BIOLOGICAL ASSESSMENT UNIT BASINWIDE ASSESSMENT REPORT

LUMBER RIVER BASIN

NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT
AND NATURAL RESOURCES
Division of Water Quality
Environmental Sciences Section

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INTROODUCTION TO PROGRAM METHODS

The Environmental Sciences Section collects a variety of biological, chemical, and physical data that can be used in many ways to assist the basinwide planning program. This report addresses the results of benthic macroinvertebrate, fish community and fish tissue monitoring in the Lumber River basin. The basin has been sampled by the Biological Assessment Unit (BAU) four times for basinwide monitoring: 1996, 2001, 2006 and 2011.

Information on Standard Operating Procedures used in BAUôs three program areas can be found at this link: http://portal.ncdenr.org/web/wq/ess/bau. A comprehensive list of all benthic macroinvertebrate samples taken from this basin can be found here: http://portal.ncdenr.org/web/wq/benthosdata, while a list of all fish community sample can be found at http://portal.ncdenr.org/web/wq/ess/bau/ncibi-scores. A definitive list of all fish tissue data can be found at: http://portal.ncdenr.org/web/wq/ess/bau/fish-tissue-data. In addition, taxonomic data for all benthic macroinvertebrate and fish community samples obtained from the Lumber River Basin can be accessed from EPAôs Storet database by following the instructions here: http://portal.ncdenr.org/web/wq/storethome.

This document is structured with physical, geographical, and biological data discussions presented in hydrologic units (HUs). General water quality conditions are given in an upstream to downstream format. Lakes data, ambient chemistry data and aquatic toxicity data, with summaries, are presented in separate reports.

BASIN DESCRIPTION

The Lumber River basin lies along the North Carolina/South Carolina border at the southeast corner of the state (Figure 1). The basin extends about 150 miles from the Sand Hills ecoregion in southern Moore and Montgomery counties to the Atlantic Ocean coastline in Brunswick County. This basin contains five level-IV ecoregions including the Atlantic Southern Loam Plains ecoregion (most of the upper coastal plain), the Southeastern and Mid-Atlantic Floodplains and Low Terraces ecoregions (a narrow band adjacent to the Lumber River and the Waccamaw River), the Carolina Flatwoods ecoregion (most of Columbus County and southern Bladen County, the sandhills and Non-riverine Swamps and Peatlands ecoregions.

There are approximately 2,283 miles of freshwater streams in the basin with about 90% classified as swamp waters. Most of the basin is forested or to a lesser extent in agriculture. The basin encompasses an area of 3,343 square miles in all or part of 10 counties including Brunswick, Columbus, Bladen, Robeson, Cumberland, Hoke, Scotland, Richmond, Moore and Montgomery. Larger municipalities include Lumberton, Laurinburg, Southern Pines, Pinehurst and Whiteville.

There are four 8-digit HUs in this basin: 03040204 (Little Pee Dee River), 03040203 (Lumber River), 03040206 (Waccamaw River) and 03040208 (Long Bay Atlantic Ocean; Figure 2) For 2011, a total of 23 benthic macroinvertebrate sites and two fish tissue samples (Lake Waccamaw and the Lumber River) were collected. Since there are no current bio-criteria for assigning bioclassifications to fish communities in the sand hills, no fish community samples were collected in 2011. However, studies will be commenced in the spring of 2013 in an effort to establish biocritiera thresholds for assigning bioclassifications based on fish community data in sandhills streams.

Figure 1. Geographical Relationships of the Lumber River Basin.

Figure 2. Eight Digit HUCS of the Lumber River Basin.

LITTLE PEE DEE RIVER HUC 03040204 – LITTLE PEE DEE RIVER

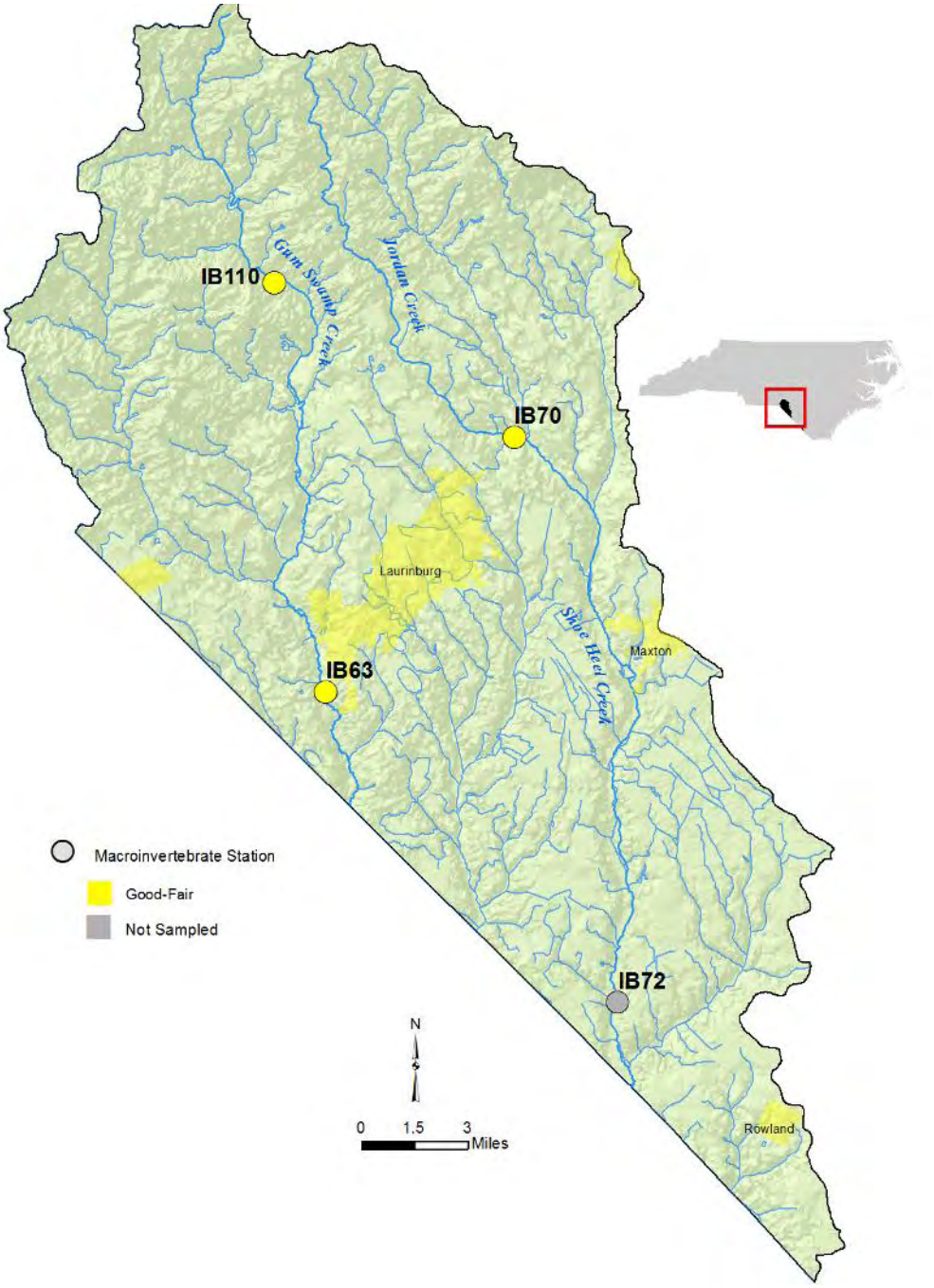


Figure 3. **Sampling sites in HUC 03040204 in the Lumber River Basin. Monitoring sites are listed in Table 1.**

River and Stream Assessment

Shoe Heel Creek (SR 1101) was not sampled in 2011 due to a lack of sufficient flow. Gum Swamp Creek (SR 1323) was moved in 2011 to SR 1001 due to bridge work. Jordan Creek and Gum Swamp Creek received the same bioclassification in 2011 and 2006 (Good-Fair). Specific summaries of the four benthic macroinvertebrate basinwide sampling events may be found in Appendix B-2.

Table 1. Waterbodies monitored in HUC 03040204 in the Lumber River Basin for basinwide assessment (2001-2011).

Station ID	Waterbody	County	Location	2001	2006	2011
IB110	Gum Swamp Cr	Scotland	SR 1001	Good	Good-Fair	Good-Fair[1]
IB72	Shoe Heel Cr	Robeson	SR 1101	Good	Good	Not Sampled[2]
IB63	Gum Swamp	Scotland	US 15-401	Good	Not Sampled[2]	Good-Fair
IB70	Jordan Cr	Scotland	US 401	Good-Fair	Good-Fair	Good-Fair
IF15	Gum Swamp Cr	Scotland	SR 1344	Not rated	Not rated	Not Sampled[3]
IF20	Joes Cr	Scotland	NC 79	Not rated	Not rated	Not Sampled[3]
IF5	(Big) Shoe Heel Cr	Scotland	SR 1433	Not rated	Not rated	Not Sampled[3]
IF21	Jordan Cr	Scotland	SR 1324	Not rated	Not rated	Not Sampled[3]
IF22	Juniper Cr	Scotland	SR 1405	Not rated	Not rated	Not Sampled[3]

[1] Site moved to SR 1001 due to bridge work. [2.] Not sampled due to lack of adequate flow. [3] Not sampled due to a lack of biocritieria for applying bioclassifications to streams in the Lumber Basin using fish community.

Special Studies

The Fayetteville Regional Office and the Planning Section requested that five benthic sites be sampled during the 2006 swamp season. Sites were chosen to fill in areas without data and to assess the effects of animal operations and urbanization. One site (Leith Creek at SR 1609) was sampled from this HUC. Results of the benthic macroinvertebrate sampling produced a swamp bioclassification of Moderate.

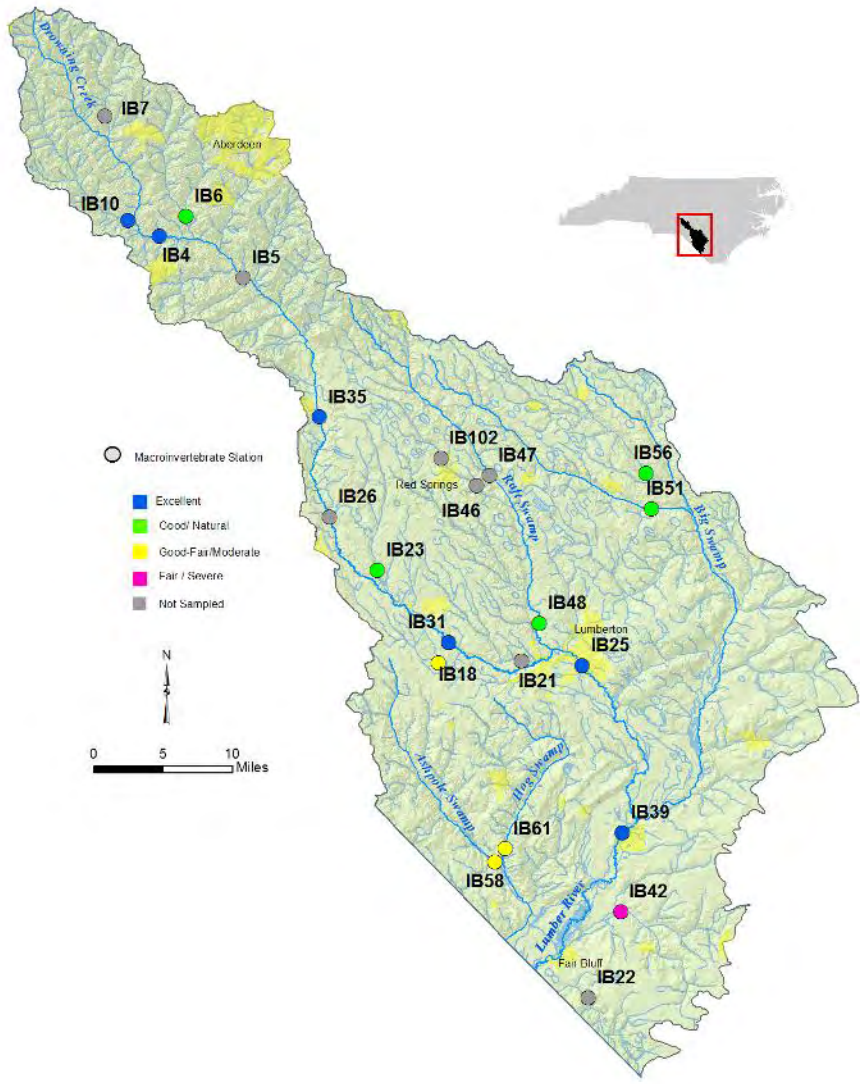


Figure 4. **Sampling sites in HUC 03040203 in the Lumber River basin. Monitoring sites are listed in Table 2.**

River and Stream Assessment

Raft Swamp (SR 1505), both sites on Little Raft Swamp (SR 1505 and SR 1323) and Bear Swamp (SR 1339) were not sampled due to a lack of flow and the extensive presence of beaverdams. In addition, Lumber River (NC 71) and Jackson Creek (SR 1122) were also not assessed in 2011. Jackson Creek was not sampled due to low flows and the Lumber River at NC 71, Gapway Swamp at SR 1356 and Drowning Creek at US 15-501 were all dropped as monitoring sites in 2011 due to logistic shortages associated with staff reductions. Please refer to Appendix B-2 for specific analysis for each of these stations.

Table 2. Waterbodies monitored in HUC 03040203 in the Lumber River basin for basinwide assessment (2001-2011).

Station ID	Waterbody	County	Location	2001	2006	2011
IB35	Lumber R	Scotland	SR 1404	Excellent	Excellent	Excellent
IB31	Lumber R	Robeson	SR 1003	Excellent	Excellent	Excellent
IB25	Lumber R	Robeson	NC 41/72	Excellent	Excellent	Excellent
IB26	Lumber R	Robeson	NC 71	Good-Fair	Good-Fair	Not Sampled[3]
IB39	Lumber R	Robeson	US 74	Excellent	Good	Excellent
IB4	Drowning Cr	Richmond	SR 1004	Excellent	Excellent	Excellent
IB5	Drowning Cr	Hoke	US 15/501	---	Excellent	Not Sampled[3]
IB7	Jackson Cr	Moore	SR 1122	Good	Good	Not Sampled[1]
IB10	Naked Cr	Richmond	SR 1003	Excellent	Excellent	Excellent
IB6	Horse Cr	Moore	SR 1102	Good	Excellent	Good
IB23	Gum Swp	Robeson	SR 1312	Natural	Natural	Natural
IB18	Back Swp	Robeson	SR 1003	Not Rated	Natural	Moderate
IB21	Bear Swp	Robeson	SR 1339	Natural	Moderate	Not Sampled[1]
IB102	Little Raft Swp	Robeson	SR 1323	---	Natural	Not Sampled[1]
IB46	Little Raft Swp	Robeson	SR 1505	Moderate	Severe	Not Sampled[1]
IB47	Raft Swp	Robeson	SR 1505	Moderate	Natural	Not Sampled[1]
IB48	Raft Swp	Robeson	SR 1527	---	Moderate	Natural
IB56	Little Marsh Swp	Robeson	SR 1907	Natural	Natural	Natural
IB51	Big Marsh Swp	Robeson	SR 1924	Natural	Natural	Natural
IB42	Porter Swp	Columbus	SR 1503	Moderate	Severe	Severe
IB58	Ashpole Swamp	Robeson	NC 41	Natural	Moderate	Moderate
IB61	Hog Swamp	Robeson	SR 2262	Natural	Moderate	Moderate
IB22	Gapway Swp	Columbus	SR 1356	Moderate	Moderate	Not Sampled[3]
IF11	Drowning Cr	Moore	NC 73	Not Rated	Not Rated	Not Sampled[2]
IF19	Jackson Cr	Moore	SR 1122	Not Rated	Not Rated	Not Sampled[2]
IF28	Naked Cr	Richmond	SR 1003	Not Rated	Not Rated	Not Sampled[2]
IF18	Horse Cr	Moore	SR 1112	---	Not Rated	Not Sampled[2]
IF10	Deep Cr	Moore	SR 1113	Not Rated	Not Rated	Not Sampled[2]
IF1	Aberdeen Cr	Moore	SR 1105	Not Rated	Not Rated	Not Sampled[2]
IF30	Quewhiffle Cr	Hoke	SR 1225	Not Rated	Not Rated	Not Sampled[2]
F27	Mountain Cr	Hoke	SR 1215	Not Rated	Not Rated	Not Sampled[2]

[1] Not sampled due to a lack of flow. [2] Not sampled due to a lack of biocritieria for applying bioclassifications to streams in the Lumber Basin using fish community. [3] Not sampled due staffing constraints.

Special Studies

The Fayetteville Regional Office and the Planning Section requested that five benthic sites be sampled during the 2006 swamp season. Sites were chosen to fill in areas without data and to assess the effects of animal operations and urbanization. One site (Ashpole Swamp at NC 130) was sampled from this HUC. Results of the benthic macroinvertebrate sampling produced a swamp bioclassification of Moderate.

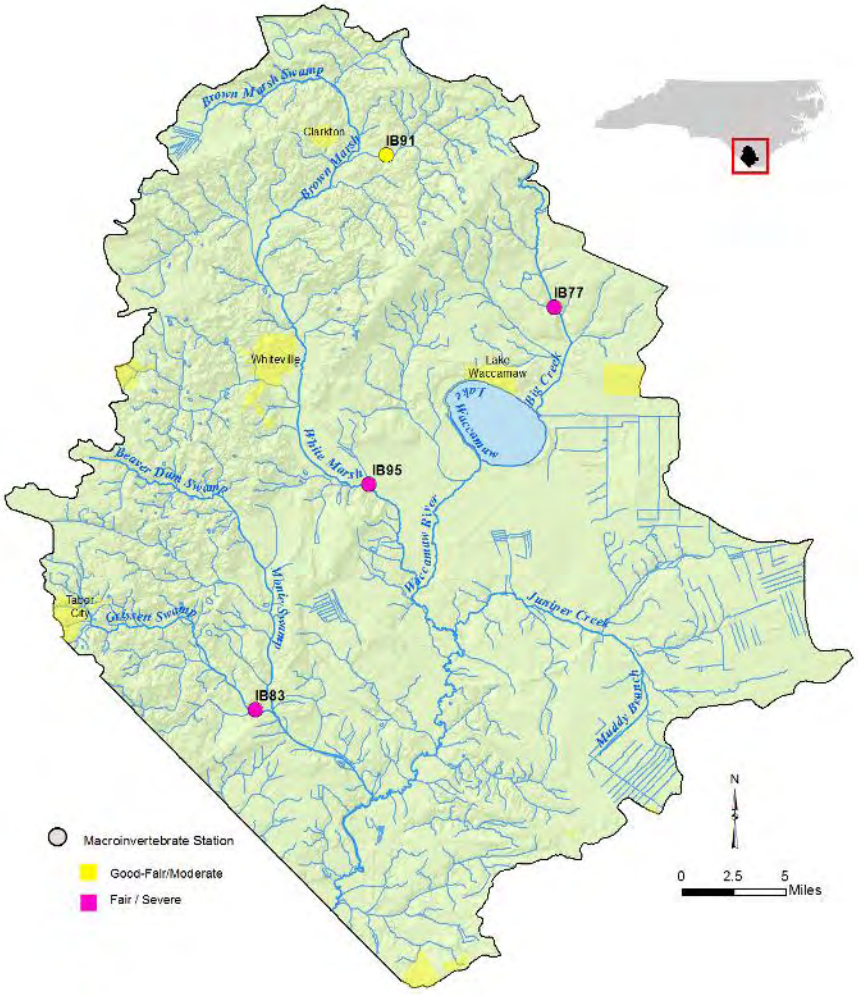


Figure 5. **Sampling sites in HUC 03040206 in the Lumber River basin. Monitoring sites are listed in Table 2.**

River and Stream Assessment

Three locations on the Waccamaw River (NC 130, NC 904, and SR 1928) were not sampled due to a lack of flow and extremely low stage and were therefore omitted from Table 2. Of the remaining four stations sampled in this HUC, only Elkton Marsh retained the same bioclassification between 2001, 2006, and 2011. Indeed, both Grisset Swamp and White Marsh Swamp decreased in bioclassification in 2011 to Severe from Moderate in 2006. Most notably, Friar Swamp declined from tow Natural ratings in 2001 and 2006 to Severe in 2011. Please refer to detailed site analysis for the waterbodies in this HUC in Appendix B-2.

Table 3. Waterbodies monitored in HUC 03040206 in the Lumber River basin for basinwide assessment (2001-2011).

Station ID	Waterbody	County	Location	2001	2006	2011
IB77	Friar Swp	Columbus	SR 1740	Natural	Natural	Severe
IB95	White Marsh	Columbus	SR 1001	Moderate	Moderate	Severe
IB91	Elkton Marsh	Bladen	SR 1710	Moderate	Moderate	Moderate
IB83	Grissett Swp	Columbus	SR 1141	Moderate	Moderate	Severe

Special Studies

The Fayetteville Regional Office and the Planning Section requested that five benthic sites be sampled during the 2006 swamp season. Sites were chosen to fill in areas without data and to assess the effects of animal operations and urbanization. One site (Western Prong at US 70 Bypass) was sampled from this HUC. Results of the benthic macroinvertebrate sampling produced a swamp bioclassification of Moderate.

LITTLE PEE DEE RIVER HUC 03040208 – LONG BAY ATLANTIC OCEAN

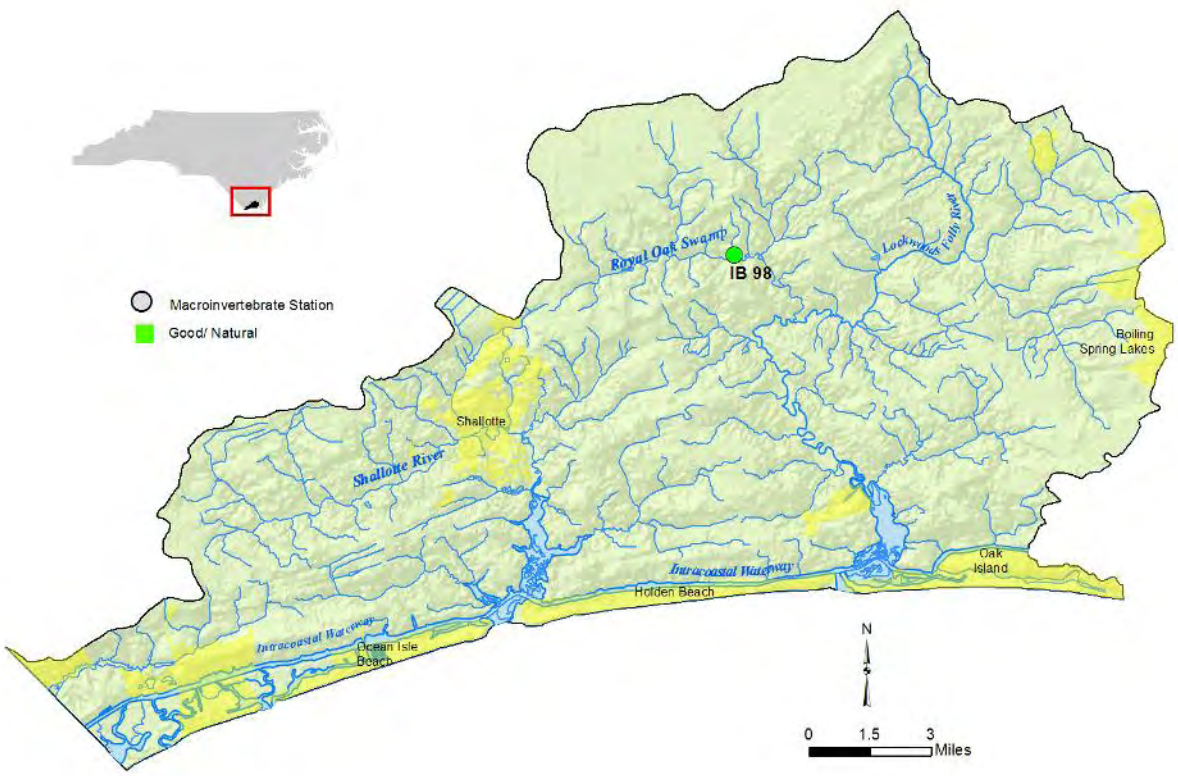


Figure 6. **Sampling sites in HUC 03040208 in the Lumber River basin. Monitoring sites are listed in Table 1.**

River and Stream Assessment

There is only one benthic macroinvertebrate station in this HUC. The 2011 rating was unchanged from both previous sampling events. A detailed summary of this site can be found in Appendix B-2. No special studies have been collected in this HUC since 2006.

Table 4. **Waterbodies monitored in HUC 03040208 in the Lumber River Basin for basinwide assessment (2001-2011).**

Map #[1]	Waterbody	County	Location	2001	2006	2011
IB98	Royal Oak Swp	Brunswick	NC 211	Natural	Natural	Natural

GLOSSARY

Assessment Unit	A stream or a segment of a stream. Assessment Unit designations are used to uniquely identify streams or stream segments for the purpose of classifying waters for protection by use (such as for drinking water supply or trout waters).
BI or NCBI	North Carolina Biotic Index. This is one of two metrics used extensively to evaluate the results of benthic sampling, and is the weighted sum of tolerance values for taxa found in the sample relative to their abundance.
Bioclassification	A classification assigned to a stream site following biological sampling of either fish or macroinvertebrates. Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each sample. For invertebrates the bioclassification is based on the number of taxa present in the intolerant groups (EPT) and the North Carolina Biotic Index (BI or NCBI) value. For fish the classification is based on abundance, condition of specimens, species richness, composition, pollution-tolerance, trophic composition, and reproductive function.
Ecoregion	An area of relatively homogeneous environmental conditions, usually defined by elevation, geology, vegetation, and soil type. Examples include Mountains, Piedmont, Coastal Plain, Sand Hills, and Carolina Slate Belt.
EPT	The insect orders Ephemeroptera, Plecoptera, and Trichoptera. As a whole, these are the most intolerant insects present in the benthic community. EPT also refers to taxa richness within the three insect orders, a metric used extensively to derive bioclassifications. Higher EPT taxa richness values are associated with better water quality.
EPT BI	North Carolina Biotic Index for the EPT portion of the benthic community. This is the weighted sum of the tolerance values of taxa in the insect orders Ephemeroptera, Plecoptera, and Trichoptera found in the sample, relative to their abundance.
HQW	High Quality Waters. Such waters are rated Excellent based on biological and physical/chemical characteristics through Division monitoring or special studies and have been approved for such designation by the state Environmental Management Commission; also, primary nursery areas designated by the Marine Fisheries Commission and all Class SA waters.
MGD	Million gallons per day. This is generally the unit in which effluent discharge flow is measured.
NPDES	National Pollutant Discharge Elimination System.
NCIBI	North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community.
ORW	Outstanding Resource Waters. These are unique and special waters of exceptional state or national recreational or ecological significance that require special protection to maintain existing uses and have been approved for such designation by the Environmental Management Commission.

GLOSSARY (continued)

Specific Conductance	The measure of the resistance of a solution to electrical flow. Resistance is reduced with increasing content of ionized salts. Reported in the units of εmhos/cm at 25 ^{o}C.
ST	Total invertebrate richness. The total number of different taxa present in a Full Scale benthic macroinvertebrate sample.
UT	Unnamed tributary.
WTP	Water treatment plant.
WWTP	Wastewater treatment plant

Appendix B-1. Summary of benthic macroinvertebrate data.

For 2011, 10 long-term benthic macroinvertebrate samples were collected in the streams and rivers of the Lumber River Basin as part of the Basinwide Assessment program. Graphical representations of bioclassification trends from 2011-2001 among these long-term basinwide benthos stations can be found below in Figure 7. As can be seen from these data, the 2011 benthic macroinvertebrate community bioclassifications pertaining to Poor, Fair, Good-Fair and Excellent sites are either identical or essentially unchanged between sampling cycles. Conversely, the number of Good bioclassifications in 2011 was drastically reduced relative to 2006 and 2001 samples. However, two sites (IB72 and IB7) were not sampled in 2011 due to flow related issues. These sites both rated Good in 2001 and 2006. Therefore, the real decline in Good bioclassifications from 2001-2011 should not include these sites. Please refer to the analysis of the benthic macroinvertebrate data detailed in Appendix B-2 for specific information on trend analysis at each of the sites sampled in 2011.

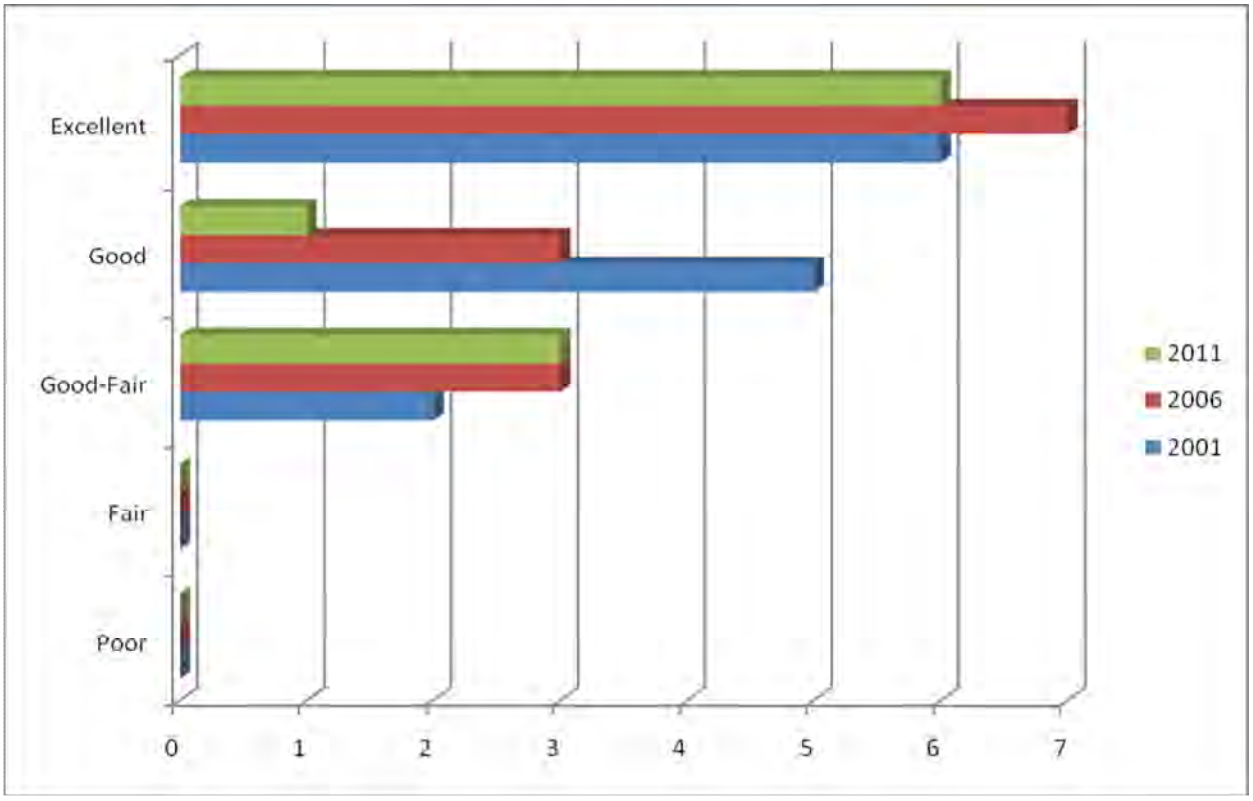


Figure 7. Stream and River Bioclassification Trends (Lumber Basin: 2001-2011).

The 2011 basinwide assessment of the swamp waters in the Lumber River basin included collections at 13 long-term benthic macroinvertebrate stations. Graphical representations of bioclassification trends from 2011-2001 among these long-term basinwide swamp stations can be found below in Figure 8. As can be seen from these data, the 2011 benthic macroinvertebrate community bioclassifications pertaining to swamp waters detected an increase in the number of Severe ratings and a corresponding reduction in Natural and Moderate bioclassifications. Most notably, IB77 rated Natural in 2001 and 2006 but declined to Severe in 2011 while IB95, IB83 declined from Moderate in 2001 and 2006 to Severe in 2011. It was noted during the sample events that water levels were somewhat higher than in 2006. This may have made sampling conditions more difficult; however it is unlikely that slightly higher water levels alone can account for the drastic decline noted at IB77. In addition to the slightly higher than normal flows, there were also a series of days with unusually cold temperatures preceding the sampling events. These anomalously cold temperatures may have resulted in increased larval mortality among the invertebrates. However, water temperatures noted in 2011 and 2006 were not significantly different and therefore do not support that theory. Interestingly, IB98 (the regional reference site) was Natural in 2011 and was unchanged from the previous Natural bioclassifications obtained at this location since ??, This suggests that the decline in bioclassifications at sites IB77, IB95 and IB83 may indicate changes in water quality and not representative of other confounding issues such as high flow or low temperature. In any event, IB77 will be resampled in 2014 since its decline was the most drastic. Please refer to the analysis of the benthic macroinvertebrate data detailed in Appendix B-2 for specific information on trend analysis at each of the sites sampled in 2011.

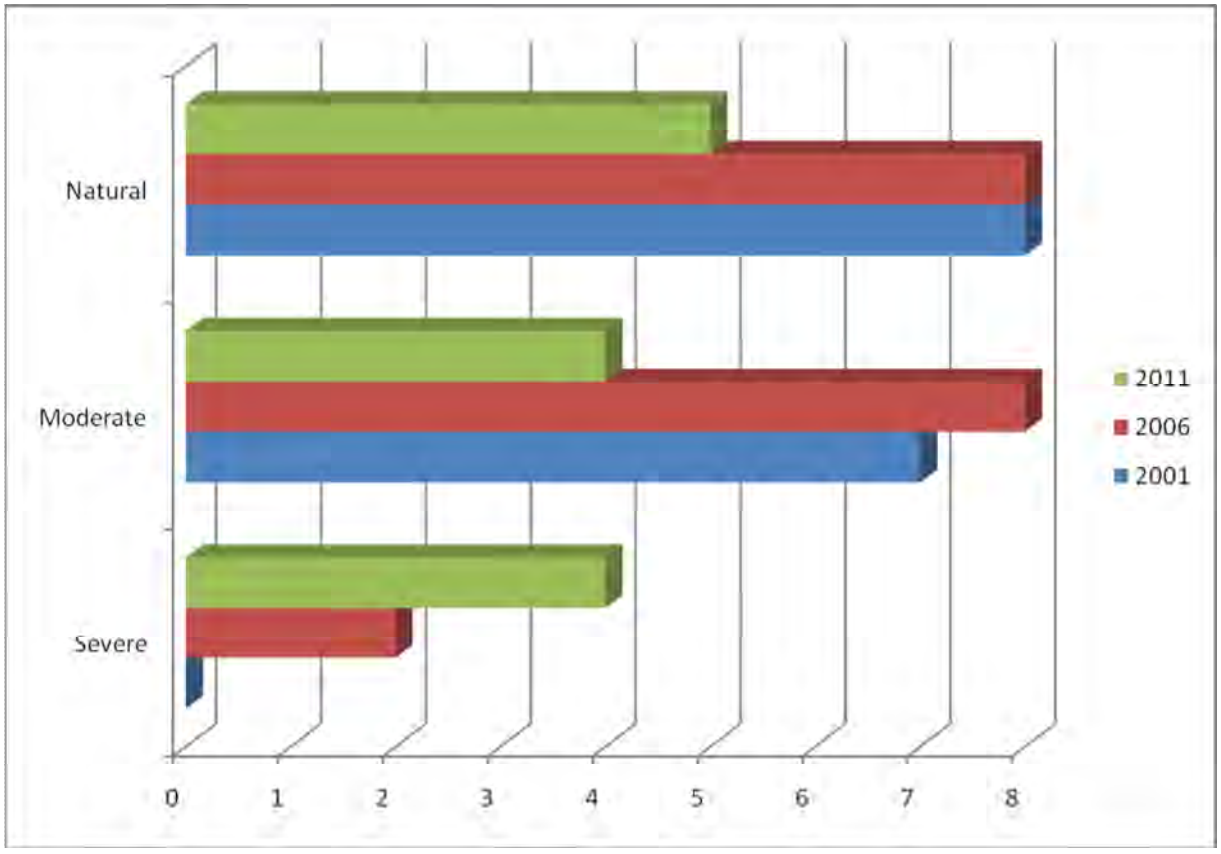


Figure 8. Swamp Bioclassification Trends (Lumber Basin: 2001-2011).

Appendix B2:

Lumber River Basin Specific Site Analyses

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
Gum Swp Cr	**SR 1001**	**IB110**	**07/20/11**	**Good-Fair**

County	Subbasin	8 digit HUC	Latitude	Longitude
Scotland	55	03040204	34.879760	-79.543490

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Sand Hills	34.5	6	0.5

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	80	20	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	26.4
Dissolved Oxygen (mg/L)	5.9
Specific Conductance (µS/cm)	20
pH (s.u.)	4.9

Water Clarity	clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	15
Bottom Substrate (15)	8
Pool Variety (10)	6
Bank Erosion (10)	8
Bank Vegetation (10)	8
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	80

Site Photograph

Substrate mostly sand with some silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
07/20/11	11247	EPT	---	17	---	3.45	Good-Fair
07/10/06	9976	EPT	---	17	---	3.70	Good-Fair
07/09/01	8450	EPT	---	22	---	3.09	Good
07/10/96	7089	EPT	---	15	---	3.25	Good-Fair
09/09/91	5713	EPT	---	17	---	3.43	Good-Fair

Data Analysis

The Gum Swamp Creek catchment drains a portion of east Scotland County and southeastern Richmond County. Land use in this watershed is primarily agriculture and forest (Sandhills State Game Lands). The basinwide sampling location for this stream was temporarily moved for the 2011 cycle upstream from SR 1323 to SR 1001 due to DOT bridge construction at SR 1323. This moved decreased the drainage area by about 5.5 square miles. In summary, water quality has remained relatively stable at Good-Fair since sampling began in 1991.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
GUM SWP	**US 15-401**	**IB63**	**07/19/11**	**Good-Fair**

County	Subbasin	8 digit HUC	Latitude	Longitude
Scotland	55	03040204	34.712500	-79.516944

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Atlantic Southern Loam Plains	117.0	8	1.2

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	75	25	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	25.4
Dissolved Oxygen (mg/L)	5.7
Specific Conductance (µS/cm)	27
pH (s.u.)	5.4

Water Clarity	clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	10
Bottom Substrate (15)	7
Pool Variety (10)	4
Bank Erosion (10)	6
Bank Vegetation (10)	8
Light Penetration (10)	9
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	69

Site Photograph

Substrate sand on top of detritus with small amounts of silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
07/19/11	11242	EPT	---	13	---	3.96	Good-Fair
07/09/01	8452	EPT	---	20	---	3.24	Good
07/09/96	7086	EPT	---	21	---	3.49	Good
09/09/91	5714	EPT	---	24	---	3.90	Excellent

Data Analysis

Situated between Laurinburg and Hamlet, NC, the catchment of this site on Gum Swamp mostly drains a portion of southeastern Scotland County. This site was not sampled in 2006 due to high flows. Macroinvertebrate habitat was sufficient although steep, clay banks and difficult wading made access to the relevant habitats challenging. Water quality appears to be decreasing as evidenced by fewer EPT taxa collected in 2011 and the eventual decline from the Excellent rating 20 years prior to the current Good-Fair. Continued monitoring is required to document any additional decrease in water quality.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
JORDAN CR	**US 401**	**IB70**	**07/15/11**	**Good-Fair**

County	Subbasin	8 digit HUC	Latitude	Longitude
Scotland	55	03040204	34.816944	-79.424167

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Atlantic Southern Loam Plains	18.9	6	0.5

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	---	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	22.4
Dissolved Oxygen (mg/L)	---
Specific Conductance (µS/cm)	28
pH (s.u.)	5.3

Water Clarity	clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	12
Bottom Substrate (15)	8
Pool Variety (10)	5
Bank Erosion (10)	6
Bank Vegetation (10)	8
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	74

Site Photograph

Substrate mostly sand with some detritus and silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
07/15/11	11246	EPT	---	17	---	4.13	Good-Fair
08/04/06	10037	EPT	---	12	---	4.08	Good-Fair
07/09/06	9975	EPT	---	15	---	3.75	Good-Fair
07/09/01	8451	EPT	---	12	---	3.33	Good-Fair
07/10/96	7088	EPT	---	15	---	3.42	Good-Fair

Data Analysis

A tributary of Shoe Heel Creek, Jordan Creek drains a portion of the Sandhills in north central Scotland County. Water quality condition and macroinvertebrate habitat have been relatively stable since sampling started in 1996 although the highest EPT richness to date was attained in 2011. This fifth consecutive Good-Fair bioclassification suggests stable conditions in this watershed.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
LUMBER R	**SR 1404**	**IB35**	**07/19/11**	**Excellent**

County	Subbasin	8 digit HUC	Latitude	Longitude
Scotland	51	03040203	34.877222	-79.345556

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Southeastern Floodplains and Low Terraces	341.2	10	0.4

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	80	---	---	---	20 (power easement)

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
Moore County Public Utilites	NC 0037508	6.7

Water Quality Parameters

Temperature (°C)	23.2
Dissolved Oxygen (mg/L)	6.6
Specific Conductance (µS/cm)	52
pH (s.u.)	5.9

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	16
Bottom Substrate (15)	13
Pool Variety (10)	8
Left Bank Stability (10)	9
Right Bank Stability (10)	9
Light Penetration (10)	7
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	87

Site Photograph

Substrate: sand and gravel, some silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
07/19/11	11245	Full Scale	70	30	4.69	3.63	Excellent
07/17/06	9970	Full Scale	81	36	4.69	3.36	Excellent
07/17/01	8441	Full Scale	90	36	4.31	3.36	Excellent
07/09/96	7065	Full Scale	75	33	3.99	2.96	Excellent
09/10/91	5717	Full Scale	83	30	5.11	3.30	Excellent
07/14/86	3808	Full Scale	88	30	5.14	3.79	Excellent

Data Analysis

This is the furthest most upstream macroinvertebrate sampling site on the Lumber River. The river at this point is designated Wild and Scenic by the National Park Service and has little development in its riparian areas. While water levels were low at the time of sampling, habitat and water quality at this site is highly favorable and sustained a rich and healthy macroinvertebrate community which included the rarely collected and pollution intolerant stonefly *Perlinella*. The Lumber River at SR 1404 rates Excellent for the sixth consecutive time indicating stable conditions in this catchment.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
LUMBER R	**SR 1003 nr PEMBROKE**	**IB31**	**07/15/11**	**Excellent**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	51	03040203	34.641667	-79.180556

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Southeastern Floodplains and Low Terraces	437.0	16	0.4

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	---	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
Moore County Public Utilites	NC 0037508	6.7
Westpoint Stevens, Inc	NC 0005762	4.5
Laurinburg-Maxto Airport	NC 0044725	1.0
Pembroke Town WWTP	NC 0027103	1.33

Water Quality Parameters

Temperature (°C)	26.5
Dissolved Oxygen (mg/L)	0.0
Specific Conductance (µS/cm)	74
pH (s.u.)	6.5

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	15
Bottom Substrate (15)	8
Pool Variety (10)	4
Left Bank Stability (10)	9
Right Bank Stability (10)	10
Light Penetration (10)	7
Left Riparian Score (5)	4
Right Riparian Score (5)	4
Total Habitat Score (100)	76

Site Photograph

Substrate: sand with detirtus and silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
07/15/11	11244	Full Scale	84	40	4.96	3.96	Excellent
07/17/06	9971	Full Scale	83	29	4.95	3.78	Excellent
07/18/01	8454	Full Scale	92	32	5.02	3.97	Excellent
07/09/96	7070	Full Scale	71	31	4.68	3.71	Excellent
09/11/91	5720	Full Scale	87	31	5.76	3.97	Excellent
08/07/90	5414	Full Scale	87	28	5.38	4.13	Excellent
07/13/88	4607	Full Scale	88	28	5.21	4.24	Excellent
07/15/86	3811	Full Scale	84	32	5.33	4.05	Excellent

Data Analysis

This site on the Lumber River is a few miles upstream of Lumberton and eliminates any effects that municipality may have on Lumber River water quality. LIke the downstream site, the presense of dishargers above this site have not affected water quality as the river at this site has never rated anything less than Excellent. A diverse and abundant macroinvertebrate community is present here and includes rare and highly pollution intolerant EPT such as the caddisfly *Oecetis sp. D* and the mayfly *Sparbarus maculatus*. Sampling at SR 1003 in 2011 resulted in the highest EPT richness ever seen from any Lumber River sampling site over the past 30 years.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
LUMBER R	**NC 41-72**	**IB25**	**07/14/11**	**Excellent**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	51	03040203	34.617500	-79.011111

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Southeastern Floodplains and Low Terraces	680.4	25	0.5

	Forested/Wetland	Residential	Agriculture	Road	Other (describe)
Visible Landuse (%)	---	75	---	---	25 (city park/greenway)

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
Moore County Public Utilites	NC 0037508	6.7
Westpoint Stevens, Inc	NC 0005762	4.5
Laurinburg-Maxton Airport Commision	NC 0044725	1.0
Pembroke Town WWTP	NC 0027103	1.33
Red Springs Town WWTP	NC 0025577	2.5

Water Quality Parameters

Temperature (°C)	29.3
Dissolved Oxygen (mg/L)	---
Specific Conductance (µS/cm)	77
pH (s.u.)	6.5

Water Clarity	clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	15
Bottom Substrate (15)	10
Pool Variety (10)	4
Bank Erosion (10)	5
Bank Vegetation (10)	8
Light Penetration (10)	3
Left Riparian Score (5)	2
Right Riparian Score (5)	2
Total Habitat Score (100)	64

Site Photograph

Substrate mostly sand with some cobble, gravel, and silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
07/14/11	11243	Full Scale	90	31	5.56	4.30	Excellent
08/04/06	10036	Full Scale	86	31	5.56	4.27	Excellent
07/18/01	8464	Full Scale	91	30	5.61	4.51	Excellent
07/10/96	7071	Full Scale	73	30	5.28	4.11	Excellent

Data Analysis

Lumber River at NC 41-72 is located on the south side of Lumberton in Robeson County. Nevertheless, this site has consistently rated Excellent since it first was sampled as a basinwide site in 1996. Large volumes of water are diluting the effluent from major discharges upstream as seen by the relatively low specific conductance recorded. Total taxa, EPT richness, and all measures of biotic index have been consistent over the last 15 years indicating stable water quality.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
LUMBER R	**US 74 @ BOARDMAN**	**IB39**	**09921/11**	**Excellent**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	51	03040203	34.443056	-78.960556

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Mid-Atlantic Floodplains and Low Terraces	1224.5	20	0.5

	Forested/Wetland	Residential	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	---	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
Lumberton City WWTP	NC 0024571	20
Buckeye Lumberton, Inc	NC 0005321	1.8
Alamac Knit Fabrics, Lumberton	NC 0004618	2.56
Pembroke Town WWTP	NC 0027103	1.33
Laurinburg-Maxto Airport Commision	NC 0044725	1.0
Westpint Stevens, Inc	NC 0005762	4.5
Moore County WSA/Moore Co WWTP	NC 0037508	6.7
Red Springs Town WWTP	NC 0025577	2.5

Water Quality Parameters

Temperature (°C)	21.8
Dissolved Oxygen (mg/L)	6.1
Specific Conductance (µS/cm)	131
pH (s.u.)	6.7
Water Clarity	clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	15
Bottom Substrate (15)	13
Pool Variety (10)	6
Left Bank Stability (10)	9
Right Bank Stability (10)	10
Light Penetration (10)	3
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	81

Site Photograph

Substrate sand with some detritus

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
09/21/11	11300	Full Scale	76	27	5.26	3.66	Excellent
08/24/06	10022	Full Scale	74	20	5.55	4.11	Good
09/10/01	8559	Full Scale	94	32	5.49	4.33	Excellent
07/11/96	7074	Full Scale	82	26	5.61	4.28	Good
09/10/91	5733	Full Scale	52	19	4.81	4.04	Good
07/13/88	4606	Full Scale	92	27	5.61	4.16	Good
06/24/86	3776	Full Scale	71	26	5.45	4.09	Good

Data Analysis

The Lumber River at US 74 is the lowermost macroinvertebrate site and lies below the City of Lumberton and 8 major dischargers. These dischargers give this site the highest specific conductance of any site on the river, almost double the next highest value (Lumber R @ NC 41-72). Sampling this segment of river requires the use of a boat to find suitable habitat and wadable areas. Previous samplings have rated this segment as Good with the exception of in 2001 when it rated Excellent. Results from 2011 have yielded another Excellent rating and an intolerant, rich, and abundant EPT community including the re-appearance of stoneflies, which were entirely absent in 2006.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
DROWNING CR	**SR 1004**	**IB4**	**07/11/11**	**Excellent**

County	Subbasin	8 digit HUC	Latitude	Longitude
Richmond	50	03040203	35.065833	-79.550000

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Sand Hills	125.5	6	0.3

	Forested/Wetland	Residential	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	---	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	26.0
Dissolved Oxygen (mg/L)	5.6
Specific Conductance (µS/cm)	34
pH (s.u.)	---

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	16
Bottom Substrate (15)	12
Pool Variety (10)	6
Bank Erosion (10)	6
Bank Vegetation (10)	10
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	85

Site Photograph

Substrate: mostly gravel with some sand and silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
07/11/11	11241	Full Scale	65	24	4.64	2.94	Excellent
07/10/06	9967	Full Scale	81	29	4.41	3.11	Excellent
07/13/01	8437	Full Scale	81	31	4.40	2.94	Excellent
07/08/96	7064	Full Scale	74	34	4.45	3.15	Excellent
09/09/91	5711	Full Scale	90	39	4.66	3.14	Excellent
07/14/88	4610	Full Scale	87	30	4.57	2.84	Excellent
09/11/85	3614	Full Scale	74	28	4.40	3.09	Excellent

Data Analysis

Drowning Creek denotes the county line between Moore, Richmond and Montgomery Counties and drains a small portion of each. Located below the confluence with Horse Creek, the sampling site rated Excellent for the seventh consecutive time. The lowest EPT and total richness ever recorded occurred in 2011. Much of this taxa decrease can be attributed to chronic low flow as much of the edge habitat was out of water and only about half to the existing channel was wetted. The taxa that did occur, however, were highly intolerant and indicated that water quality has not declined since 1985.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
NAKED CR	**SR 1003**	**IB10**	**07/11/11**	**Excellent**

County	Subbasin	8 digit HUC	Latitude	Longitude
Richmond	50	03040203	35.081944	-79.590278

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Sand Hills	37.1	5	0.2

	Forested/Wetland	Residential	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	---	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	24.1
Dissolved Oxygen (mg/L)	5.8
Specific Conductance (µS/cm)	30
pH (s.u.)	6.3

Water Clarity	clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	15
Bottom Substrate (15)	12
Pool Variety (10)	6
Left Bank Stability (10)	6
Right Bank Stability (10)	8
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	82

Site Photograph

Substrate sand and gravel, some silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
07/11/11	11239	Full Scale	76	32	4.60	3.24	Excellent
07/10/06	9966	Full Scale	91	31	4.86	3.39	Excellent
07/13/01	8438	Full Scale	98	41	4.51	3.65	Excellent
07/08/96	7062	Full Scale	81	33	4.66	3.51	Excellent
09/09/91	5710	Full Scale	94	35	4.74	3.25	Excellent
07/17/90	5383	Full Scale	80	34	4.70	3.37	Excellent

Data Analysis

Naked Creek is sampled just above the confluence with Drowning Creek and drains small areas of northeastern and southeastern Richmond and Montgomery Counties, respectively. Total taxa and EPT richness, while not as high as in the past, was sufficient for Naked Creek to garner its sixth consecutive basinwide Excellent Rating. It is probable that chronic low water levels affected the macroinvertebrate community in 2011 as much edge habitat and woody debris were out of water and many gravel bars were exposed. This sixth consecutive Excellent bioclassification suggests stable conditions in this catchment and favorable water quality.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
HORSE CR	**SR 1102**	**IB6**	**07/20/11**	**Good**

County	Subbasin	8 digit HUC	Latitude	Longitude
Moore	50	03040203	35.086667	-79.516667

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Sand Hills	40.6	6	0.4

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	---	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	23.9
Dissolved Oxygen (mg/L)	7.1
Specific Conductance (µS/cm)	21
pH (s.u.)	5.7

Water Clarity	clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	15
Bottom Substrate (15)	10
Pool Variety (10)	5
Left Bank Stability (10)	8
Right Bank Stability (10)	8
Light Penetration (10)	9
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	80

Site Photograph

Substrate sand with significant gravel, some silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
07/20/11	11248	EPT	---	18	---	3.48	Good
07/10/06	9974	EPT	---	26	---	3.00	Excellent
07/09/01	8435	EPT	---	20	---	3.06	Good
07/08/96	7063	EPT	---	28	---	3.28	Excellent
09/09/91	5712	EPT	---	26	---	3.01	Excellent

Data Analysis

The Horse Creek catchment encompasses Sandhills State Game Lands and portions of Pinebluff and Pinehurst. Low water levels in 2011 were evident with root-mats out of water and much of the channel dry. The low flow contributed to lower EPT levels as edge taxa collected in previous years, particularly leptocerid caddisflies, were almost completely absent in 2011. The bioclassification based on macroinvertebrates declined from Excellent in 2006 to the current 2011 rating of Good. Effects of upstream municipal development, while confounded by drought, may also have an effect on water quality in Horse Creek.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
GUM SWP	**SR 1312**	**IB23**	**02/22/11**	**Natural**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	51	03040203	34.717500	-79.271389

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Atlantic Southern Loam Plains	33.0	n.a.	0.2

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	---	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	14.9
Dissolved Oxygen (mg/L)	---
Specific Conductance (µS/cm)	102
pH (s.u.)	5.7

Water Clarity	clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	15
Bottom Substrate (15)	13
Pool Variety (10)	8
Bank Erosion (10)	10
Bank Vegetation (10)	10
Light Penetration (10)	10
Left Riparian Score (5)	4
Right Riparian Score (5)	5
Total Habitat Score (100)	90

Site Photograph

Substrate sand and silt, detritus

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/22/11	11140	Swamp	68	23	5.40	4.77	Natural
02/24/06	9794	Swamp	78	22	6.16	4.92	Natural
02/07/06	9782	Swamp	84	28	6.19	5.16	Natural
02/08/01	8378	Swamp	75	21	6.12	4.91	Natural

Data Analysis

The site is approximately 5 miles east of the town of Maxton. Land use is mostly forest although some previous logging activities have been noted. Gum Swamp is a well braided and sandy-bottomed swamp with many good flow areas. The high quality habitat is reflected in the high number of EPT taxa consistently collected for a swamp system . One endemic mayfly not previously recorded at this site, but present in 2011, was *Eurylophella oviruptis* which was described in the taxonomic literature since the last basinwide sample. The substantially lower biotic index is due primarily to the high number of Plecoptera (6) and fewer midge taxa (16) collected in 2011 compared to previous years. The fourth consecutive Natural rating indicates the benthic community is intolerant and that water quality is favorable with essentially no change since 2001.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
BACK SWP	**SR 1003**	**IB18**	**02/23/11**	**Moderate**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	51	03040203	34.620278	-79.193611

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Southeastern Floodplains and Low Terraces	12.5	9	0.2

	Forested/Wetland	Residential	Agriculture	Road	Other (describe)
Visible Landuse (%)	20	20	---	---	60 (active logging)

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	13.1
Dissolved Oxygen (mg/L)	10.0
Specific Conductance (µS/cm)	89
pH (s.u.)	6.0

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	5
Instream Habitat (20)	12
Bottom Substrate (15)	13
Pool Variety (10)	4
Bank Erosion (10)	4
Bank Vegetation (10)	7
Light Penetration (10)	8
Left Riparian Score (5)	3
Right Riparian Score (5)	3
Total Habitat Score (100)	59

Site Photograph

Substrate: sand and silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/23/11	11142	Swamp	75	23	6.02	5.01	Moderate
02/07/06	9781	Swamp	59	22	5.86	4.67	Natural

Data Analysis

Back Swamp is a highly channelized stream about 7 miles west of Lumberton and it drains a small western portion of Robeson County. Watershed use is predominantly agricultural use including forestry practices. Storm water discharge enters the stream midsite via a small culvert. Only small amounts of woody debris or other hard substrates were available at the time of sampling although root-mats and aquatic macrophytes (*Myriophyllum* spp. and *Vallisneria* spp) were plentiful. Both the total number of taxa and EPT taxa richness increased since 2006. However, the increased Biotic Index, while not large, was sufficient to decrease the bioclassification to Moderate. A larger number of Chironomidae and fewer stoneflies collected in 2011 were responsible for the increased biotic index. Still, water quality remains largely stable.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
RAFT SWP	**SR 1527**	**IB48**	**02/23/11**	**Natural**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	52	03040203	34.661667	-79.065833

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Southeastern Floodplains and Low Terraces	158.7	12	1.0

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	50	10	---	---	10 (power easement), 30 (logged)

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
Red Springs WWTP	NC0025577	2.5

Water Quality Parameters

Temperature (°C)	11.8
Dissolved Oxygen (mg/L)	6.9
Specific Conductance (µS/cm)	54
pH (s.u.)	5.3

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	15
Bottom Substrate (15)	12
Pool Variety (10)	4
Left Bank Stability (10)	10
Right Bank Stability (10)	10
Light Penetration (10)	9
Left Riparian Score (5)	3
Right Riparian Score (5)	5
Total Habitat Score (100)	83

Site Photograph

Substrate: sand, detritus, and silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/23/11	11141	Swamp	56	23	5.60	4.97	Natural
02/07/06	9780	Swamp	42	12	6.40	5.73	Moderate

Data Analysis

Introduced as a new basinwide site in 2006, Raft Swamp at SR 1527 integrates the entire Raft and Little Raft Swamp watersheds. After rating Moderate in 2006, sampling in 2011 resulted in a Natural bioclassification. Sampling was performed upstream of a power easement where the channel was, while deep, wadable. Also, there were many braided channels which provided good habitat and supported a rich and intolerant macroinvertebrate community. EPT richness was almost double that collected in 2006 and included 6 species of stoneflies. Further sampling should indicate whether this waterbody will remain Natural but at this time there appear to be no significant water quality issues.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
L MARSH SWP	**SR 1907**	**IB56**	**02/20/11**	**Natural**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	53	03040203	34.818889	-78.929722

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Atlantic Southern Loam Plains	44.1	10	1.2

	Forested/Wetland	Residential	Agriculture	Road	Other (describe)
Visible Landuse (%)	50	50	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	11.3
Dissolved Oxygen (mg/L)	7.2
Specific Conductance (µS/cm)	60
pH (s.u.)	5.6

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	10
Instream Habitat (20)	10
Bottom Substrate (15)	5
Pool Variety (10)	4
Bank Erosion (10)	10
Bank Vegetation (10)	10
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	69

Site Photograph

Substrate: detritus and silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/20/11	11136	Swamp	67	18	6.21	5.05	Natural
02/24/06	9796	Swamp	67	14	6.11	5.03	Natural
02/07/01	8372	Swamp	67	17	6.32	5.12	Natural

Data Analysis

The catchment of Little Marsh Swamp at SR 1907 includes the small municipality of Parkton and a small portion of northern Robeson County. This swamp stream has a deep main channel which is only wadable in some sections and therefore has not been sampled extensively during any basinwide cycle. Despite this, many braids are easily sampled and more EPT taxa were collected in 2011 than in any other year. This is one site where the recently described mayfly *Eurylophella oviruptis* can be found. Total taxa richness has remained highly stable over the past 10 years. Little Marsh Swamp received its third consecutive Natural rating indicating stable water quality in this catchment.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
BIG MARSH SWP	**SR 1924**	**IB51**	**02/20/11**	**Natural**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	53	03040203	34.781944	-78.923611

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Atlantic Southern Loam Plains	56.8	12	1.0

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	70	30	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	15.6
Dissolved Oxygen (mg/L)	5.9
Specific Conductance (µS/cm)	80
pH (s.u.)	5.4

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	12
Bottom Substrate (15)	9
Pool Variety (10)	5
Bank Erosion (10)	10
Bank Vegetation (10)	10
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	81

Site Photograph

Substrate: detritus and silt

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/20/11	11138	0	72	19	6.55	5.57	Natural
02/24/06	9795	0	87	19	6.48	5.03	Natural
02/07/01	8373	0	76	20	6.08	4.78	Natural

Data Analysis

Big Marsh Swamp drains the area to the west and northwest of Robeson County. There are some minor dischargers into the stream but they are distant enough to have little impact on the water quality at the site. The macroinvertebrate community collected in 2011 closely resembles that collected during the 2006 basinwide cycle, particularly in EPT taxa. Overall, Big Marsh Swamp supports a healthy and stable benthic community. However, the steadily increasing BI and EPTBI (since 2001) suggests slowly worsening physico-cemical conditions at this location.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Deirdre Black

Waterbody	Location	Station ID	Date	Bioclassification
PORTER SWP	**SR 1503**	**IB42**	**02/07/11**	**Severe**

County	Subbasin	8 digit HUC	Latitude	Longitude
COLUMBUS	51	03040203	34.360278	-78.962500

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Mid-Atlantic Floodplains and Low Terraces	60.6	>200	0.8

	Forested/Wetland	Residential	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	0	0	0	

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
None		

Water Quality Parameters

Temperature (°C)	8.2
Dissolved Oxygen (mg/L)	6.5
Specific Conductance (µS/cm)	88
pH (s.u.)	5.2

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (5)	15
Instream Habitat (20)	16
Bottom Substrate (15)	4
Pool Variety (10)	8
Riffle Habitat (16)	0
Bank Erosion (7)	10
Bank Vegetation (7)	6
Light Penetration (10)	7
Left Riparian Score (5)	5
Right Riparian Score (5)	3
Total Habitat Score (100)	74

Site Photograph

Substrate: Silt and detritus.

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/07/11	11129	Swamp	18	0	6.92	---	Severe
02/08/06	9783	Swamp	38	1	8.09	3.10	Severe
02/06/01	8371	Swamp	49	6	7.79	6.42	Moderate
03/15/96	7025	Swamp	41	6	7.07	6.61	Moderate
03/05/92	5805	Swamp	60	6	7.32	5.78	Not Rated

Data Analysis

This basinwide site is located downstream of a hog farm and the surrounding watershed has recently been logged. A well defined channel with good flow exists at this location. Not a single EPT taxon was collected in 2011 and only one EPT taxon was collected in 2006. All previous collections had six EPT taxa. In addition, total taxa richness in 2011 was 50-75% lower than that recorded in previous collections. Habitat was moderately favorable for macrobenthos colonization and flows appeared higher than normal. Whether fluctuations in flow or an outside source or a combination of both is responsible for the elimination of EPT taxa previously found in Porter Swamp at SR 1503 cannot be determined. Follow up sampling in 2013 should be conducted to confirm the 2011 bioclassification.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
ASHPOLE SWP	**NC 41**	**IB58**	**02/22/11**	**Moderate**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	54	03040203	34.411944	-79.121667

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Atlantic Southern Loam Plains	93.2	0	0.2

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	80	---	---	---	20

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	14.7
Dissolved Oxygen (mg/L)	0.0
Specific Conductance (µS/cm)	91
pH (s.u.)	5.5

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	15
Bottom Substrate (15)	13
Pool Variety (10)	8
Bank Erosion (10)	10
Bank Vegetation (10)	10
Light Penetration (10)	8
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	89

Site Photograph

Substrate: sand, silt and detritus

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/22/11	11137	Swamp	24	0	7.41	---	Moderate
02/28/06	9798	Swamp	49	10	5.89	5.06	Moderate
02/23/06	9793	Swamp	60	13	6.22	5.12	Moderate
01/30/01	8221	Swamp	53	11	6.40	5.30	Natural
03/15/96	7023	Swamp	53	10	6.39	5.15	Natural

Data Analysis

This basinwide site, a few miles south of Fairmont, assesses the water quality of Ashpole Swamp immediately above the confluence of Hog Swamp. The Ashpole Swamp watershed encompasses diverse agricultural activities but has a large portion devoted to animal operations, particularly chicken farms. Not a single EPT taxon was collected in 2011 whereas all previous collections never resulted in fewer than 10 EPT taxa. In addition, only half the number of other taxa, as compared to other years, were collected. Habitat was favorable for macrobenthos colonization and flows were good suggesting an outside source for the apparent disturbance that eliminated the EPT taxa previously found in Ashpole Swamp at NC 41.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Steven Beaty

Waterbody	Location	Station ID	Date	Bioclassification
HOG SWP	**SR 2262**	**IB61**	**02/22/11**	**Moderate**

County	Subbasin	8 digit HUC	Latitude	Longitude
Robeson	54	03040203	34.426111	-79.108889

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Atlantic Southern Loam Plains	63.3	0	0.4

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	80	20	---	---	---

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
none	---	---

Water Quality Parameters

Temperature (°C)	15.6
Dissolved Oxygen (mg/L)	0.0
Specific Conductance (µS/cm)	104
pH (s.u.)	5.4

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (15)	15
Instream Habitat (20)	10
Bottom Substrate (15)	4
Pool Variety (10)	10
Bank Erosion (10)	10
Bank Vegetation (10)	10
Light Penetration (10)	10
Left Riparian Score (5)	2
Right Riparian Score (5)	5
Total Habitat Score (100)	76

Site Photograph

Substrate: detritus and silt, some areas of sand

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/22/11	11139	Swamp	32	4	6.98	6.18	Moderate
02/23/06	9800	Swamp	57	5	7.15	5.62	Moderate
01/31/01	8222	Swamp	52	11	6.36	5.72	Natural
03/13/96	7022	Swamp	51	13	6.42	5.42	Natural

Data Analysis

Located just above the confluence of Ashpole Swamp, the Hog Swamp sampling site at SR 2262 drains Fairmont and the area just north of town. It is a highly braided stream with abundant backwater and flows only at snags. Macroinvertebrate habitat was relatively good and the submergent *Vallisnera* was abundant. This site has maintained the Moderate rating it first received in 2006. A decrease in EPT richness, similar to that seen in the nearby Ashpole Swamp, is responsible for the recent decline in bioclassifications. The biological data suggest that an initial long-term decrease in water quality occurred between the 2001 and 2006 samplings but has remained mostly stable (at Moderate) since.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Eric Fleek

Waterbody	Location	Station ID	Date	Bioclassification
FRIAR SWP	**SR 1740**	**IB77**	**03/02/11**	**Severe**

County	Subbasin	8 digit HUC	Latitude	Longitude
COLUMBUS	56	03040206	34.368333	-78.460278

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Carolina Flatwoods	20.4	4	0.3

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	0	0	0	

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
None	N/A	N/A

Water Quality Parameters

Temperature (°C)	6.5
Dissolved Oxygen (mg/L)	9.6
Specific Conductance (µS/cm)	61
pH (s.u.)	5.6

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (5)	12
Instream Habitat (20)	20
Bottom Substrate (15)	5
Pool Variety (10)	8
Riffle Habitat (16)	10
Bank Erosion (7)	7
Bank Vegetation (7)	10
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	82

Site Photograph

Substrate: Silt and sand.

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/09/11	11133	Swamp	29	4	7.71	6.37	Severe
02/21/06	9790	Swamp	64	13	6.22	5.43	Natural
02/01/01	8244	Swamp	49	11	6.74	6.04	Natural
02/18/99	7819	Swamp	45	10	5.95	4.49	Natural
03/03/98	7518	Swamp	44	9	5.80	4.94	Natural
02/25/97	7255	Swamp	48	13	6.35	5.68	Natural
03/13/96	7018	Swamp	48	12	6.03	5.56	Natural

Data Analysis

The 2011 community sustained its lowest ST, EPT, and highest BI and EPTBI since monitoring started here in 1996. Numerous intolerant taxa collected in previous years but absent in 2011 included the mayflies *Eurylophella doris* , *Leptophlebia spp* , *Acerpenna pygmaea* as well as several caddisflies including *Pycnopsyche spp* , *Ptilostomis spp* ., and *Molanna tryphena* . Compared to most of the earlier collections, their was a substantial reduction in Odonate taxa, as well as a substantial reduction in the number of taxa that require flow. These included the mayfly *Maccaffertium mexicanum* , the caddisflies *Cheumatopsyche spp* and *Hydropsyche decalda* as well as a drastic reduction in the diversity and abundance of blackfly taxa. These declines suggest reduced flows preceeding the sample were the primary agent responsible for the reduction in bioclassification. Follow up sampling in 2013 should be undertaken to confirm the 2011 bioclassification.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Deirdre Black

Waterbody	Location	Station ID	Date	Bioclassification
WHITE MARSH	**SR 1001**	**IB95**	**02/08/11**	**Severe**

County	Subbasin	8 digit HUC	Latitude	Longitude
COLUMBUS	58	03040206	34.244444	-78.617778

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Mid-Atlantic Floodplains and Low Terraces	283.3	>200	0.5

	Forested/Wetland	Residential	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	0	0	0	

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
City of Whiteville WWTP	NC0021920	3.0

Water Quality Parameters

Temperature (°C)	9.4
Dissolved Oxygen (mg/L)	8.9
Specific Conductance (µS/cm)	98
pH (s.u.)	6.0

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (5)	12
Instream Habitat (20)	16
Bottom Substrate (15)	4
Pool Variety (10)	8
Riffle Habitat (16)	0
Bank Erosion (7)	10
Bank Vegetation (7)	6
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	76

Site Photograph

Substrate: Silt and detritus.

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/08/11	11131	Swamp	19	0	8.03	0.00	Severe
02/22/06	9789	Swamp	50	9	6.57	4.90	Moderate
02/01/01	8242	Swamp	33	2	7.32	6.01	Moderate

Data Analysis

Historically, water quality conditions appeared to have improved with the increase in EPT richness from two taxa collected in 2001 to nine taxa collected in 2006. However, in 2011 no EPT taxa and no Odonate taxa were collected. This resulted in the lowest ST, EPT and highest BI measured since monitoring at this site began in 2001. Although the last non-compliant Whole Effluent Toxicity test at the Whiteville WWTP occurred in March 2008, in the year preceding the 2011 benthic sample, the Whiteville WWTP had five water quality standard violations, four for Total Mercury and one for Total Zinc. In addition, most of the violations occurred in early 2012, although one Total Mercury violation occurred 3 months prior to benthic sampling. The Zinc and Mercury could have played a role in the decline in the benthic community noted in 2011. However, the same general trend noted here in White Marsh was also observed in Friar Swamp and Grissett Swamp which also had significant declines in EPT and overall taxa richness. It is therefore possible that natural fluctuations in temperature or flow or some other combination of natural factors may have been responsible for the decline in bioclassification noted at White Marsh, Friar Swamp, and Grissett Swamp. Therefore, follow up sampling should be conducted to confirm the 2011 bioclassification.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Eric Fleek

Waterbody	Location	Station ID	Date	Bioclassification
ELKTON MARSH	**SR 1710**	**IB91**	**03/15/11**	**Moderate**

County	Subbasin	8 digit HUC	Latitude	Longitude
BLADEN	58	03040206	34.475556	-78.601944

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Carolina Flatwoods	37.3	4	0.3

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	0	0	0	

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
None	N/A	N/A

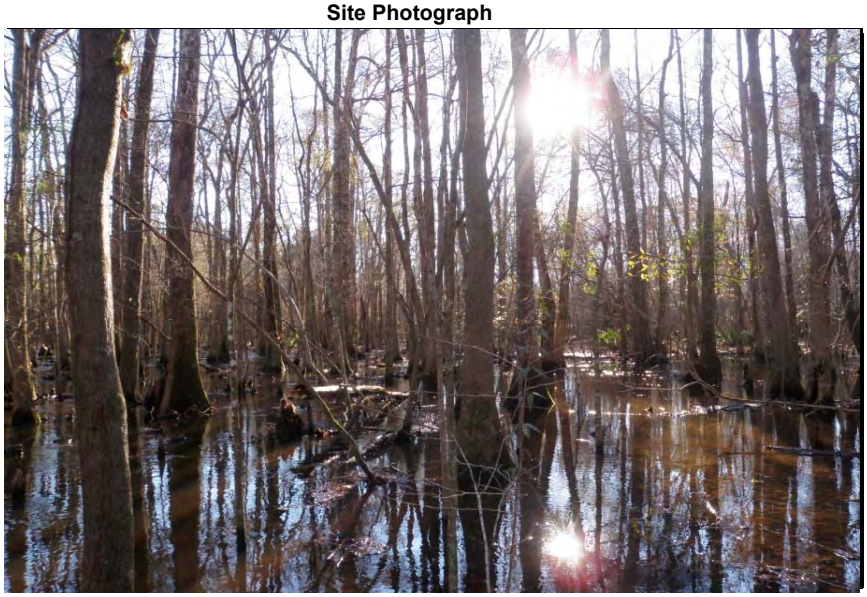
Water Quality Parameters

Temperature (°C)	11.9
Dissolved Oxygen (mg/L)	7.7
Specific Conductance (µS/cm)	58
pH (s.u.)	6.0
Water Clarity	clear/tannic

Habitat Assessment Scores (max)

Channel Modification (5)	15
Instream Habitat (20)	16
Bottom Substrate (15)	7
Pool Variety (10)	5
Riffle Habitat (16)	0
Bank Erosion (7)	10
Bank Vegetation (7)	10
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	83

Site Photograph



Substrate Silt and sand

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
03/15/11	11152	Swamp	31	3	6.56	5.87	Moderate
02/08/11	11132	Swamp	22	1	7.26	6.70	Moderate
02/22/06	9791	Swamp	60	5	7.46	4.86	Moderate
02/05/01	8386	Swamp	29	4	6.16	5.68	Moderate
03/13/96	7019	Swamp	37	5	6.89	4.83	Moderate

Data Analysis

Bioclassifications at this location have been identical since monitoring started in 1996 and with the exception of the February 2011 and 2006 sample, the biotic index (BI) values have also been stable. Although there have been large fluctuatios in total species diversity (ST) at this site, the overal pollution tolerance of this community has remained relatively stable since 1996 indicating Moderate water qualty at this site. However, compared to the most recent sample in 2006, several taxa indicitive of organic pollution present in 2006 were absent in 2011 and included the chironomid *Chironomus spp* , the gastropod *Physa spp* , and several oligochaetes including *Slavinia appendiculata* , *Quistadrilus multisetosus* , *Dero spp* , and *Nais spp* .

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Deirdre Black

Waterbody	Location	Station ID	Date	Bioclassification
GRISSETT SWP	**SR 1141**	**IB83**	**02/08/11**	**Severe**

County	Subbasin	8 digit HUC	Latitude	Longitude
COLUMBUS	57	03040206	34.086111	-78.714722

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Mid-Atlantic Floodplains and Low Terraces	56.8	>200	0.6

	Forested/Wetland	Residential	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	0	0	0	

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
Tabor City WWTP	NC0026000	1.1

Water Quality Parameters

Temperature (°C)	8.8
Dissolved Oxygen (mg/L)	8.7
Specific Conductance (µS/cm)	95
pH (s.u.)	6.1

Water Clarity: turbid

Habitat Assessment Scores (max)

Channel Modification (5)	15
Instream Habitat (20)	17
Bottom Substrate (15)	4
Pool Variety (10)	8
Riffle Habitat (16)	0
Bank Erosion (7)	10
Bank Vegetation (7)	5
Light Penetration (10)	9
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	78

Site Photograph

Substrate Detritus and sand.

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
02/08/11	11130	Swamp	19	2	8.18	5.80	Severe
02/21/06	9788	Swamp	47	5	7.03	5.84	Moderate
02/05/01	8387	Swamp	36	6	7.77	4.74	Moderate

Data Analysis

At this location, approximately 12 miles downstream of the Tabor City WWTP, Grissett Swamp is highly braided with four closely-spaced bridges of SR 1141 spanning the site. Compared to earlier collections, the 2011 benthic community had the lowest ST, EPT and highest BI since monitoring began here in 2001. Although flows appeared higher than normal during the sample, all available habitats were successfully sampled during the collection. Despite this, no representative species from the orders Ephmeroptera, Plecoptera, Odonata and Coleoptera were obtained in 2011. The absence of mayfly (Ephemeroptera) and stonefly (Plecoptera) taxa may indicate lower than average flows, and therefore increased physico-chemical in the months preceding the sample. In addition the absence of Odonata and Coleoptera taxa, which are typical of snag and root mat habitat, suggest flows may have been reduced enough that these habitats were not submerged for sometime prior to sampling. Follow up sampling in 2013 should be conducted to confirm the substantial drop in the 2011 bioclassification.

BENTHIC MACROINVERTEBRATE SAMPLE

Analyst: Eric Fleek

Waterbody	Location	Station ID	Date	Bioclassification
ROYAL OAK SWP	**NC 211**	**IB98**	**03/15/11**	**Natural**

County	Subbasin	8 digit HUC	Latitude	Longitude
BRUNSWICK	59	03040208	34.033333	-78.280278

Level IV Ecoregion	Drainage Area (mi2)	Stream Width (m)	Stream Depth (m)
Carolina Flatwoods	20.2	8	0.5

	Forested/Wetland	Urban	Agriculture	Road	Other (describe)
Visible Landuse (%)	100	0	0	0	

Upstream NPDES Dischargers (>1MGD or <1MGD and within 1 mile)	NPDES Number	Volume (MGD)
None	N/A	N/A

Water Quality Parameters

Temperature (°C)	10.2
Dissolved Oxygen (mg/L)	10.3
Specific Conductance (µS/cm)	121
pH (s.u.)	6.2

Water Clarity: clear/tannic

Habitat Assessment Scores (max)

Channel Modification (5)	15
Instream Habitat (20)	18
Bottom Substrate (15)	5
Pool Variety (10)	6
Riffle Habitat (16)	0
Bank Erosion (7)	10
Bank Vegetation (7)	10
Light Penetration (10)	10
Left Riparian Score (5)	5
Right Riparian Score (5)	5
Total Habitat Score (100)	84

Site Photograph

Substrate: Sand and silt.

Sample Date	Sample ID	Method	ST	EPT	BI	EPT BI	Bioclassification
03/15/11	11151	Swamp	80	14	6.59	5.24	Natural
02/21/06	9787	Swamp	75	17	6.28	5.19	Natural
02/05/01	8388	Swamp	58	18	5.85	4.63	Natural
02/18/99	7820	Swamp	75	21	6.20	5.07	Natural
03/03/98	7526	Swamp	55	18	5.99	4.72	Natural

Data Analysis

Royal Oak Swamp continues to be a stable, pollution intolerant community characterized by high species diversity (ST), EPT diversity and low biotic indices. Facultative or intolerant taxa consistently collected at this site include the mayfly *Eurylophella doris* , *Leptophlebia bradleyi* , and the caddisflies *Oecetis cinerascens* , two species of *Ceraclea* (*C. tarsipunctata, C. resurgens*) and *Ptilostomis spp* . Based on the long record of invertebrate data, water quality at this location continues to be favorable.