the effects of point source dischargers by providing less dilution of wastes.

For these reasons, all between-year changes in the biological communities are considered in light of flow conditions (high, low or normal) for one month prior to the sampling date. Daily flow information is obtained from the closest available USGS monitoring site and compared to the long-term mean flows. High flow is defined as a mean flow >140% of the long-term mean for that time period, usually July or August. Low flow is defined as a mean flow <60% of the long-term mean, while normal flow is 60-140% of the mean. While broad scale regional patterns are often observed, there may be large geographical variation within the state and large variation within a single summer period.

Habitat Evaluation

DWQ has developed a habitat assessment form to better evaluate the physical habitat of a stream. The habitat score has a potential range of 1-100, based on evaluation of channel modification, amount of instream habitat, type of bottom substrate, pool variety, bank stability, light penetration and riparian zone width. Higher numbers suggest better habitat quality, but no criteria have been developed for assigning ratings indicating Excellent, Good, Fair or Poor habitat.

Table A-II-1 Benthic Macroinvertebrate Data Collected in the Roanoke River Basin, 1983 - 1999 (Current basinwide monitoring sites have the map number bolded.)

Subbasin/ Stream	Location	County	Site No.	Index No.	Date	S/ EPT S	NCBI/ EPT BI	Bio Class[1]
03-02-01								
Dan R	NC 704	Stokes	B-1	22-(1)	08/99	85/41	4.19/3.30	G
					08/94	57/28	3.84/3.51	G
					07/90	94/48	4.48/3.68	E
					07/88	89/38	4.06/2.98	G
					07/86	84/37	4.00/3.17	G
					08/84	86/36	4.66/3.58	G
Dan R	SR 1695	Stokes	B-2	22-8	08/99	72/37	4.57/3.95	G
					08/94	45/20	4.75/3.87	G-F
North Double Cr	SR 1504	Stokes	B-3	22-10	08/99	-/25	-/3.97	G-F
					08/94	-/17	-/4.63	F
UT Cascade Cr (family cabins)		Stokes	B-4		06/95	37/15	4.34/1.96	G-F
Cascade Cr	SR 2012	Stokes	B-5	22-12-(2)	06/95	54/26	2.96/1.98	G
					09/90	-/23	-/2.99	G-F
Cascade Cr	Near SR 1001	Stokes	B-6	22-12-(2)	03/91	-/26	-/2.94	G
					09/90	-/26	-/3.48	G
Cascade Cr (above swimming lake)		Stokes	B-7	22-12-1	06/95	69/31	3.35/1.77	E
					03/93	-/34	-/1.61	E
					08/91	-/26	-/1.59	G
					03/91	-/35	-/1.69	E
					09/90	-/22	-/1.88	G
Indian Cr (above trail)		Stokes	B-8	22-13-(1)	03/93	-/30	-/1.47	E
					03/91	-/25	-/1.38	G
Indian Cr (below trail)		Stokes	B-9	22-13-(1)	03/93	-/34	-/1.54	E
					03/91	-/27	-/1.22	E
					09/90	-/26	-/2.57	E
Indian Cr	SR 1001	Stokes	B-10	22-13-(2)	09/90	-/22	-/2.33	G
Indian Cr	SR 1487	Stokes	B-11	22-13-(2)	09/90	-/27	-/2.76	G
Snow Cr	SR 1673	Stokes	B-12	22-20	08/00			G
					08/99	-/18	-/4.37	F
					08/94	-/22	-/4.00	G-F
Town Fk Cr	SR 1970	Stokes	B-13	22-25	09/95	-/7	-/5.95	P
Town Fk Cr	SR 1961	Stokes	B-14	22-25	09/95	89/26	5.17/4.77	G-F
Town Fk Cr	SR 1955	Stokes	B-15	22-25	09/95	-/26	-/4.69	G-F
Town Fk Cr	US 311	Stokes	B-16	22-25	02/88	-/19	-/4.43	G-F
Town Fk Cr	SR 1917	Stokes	B-17	22-25	08/94	-/15	-/4.59	G-F
					02/88	-/24	-/4.21	G-F
Neatman Cr	SR 1961	Stokes	B-18	22-25-6	09/95	-/29	-/4.27	G
UT Dan R,	US 311	Stokes	B-19	22-(28.5)	02/87	-/21	-/4.00	G-F
UT Dan R (near raceway)		Stokes	B-20	22-(28.5)	02/87	-/15	-/4.40	F
03-02-02								
Mayo R	SR 1358	Rockingham	B-1	22-30-(1)	08/99	70/32	4.26/3.44	G
					08/94	64/38	3.60/3.24	G
					08/89	79/42	4.78/4.02	G
					03/89	96/54	3.72/2.85	G
					07/87	87/40	4.78/4.10	G
					07/86	102/37	5.07/3.95	G
Mayo R	NC 770	Rockingham	B-2	22-30-(1)	03/89	-/37	-/3.49	G-F
Mayo R	US 220 Bus	Rockingham	B-3	22-30-(1)	03/89	-/44	-/3.29	G-F
Mayo R	NC 135	Rockingham	B-4	22-30-(10)	08/89	-/28	-/4.12	G
Mayo R	SR 2177	Rockingham	B-5	22-30-(10)	08/99	52/21	5.22/4.25	G-F
					09/94	71/33	4.70/4.33	G
03-02-03								
Dan R	SR 2150	Rockingham	B-1	22-(31.5)	08/89	64/26	5.50/4.66	G
					07/87	92/32	5.67/4.61	G
Dan R	SR 1761	Rockingham	B-2	22-(39)	08/91	55/26	5.07/4.30	E
					07/87	68/26	5.14/4.15	G
					07/86	61/20	5.87/4.64	G-F
					09/84	56/17	5.71/4.41	G-F
					08/83	65/22	5.53/4.70	G

Subbasin/ Stream	Location	County	Site No.	Index No.	Date	S/ EPT S	NCBI/ EPT BI	Bio Class[1]
03-02-03 (con't)								
Smith R (near NC/VA state line)	VA 922		B-3	22-40-(1)	09/84	63/21	5.74/4.42	G-F
Smith R	NC 14	Rockingham	B-4	22-40-(3)	09/99	51/18	5.23/3.67	F
					08/94	58/18	5.66/4.43	F
					07/90	81/31	5.52/4.18	G-F
					07/88	69/24	6.03/5.08	F
					07/86	57/18	6.14/4.71	F
Wolf Island Cr	NC 700	Caswell	B-5	22-48	07/88	82/24	5.81/4.82	G
					07/85	68/25	5.40/4.69	G
					08/83	76/24	5.52/4.53	G
UT Hogans Cr	VA 736	Pittsylvania	B-6	22-50	06/98	44/16	4.94/4.04	NR
					11/96	48/12	6.15/4.71	NR
UT Hogans Cr (above ponds)	Off SR 1503	Caswell	B-7	22-50	06/98	43/13	5.25/4.61	NR
					11/96	36/10	6.13/4.92	NR
UT Hogans Cr (below ponds)	Off SR 1503	Caswell	B-8	22-50	06/98	48/12	5.89/5.67	NR
					11/96	41/7	6.42/3.95	NR
Jones Cr	SR 2632	Rockingham	B-9	22-50-3	01/92	-/29	-/4.56	G
Jones Cr	SR 2571	Rockingham	B-10	22-50-3	12/87	83/27	5.55/4.50	G
03-02-04								
Dan R	NC 57	Caswell	B-1	22-39	08/99	66/32	5.42/4.54	G
Country Line Cr	NC 57	Caswell	B-2	22-56-(3.7)	08/94	-/14	-/4.42	G-F
					07/90	73/26	5.51/4.52	G
					07/87	78/26	5.77/4.95	G
					08/83	72/19	5.80/4.34	G-F
03-02-05								
Hyco Cr (North Hyco Cr)	US 158	Caswell	B-1	22-58-1	08/94	-/10	-/5.93	F
					07/90	65/20	5.91/5.27	G-F
					07/87	74/23	5.86/5.15	G-F
					07/86	78/21	5.88/5.07	G-F
Marlowe Cr	SR 1322	Person	B-2	22-58-12-6	08/99	53/9	6.34/5.74	F
					08/94	33/5	6.90/6.49	P
03-02-06								
Island Cr	SR 1445	Granville	B-1	23-4	08/94	-/17	-/5.10	G-F
L Island Cr	SR 1342	Vance	B-2	23-4-3	05/88	-/21	-/4.88	G-F
Nutbush Cr (above WWTP)	NC 39	Vance	B-3	23-8-(1)	11/94	58/12	6.89/6.13	F
					10/94	54/12	6.96/5.77	F
					05/88	44/6	7.40/6.75	F
Nutbush Cr (below WWTP)	Off NC 39	Vance	B-4	23-8-(1)	11/94	48/7	7.19/6.20	F
Nutbush Cr	SR 1317	Vance	B-5	23-8-(1)	08/99	41/8	6.72/6.75	F
					10/94	50/8	6.74/6.31	F
					08/94	44/8	6.83/6.88	F
					05/88	35/3	8.14/6.45	P
Anderson Swamp Cr	I-85	Vance	B-6	23-8-6-(1)	02/90	49/13	6.98/5.71	NR
UT Anderson Swamp Cr	US 1/158	Vance	B-7	23-8-6-(1)	02/90	18/2	7.55/7.75	NR
03-02-07								
Smith Cr	US 1	Warren	B-1	23-10	07/99	59/12	6.56/5.51	F
					08/94	53/6	6.94/6.15	F
					07/89	59/12	6.75/5.06	F
					07/86	56/10	6.22/5.13	F
					08/84	56/12	6.42/5.36	F
Sixpound Cr	SR 1306	Warren	B-2	23-13	07/99	54/14	5.50/5.04	G-F
					08/94	-/12	-/5.32	F
03-02-08								
Deep Cr	US 158	Halifax	B-1	23-24-(1)	07/99	58/11	6.40/5.17	NR
					08/94	64/13	6.36/5.70	F
Roanoke R (below Weldon)	US 158	Halifax	B-2	23-(26)	09/94	45/16	5.29/4.68	G
Roanoke R (boat access),		Halifax	B-3	23-(26)	03/99	76/28	5.26/4.36	G
Roanoke R	US 258	Halifax	B-4	23-(26)	07/99	41/19	5.21/4.76	G
					03/99	67/30	5.37/4.72	G
					09/94	45/16	4.90/4.28	G

Subbasin/ Stream	Location	County	Site No.	Index No.	Date	S/ EPT S	NCBI/ EPT BI	Bio Class[1]
03-02-08 (con't)								
Smith R (near NC/VA state line)	VA 922		B-3	22-40-(1)	09/84	63/21	5.74/4.42	G-F
					07/85	49/16	5.92/4.88	G-F
Quankey Cr	NC 903	Halifax	B-5	23-30	02/99	40/9	6.66/5.92	NR
Quankey Cr	NC 561	Halifax	B-6	23-30	09/99	-/9	-/5.51	F
Quankey Cr (above WWTP)		Halifax	B-7	23-30	12/92	51/7	6.55/5.69	F
Quankey Cr (below WWTP)		Halifax	B-8	23-30	12/92	57/9	6.41/5.28	F
Oconeechee Cr	SR 1126	Northampton	B-9	23-31	02/99	22/4	6.48/6.85	NR
Conoconnara Swp	NC 561,	Halifax	B-10	23-33	02/99	31/5	6.44/6.80	NR
					07/84	39/3	7.49/6.26	NR
Kehukee Swp	SR 1804	Halifax	B-11	23-42	09/99	-/6	-/6.19	NR
					02/99	59/8	7.10/6.44	NR
03-02-09								
Roanoke R (below Hamilton),	NC 125/903	Martin	B-1	23-(26)	03/99	61/23	5.82/4.80	G-F
					09/94	51/19	5.21/4.39	G
Roanoke R (below Williamston)	US 17	Martin	B-2	23-(26)	07/99	45/17	5.96/4.77	G-F
					03/99	73/23	6.32/5.07	G-F
					09/94	53/17	5.70/4.80	G-F
Indian Cr	SR 1108	Bertie	B-3	23-47	03/97	30/1	7.40/7.78	NR
Conoho Cr	NC 125/903	Martin	B-4	23-49	02/99	29/3	7.28/7.56	NR
					08/94	23/0	7.49/-	NR
Conoho Cr	SR 1417	Martin	B-5	23-49	02/99	39/5	6.26/4.80	NR
Hardison Mill Cr	NC 171	Martin	B-6	23-50-3	02/99	24/2	7.69/7.65	NR
Hardison Mill Cr	SR 1528	Martin	B-7	23-50-3	02/99	27/3	7.28/7.65	NR
Deep Run Swp	NC 171	Martin	B-8	23-52-1-1	02/99	21/1	7.61/7.78	NR
Welch Cr	SR 1552	Martin	B-9	23-55	02/99	32/3	7.20/6.92	NR
Roanoke R	NC 45	Bertie	B-10	23-(53)	07/99	59/9	7.35/6.56	NR
					09/94	52/9	7.52/6.08	NR
					06/92	60/8	7.48/5.82	NR
					07/90	51/10	7.48/6.23	NR
					07/88	60/7	7.93/6.62	NR
					07/86	50/8	7.68/6.77	NR
					07/85	37/4	8.16/6.50	NR
					07/84	42/6	7.63/6.18	NR
					07/83	38/6	8.07/5.42	NR
Conaby Cr	SR 1114	Washington	B-11	23-56	04/94	68/5	7.01/5.89	NR
Conaby Cr	SR 1325	Washington	B-12	23-56	04/94	41/0	7.44/-	NR
03-02-10								
Cashie R (above WWTP)	off NC 11	Bertie	B-1	24-2-(1)	06/84	37/0	8.61/-	NR
Cashie R (below WWTP)	off NC 11	Bertie	B-2	24-2-(1)	06/84	41/0	8.39/-	NR
Cashie R	SR 1219	Bertie	B-3	24-2-(1)	02/99	41/6	7.47/7.23	NR
					06/84	43/2	8.24/7.00	NR
					07/83	34/2	8.54/7.00	NR
Cashie R	SR 1257	Bertie	B-4	24-2-(1)	02/99	34/7	6.78/6.09	NR
Hoggard Mill Cr	SR 1301	Bertie	B-5	24-2-6	02/99	46/7	6.74/6.37	NR
Wading Place Cr	NC 308	Bertie	B-6	24-2-8	03/99	35/3	7.35/7.42	NR
Roquist Swp	US 13/17	Bertie	B-7	24-2-8	02/99	31/4	6.98/5.48	NR
Cashie R	SR 1500	Bertie	B-8	24-2-(9)	09/94	56/9	8.10/6.34	NR

[1] E = Excellent, G = Good, G-F = Good-Fair, F = Fair, P = Poor, and NR = Not Rated.

Fish Community Sampling Methodology and Bioclassification Criteria

At each sample site, a 600-foot section of stream is measured and selected. Fish in the delineated stretch of stream are then collected using two backpack electrofishing units and two persons netting the stunned fish. After collection, all readily identifiable fish are examined for sores, lesions, fin damage, or skeletal anomalies, measured (total length to the nearest 1 mm), and then released. Those fish that are not readily identifiable are preserved and returned to the laboratory for identification, examination, and measurement. Detailed descriptions of the sampling methods may be found on the Environmental Sciences Branch website: http://www.esb.enr.state.nc.us/BAUwww/IBI%20Methods%202.pdf.

The assessment of biological integrity using the North Carolina Index of Biotic Integrity (NCIBI) is provided by the cumulative assessment of 12 parameters or metrics. The values provided by the metrics are converted into scores on a 1, 3 or 5 scale. A score of 5 represents conditions which would be expected for undisturbed reference streams in the specific river basin or ecoregion, while a score of 1 indicates that the conditions deviate greatly from those expected in undisturbed streams of the region. Each metric is designed to contribute unique information to the overall assessment. The scores for all metrics are then summed to obtain the overall NCIBI score. Finally, the score (an even number between 12 and 60) is then used to determine the ecological integrity class, as proposed by Karr (1981), of the stream from which the sample was collected (Table A-II-2).

Table A-II-2 Original Scores, Integrity Classes, and Class Attributes for Evaluating Fish Communities Using Karr's 1981 Index of Biotic Integrity

NCIBI Scores	Integrity Classes	Class Attributes*
> 58	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, along with a full array of size classes and a balanced trophic structure.
48-52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant species; some species are present with less than optimal abundances or size distributions; and the trophic structure shows some signs of stress.
40-44	Fair	Signs of additional deterioration include the loss of intolerant species, fewer species, and a highly skewed trophic structure.
28-34	Poor	Dominated by omnivores, tolerant species, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; and diseased fish often present.
< 22	Very Poor	Few fish present, mostly introduced or tolerant species; and disease fin damage and other anomalies are regular.
-----	No fish	Repeated sampling finds no fish.

* Over-lapping classes share attributes with classes greater than and less than the respective IBI score.

The NCIBI has been revised since the 1997 Standard Operating Procedures were printed (NCDEHNR 1997). Recently, the focus of using and applying the NCIBI has been restricted to wadeable streams that can be sampled by a crew of four persons. The bioclassifications and criteria have also been re-calibrated against regional reference site data (Table A-II-3).

Table A-II-3 Revised Scores and Classes for Evaluating the Fish Community of a Wadeable Stream Using the NCIBI in the Piedmont Portion of the Cape Fear, Neuse, Roanoke and Tar River Basins

NCIBI Scores	NCIBI Classes
> 54	Excellent
46 - 52	Good
40 - 44	Good-Fair
34 - 38	Fair
≤ 32	Poor

The definition of the piedmont for these four river basins is based upon a map of North Carolina watersheds by Fels (1997). Specifically for the Roanoke River basin, the piedmont encompasses the entire basin above Roanoke Rapids, NC and a small area between Roanoke Rapids and Halifax, NC.

Work began in 1998 to develop a fish community boat sampling method that could be used in non-wadeable coastal plain streams. Plans are to sample 10-15 reference sites with the boat method once it is finalized. As with the benthos in swamp streams, several years of reference site data will be needed before criteria can be developed with confidence to evaluate the biological integrity of large streams and rivers, like the Roanoke River, using the fish community.

Table A-II-4 Fish Community Data Collected in the Roanoke River Basin, 1990-1999 (Sites sampled during the current five-year basinwide cycle are bolded.)

Subbasin	Waterbody	Station	County	Date	NCIBI Rating
03-02-02	Paw Paw Cr	SR 1360	Rockingham	08/90	Good
03-02-03	Wolf Island Cr	NC 700	Caswell	10/94	Excellent
03-02-04	Cane Cr	SR 1527	Caswell	10/94	Good-Fair
03-02-04	Country Line Cr	NC 57	Caswell	09/94	Good
03-02-04	Moon Cr	SR 1511	Caswell	09/94	Good
03-02-05	Marlowes Cr	SR 1322	Person	09/94	Good-Fair
03-02-06	**Grassy Cr**	**SR 1300**	**Granville**	**06/99**	**Good**
		SR 1436	Granville	06/94	Good
03-02-06	**Island Cr**	**SR 1445**	**Granville**	**06/99**	**Excellent**
				06/94	Good
03-02-06	Nutbush Cr	SR 1317	Vance	10/94	Good-Fair
03-02-07	Six Pound Cr	SR 1306	Warren	05/94	Good-Fair
03-02-07	Smith Cr	US 1	Warren	05/94	Good-Fair
03-02-08	Conoconnara Swp	NC 561	Halifax	09/94	Not Rated
03-02-08	Deep Cr	US 158	Halifax	09/94	Good
03-02-08	Kehukee Swp	SR 1804	Halifax	10/94	Not Rated
03-02-08	Quankey Cr	SR 1619	Halifax	09/94	Good-Fair
03-02-10	Cashie R	SR 1257	Bertie	10/94	Not Rated

Fish Tissue Criteria

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.
- Environmental Protection Agency (EPA) recommended screening values.
- Criteria adopted by the North Carolina State Health Director.

Sample results which exceed these levels are a human health concern and are evaluated by the NC Division of Occupational and Environmental Epidemiology at DWQ's request. 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. Presently, the FDA has only developed metals criteria for mercury.

The EPA has recommended screening values for target analytes which are formulated from a risk assessment procedure (EPA, 1995). These are the concentrations of analytes in edible fish tissue that are of potential public health concern. DWQ compares fish tissue results with EPA screening values to evaluate the need for further intensive site-specific monitoring.

Table A-II-5 Fish Tissue Criteria

Contaminant	FDA Action Levels	US EPA Screening Values	NC Health Director
Metals			
Cadmium	--	10.0	--
Mercury	1.0	0.6	--
Selenium	--	50.0	5.0
Organics			
Aldrin	0.3	--	--
Chlorpyrifos	--	30	--
Total chlordane [1]	--	0.08	--
Cis-chlordane	0.3	--	--
Trans-chlordane	0.3	--	--
Total DDT [2]	--	0.3	--
Dieldrin	--	0.007	--
Dioxins (total)	--	0.7	3.0
Endosulfan (I and II)	--	60.0	--
Endrin	0.3	3.0	--
Heptachlorepoxide	--	0.01	--
Hexachlorobenzene	--	0.07	--
Lindane	--	0.08	--
Mirex	--	2.0	--
Total PCBs	--	0.01	--
PCB-1254	2.0	--	--
Toxaphene	--	0.1	--

[1] Total chlordane includes the sum of cis-and trans- isomers as well as nonachlor and oxychlordane.

[2] Total DDT includes the sum of all its isomers and metabolites (i.e., p,p DDT, o,p DDT, DDE, and DDD).

Note: All wet weight concentrations are reported in parts per million (ppm, µg/g), except for dioxin which is in parts per trillion (ppt, pg/g).

The North Carolina State Health Director has adopted a selenium limit of 5 µg/g for issuing an advisory. Although the EPA has suggested a screening value of 0.7 ppt (pg/g) for dioxins, the State of North Carolina currently uses a value of 3.0 ppt in issuing an advisory.

Table A-II-6 Wet Weight Concentrations of Mercury (Hg), Arsenic (As) and Cadmium (Cd) in Fish Tissue from the Roanoke River Basin (1994 – 1999)

Subbasin/ Site	County	Date	Species	Total Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Cd (µg/g)
03-02-03								
Dan River near Eden	Rockingham	08/31/1999	*Bluegill*	16	77	0.05	ND[1]	ND[1]
			Channel catfish	35.5	358	0.10	ND	ND
			Golden redhorse	37.8	335	0.36	ND	ND
			Golden redhorse	33	387	0.17	ND	ND
			Golden redhorse	31.2	300	0.27	ND	ND
			Golden redhorse	33.5	378	0.23	ND	ND
			Golden redhorse	37.1	476	0.37	ND	ND
			Golden redhorse	34.3	426	0.17	ND	ND
			Largemouth bass	30	374	0.20	ND	ND
			Largemouth bass	28.2	304	0.13	ND	ND
			Largemouth bass	27.5	260	0.12	ND	ND
			Quillback	38.2	796	0.29	ND	ND
			Redbreast sunfish	16.3	88	0.07	ND	ND
			Redbreast sunfish	13.2	44.2	0.10	ND	ND
			Redear sunfish	15.7	73.5	0.04	ND	ND
			Golden redhorse	37.8	414	0.22	ND	ND
			Snail bullhead	30.1	369	0.03	ND	ND
			Snail bullhead	31	346	0.03	ND	ND
			White catfish	29	334	0.16	ND	ND
03-02-06								
Kerr Lake at mouth of Nutbush Cr	Vance	05/20/1999	*Bluegill*	18.4	125	0.12	ND	ND
			Chain pickerel	57	1552	0.39	ND	ND
			Chain pickerel	53	1219	0.31	ND	ND
			Largemouth bass	46.5	1470	0.56	ND	ND
			Largemouth bass	42	1121	0.51	ND	ND
			Largemouth bass	43.8	984	0.65	ND	ND
			Largemouth bass	38	671	0.41	ND	ND
			Largemouth bass	38.5	767	0.59	ND	ND
			Largemouth bass	31	500	0.35	ND	ND
			Largemouth bass	33.6	477	0.52	ND	ND
			Largemouth bass	30.5	412	0.34	ND	ND
			Largemouth bass	31.5	423	0.26	ND	ND
			Largemouth bass	29.5	401	0.28	ND	ND
			Redear sunfish	27.5	377	0.06	ND	ND
			Redear sunfish	26.8	419	0.11	ND	ND
			Redear sunfish	22	179	0.08	ND	ND
			White catfish	27	241	0.34	ND	ND
		01/28/1999	*Striped bass*	70				
			Striped bass	467				
			Striped bass	48.2				
			Striped bass	42.5				
			Striped bass	73.2				
			Striped bass	41				
			Striped bass	77.1				
			Striped bass	65				
			Striped bass	44.6				
			Striped bass	67				
			Striped bass	41.7				
			Striped bass	44.3				
			Striped bass	74.8				
			Striped bass	39.5				
			Striped bass	42.4				
			Striped bass	70.1				
			Striped bass	72.2				
			Striped bass	44.5				
			Striped bass	78.2				

Subbasin/ Site	County	Date	Species	Total Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Cd (µg/g)
03-02-07								
Lake Gaston near Henrico	Halifax	07/08/1999	*Bluegill*	17.5	104.6	0.05	ND	ND
			Bluegill	18.1	119.3	0.05	ND	ND
			Bluegill	14.8	76.5	0.03	ND	ND
			Channel catfish	49.2	1096	0.05	ND	ND
			Channel catfish	48.2	1013	0.21	ND	ND
			Channel catfish	48.5	1172	0.05	ND	ND
			Channel catfish	43.5	804	0.10	ND	ND
			Channel catfish	47.8	1136	0.07	ND	ND
			Largemouth bass	25	212	0.07	ND	ND
			Largemouth bass	29.5	343	0.10	ND	ND
			Largemouth bass	31.1	423	0.07	ND	ND
			Largemouth bass	36.2	612	0.29	ND	ND
			Largemouth bass	42.6	962	0.37	ND	ND
			Largemouth bass	38.2	797	0.19	ND	ND
			Largemouth bass	37.4	728	0.14	ND	ND
			Largemouth bass	40.1	979	0.24	ND	ND
			Largemouth bass	45.3	1077	0.20	ND	ND
			Largemouth bass	45	1585	0.27	ND	ND
			Yellow perch	19.7	87.3	0.05	ND	ND
			Yellow perch	24.4	169	0.12	ND	ND
03-02-08								
Roanoke River at Weldon	Halifax	05/19/99	*Bluegill*	14.9	66.6	0.07	ND	ND
			Bluegill	15.7	77.5	0.06	ND	ND
			Black crappie	25.1	254	0.28	ND	ND
			Largemouth bass	43.1	1193	0.57	ND	ND
			Largemouth bass	40.7	1095	0.33	ND	ND
			Largemouth bass	38.2	657	0.43	ND	ND
			Largemouth bass	30.2	371	0.29	ND	ND
			Largemouth bass	32.3	412	0.43	ND	ND
			Largemouth bass	29.3	330	0.33	ND	ND
			Largemouth bass	25.3	244.5	0.23	ND	ND
			Largemouth bass	21.9	139.5	0.18	ND	ND
			Redbreast sunfish	17	92	0.10	ND	ND
			Striped bass	47.5	1256	0.20	ND	ND
			Striped bass	43.8	986	0.21	ND	ND
			Striped bass	45.3	907	0.24	ND	ND
			Striped bass	42.8	732	0.20	ND	ND
			Striped bass	39.7	661	0.19	ND	ND
			Striped bass	43.1	1540	0.51	ND	ND
			White catfish	37.5	575	0.07	ND	ND
			White catfish	33.8	528	0.15	ND	ND
			Yellow perch	23.8	188	0.17	ND	ND
		09/20/1995	*Bowfin*	39.5	621	0.13	—	—
			Bowfin	42	686	0.13	—	—
			Bowfin	46	992	0.11	—	—
			Bowfin	53.5	1223	0.67	—	—
			Bowfin	64	2701	0.68	—	—
			Bowfin	57.5	2394	0.56	—	—

Subbasin/ Site	County	Date	Species	Total Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Cd (µg/g)
03-02-08 (con't)								
Roanoke River at Scotland Neck	Halifax	05/19/99	*Bowfin*	58	1847	0.52	ND	ND
			Bowfin	55	1417	0.47	ND	ND
			Bowfin	60.1	2010	1.1	ND	ND
			Bowfin	50	1100	0.39	ND	ND
			Bowfin	54.9	1429	0.41	ND	ND
			Bowfin	49.5	1349	0.57	ND	ND
			Bluegill	17.5	116	0.14	ND	ND
			Channel catfish	54.8	1654	0.15	ND	ND
			Channel catfish	43.5	641	0.10	ND	ND
			Largemouth bass	40.2	966	0.71	ND	ND
			Largemouth bass	32.5	533	0.46	ND	ND
			Largemouth bass	31.2	412	0.52	ND	ND
			Redbreast sunfish	18.9	167	0.06	ND	ND
			Striped bass	49	1245	0.26	ND	ND
			Striped bass	45.2	1004	0.28	ND	ND
			Striped bass	48	1128	0.20	ND	ND
			Striped bass	47	1082	0.11	ND	ND
			Striped bass	45	1054	0.18	ND	ND
			Striped bass	43.2	835	0.15	ND	ND
			Striped bass	43.5	901	0.10	ND	ND
			Striped bass	41.1	652	0.26	ND	ND
			White catfish	36	712	0.42	ND	ND
			White catfish	28.7	305.5	0.19	ND	ND
03-02-09								
Roanoke River at Plymouth	Washington	07/21/1999	*Bowfin*	55.5	1738	0.56	ND	ND
			Bowfin	52.5	1321	0.47	ND	ND
			Bowfin	45.7	837	0.50	ND	ND
			Bowfin	42.5	690	0.31	ND	ND
			Bluegill	17.9	133.6	0.07	ND	ND
			Chain pickerel	47.8	640	0.64	ND	ND
			Largemouth bass	41.6	1165	0.44	ND	ND
			Largemouth bass	44.1	1282	0.53	ND	ND
			Largemouth bass	39.3	924	0.68	ND	ND
			Largemouth bass	37.6	759	0.48	ND	ND
			Largemouth bass	37.2	797	0.40	ND	ND
			Largemouth bass	37.1	821	0.64	ND	ND
			Largemouth bass	39	619	0.84	ND	ND
			Largemouth bass	37.6	703	0.49	ND	ND
			Largemouth bass	33.2	484	0.42	ND	ND
			Largemouth bass	28.9	342	0.45	ND	ND
			Largemouth bass	36.2	639	0.36	ND	ND
			Redear sunfish	25.5	313	0.13	ND	ND
			Redear sunfish	26.1	338	0.22	ND	ND
			Redear sunfish	19.4	140	0.12	ND	ND
			Yellow perch	23.6	190.3	0.20	3.9	ND
			Yellow perch	20.1	119	0.16	ND	ND
		07/06/1995	*Bowfin*	44.8	900	0.43	—	—
			Bowfin	54	1500	0.37	—	—
			Bowfin	54.7	1700	0.45	—	—
			Bowfin	52.1	1200	0.6	—	—
			Bowfin	67.1	3000	1	—	—
			Bowfin	69.5	3500	1.5	—	—
			Bowfin	72.6	3900	1.2	—	—

Subbasin/ Site	County	Date	Species	Total Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Cd (µg/g)
03-02-09 (con't)								
Roanoke River at US-17	Martin	07/06/1999	*Bowfin*	57.3	1815	0.65	ND	ND
			Bowfin	57	1959	0.76	ND	ND
			Bowfin	65.1	2633	1.3	ND	ND
			Bluegill	23	290	0.30	ND	ND
			Bluegill	18.8	150.5	0.30	ND	ND
			Bluegill	17.6	132	0.17	ND	ND
			Bluegill	16.8	99	0.27	ND	ND
			Largemouth bass	44.8	1226	1.3	ND	ND
			Largemouth bass	42.1	1090	1.4	ND	ND
			Largemouth bass	36.5	853	0.86	ND	ND
			Largemouth bass	39.7	894	0.94	ND	ND
			Largemouth bass	37.1	850	0.76	ND	ND
			Largemouth bass	35.1	692	0.94	ND	ND
			Largemouth bass	33	574	0.82	ND	ND
			Largemouth bass	33.8	704	0.75	ND	ND
			Largemouth bass	33	525	0.68	ND	ND
			Largemouth bass	26.4	253	0.44	ND	ND
			Largemouth bass	22.5	155	0.35	ND	ND
			Redear sunfish	20.9	187	0.19	ND	ND
			White catfish	38	768	0.64	ND	ND
			White catfish	35	588	0.67	ND	ND
			White catfish	36.2	610	0.39	ND	ND
			White catfish	33.1	518	0.67	ND	ND
			White catfish	33.2	408	0.31	ND	ND
		07/06/1995	*Bowfin*	51.1	110	0.85	—	—
			Bowfin	53	1200	0.84	—	—
			Bowfin	54.5	1300	0.85	—	—
			Bowfin	53.3	1300	0.84	—	—
			Bowfin	54.1	1200	0.98	—	—
			Bowfin	69.5	2800	2.4	—	—
			Bowfin	58.1	1700	1.2	—	—
			Bowfin	67.3	2400	2.2	—	—
03-02-10								
Cashie River at Windsor	Bertie	07/21/1999	*Bowfin*	54.5	1426	1.5	ND	ND
			Bowfin	53	1495	1.5	ND	ND
			Bowfin	53	1468	1.3	ND	ND
			Bowfin	50.5	1239	1.0	ND	ND
			Bowfin	41	663	0.69	ND	ND
			Bowfin	41.5	649	0.67	ND	ND
			Bluegill	22.1	202	0.68	ND	ND
			Bluegill	16.8	205	0.31	ND	ND
			Bluegill	15.5	78	0.20	ND	ND
			Black crappie	22.1	183.5	0.45	ND	ND
			Black crappie	19.9	118	0.24	ND	ND
			Brown bullhead	37.5	694.3	0.17	ND	ND
			Chain pickerel	39.6	435	0.80	ND	ND
			Largemouth bass	50.7	2201	1.4	ND	ND
			Largemouth bass	51.5	2185	1.9	ND	ND
			Largemouth bass	42	1088	0.64	ND	ND
			Largemouth bass	33.7	503	1.1	ND	ND
			Largemouth bass	29	350	0.58	ND	ND
			Largemouth bass	30.1	420	0.44	ND	ND
			Largemouth bass	27	285	0.42	ND	ND
			Largemouth bass	29.8	325	0.65	ND	ND
			Largemouth bass	27.4	279	0.44	ND	ND
			Largemouth bass	25.1	219	0.49	ND	ND
			Yellow bullhead	32.3	498	0.56	ND	ND

[1] ND = non-detect; detection level for arsenic = 1.0 µg/g and for cadmium = 0.1 µg/g.

Table A-II-7 Wet Weight Concentrations of PCBs in Fish Tissue from John H. Kerr Reservoir at the Mouth of Nutbush Creek, Vance County (1999)

Date Sampled	Species	Total Length (mm)	Weight (g)	PCB (µg/g)[1]
01/28/1999	*Striped bass*	467	---	ND
01/28/1999	*Striped bass*	482	---	ND
01/28/1999	*Striped bass*	425	---	ND
01/28/1999	*Striped bass*	732	---	ND
01/28/1999	*Striped bass*	410	---	ND
01/28/1999	*Striped bass*	771	---	ND
01/28/1999	*Striped bass*	650	---	ND
01/28/1999	*Striped bass*	446	---	ND
01/28/1999	*Striped bass*	670	---	ND
01/28/1999	*Striped bass*	417	---	ND
01/28/1999	*Striped bass*	443	---	ND
01/28/1999	*Striped bass*	748	---	ND
01/28/1999	*Striped bass*	395	---	ND
01/28/1999	*Striped bass*	424	---	ND
01/28/1999	*Striped bass*	701	---	ND
01/28/1999	*Striped bass*	722	---	ND
01/28/1999	*Striped bass*	445	---	ND
01/28/1999	*Striped bass*	782	---	0.162
01/28/1999	*Striped bass*	700	---	0.222
05/20/1999	*Largemouth bass*	465	1470	ND
05/20/1999	*Largemouth bass*	420	1121	ND
05/20/1999	*Largemouth bass*	438	984	ND
05/20/1999	*Largemouth bass*	380	671	ND
05/20/1999	*Largemouth bass*	385	767	ND

[1] ND = not detected; detection level was 0.125 µg/g.

Lakes Assessments

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. 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 used to produce a NCTSI score for each lake, using the equations:

TONScore = ((Log (TON) + 0.45)/0.24)*0.90

TPScore = ((Log (TP) + 1.55)/0.35)*0.92

SDScore = ((Log (SD) – 1.73)/0.35)*-0.82

CHLScore = ((Log (CHL) – 1.00)/0.48)*0.83

NCTSI = TONScore + TPScore + SDScore + CHLScore

In general, NCTSI scores relate to trophic classifications (Table A-II-8). 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 because of the potential variability of data collections which usually involve sampling a limited number of times during the growing season.

Table A-II-8 Lakes classification criteria

NCTSI Score	Trophic Classification
< -2.0	Oligotrophic
-2.0 – 0.0	Mestrophic
0.0 – 5.0	Eutrophic
> 5.0	Hypereurtrophic