The Black River Watershed Restoration and Protection Plan Addendum

November 2008

Completed by the
Rutgers Cooperative Extension
Water Resources Program
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A. Introduction

The Rutgers Cooperative Extension Water Resources Program completed The Black River Watershed Restoration and Protection Plan in August of 2008. This plan was designed to address deteriorating water quality and the impacts of nonpoint source pollution. Recommendations to improve the water quality were based on chemical and biological analyses and the inspection of land use and stormwater infrastructure throughout the watershed.

Based upon the Integrated List of Waterbodies (NJDEP, 2006), the Black River is impaired for bacteria, temperature, pH, phosphorus and aquatic life. Additional sampling was performed to confirm these impairments, as well as to identify and quantify the sources that are causing the impairments. Water quality samples were collected at four locations in the watershed. These samples were analyzed for fecal coliform, *Escheria coli* (*E. coli*), nutrients, total suspended solids, dissolved oxygen, pH and temperature. The benthic macroinvertebrate community was also assessed at two locations in the watershed.

The original plan used water quality data collected in the months of September and October of 2007. Additional data was collected during the month of June 2008 to provide information on the quality of the water during a warmer summer month. This addendum to the original report will present and discuss the data collected in the summer of 2008.

B. Water Quality Sampling

The characterization of the Black River Watershed can be found in Section 2 of the original Plan. Sampling sites for the 2008 events were identical to those sampled in 2007.

B.1 Overview of Sampling Dates and Parameters

Five sampling events took place in June of 2008. These events were planned to follow a five-sample in thirty-day regimen to produce a geometric mean for fecal coliform and *E. coli*. Sampling was performed without regard to weather conditions to produce results that would capture the variability of water quality in relation to precipitation conditions. June 2008 was a relatively dry month; there was only a small amount of precipitation prior to or during the five sampling events. Precipitation totals for the 24 hours preceding sampling are provided in Table 1.

Table 1: Sampling Dates, Precipitation Totals and Parameters

Date	Precip (in/24hrs)	Fecal Coliform	E.coli	Ortho-P, diss	P, total as P	TSS	pH	Temp	Dissolved Oxygen	Flow
6/03/08	***0***	✓	✓				✓	✓	✓	✓
6/11/08	***0.08***	✓	✓	✓	✓	✓	✓	✓	✓	✓
6/17/08	***0.2***	✓	✓	✓	✓	✓	✓	✓	✓	✓
6/19/08	***0.06***	✓	✓				✓	✓	✓	✓
6/25/08	***0.2***	✓	✓				✓	✓	✓	✓

B.2 Fecal Coliform

The Lamington River has a "Priority Implementation" rating at the State level and has been calculated as requiring a 90% reduction of fecal coliform concentration. The Total Maximum Daily Load (TMDL) was based upon the fecal coliform surface water quality criteria:

> *"Fecal coliform levels shall not exceed a geometric average of 200/100 ml nor should more than 10 percent of the total samples taken during any 30-day period exceed 400/100 ml."*

The surface waters of the Black River were analyzed for fecal coliform concentrations during June of 2008. The results for the individual sites can be found in Table 2. Data marked in bold font is a point that has exceeded the water quality standards.

Table 2: 2008 Fecal Coliform concentrations per site

		Fecal Coliform (CFU/100ml)		
	Site 4	**Site 3**	**Site 2**	**Site 1**
6/03/08	20	210	110	56
6/11/08	260	**440**	84	82
6/17/08	160	200	150	150
6/19/08	60	340	90	120
6/25/08	190	160	60	90

The descriptive statistics developed from the site analysis of the fecal coliform concentrations can be found in Table 3.

Table 3: June 2008 Descriptive Statistics for Fecal Coliform Concentrations

	Fecal Coliform (col/100 ml)		
	Min	Max	Geometric Mean
Site 4	20	260	99
Site 3	160	440	**251**
Site 2	60	150	94
Site 1	56	150	94

The geometric mean of all the fecal coliform data is 113.57 col/100ml. This level is slightly higher than the data acquired during the months of September and October of 2007 which was 90.6 col/100ml.

In the 2007 data, the elevated levels of fecal coliform were directly related to wet weather events. Since the data collected in 2008 did not include any wet weather sampling events, a comparison between 2007 and 2008 wet weather data cannot be made. For one sampling event, elevated fecal coliform concentrations were observed for Site 3.

B.3 E.Coli

New Jersey has replaced its fecal coliform criteria with *E. coli* criteria. According to the surface water quality standards (N.J.A.C. 7:9B):

> *"E. coli levels for FW2 waters shall not exceed a geometric mean of 126 CFU/100ml or a single sample maximum of 235 CFU/100ml."*

The 2007 data indicated that the Black River was not meeting water quality criteria for *E. coli*. During the 2008 events, two single samples, one at Site 3 and one at Site 2 exceeded the criteria

for a single sample. The resultant data collected and analyzed for each site can be seen in Table 4.

Table 4: 2008 *E. coli* concentrations per site

***E. coli* (col/100ml)**				
Date	**Site 4**	**Site 3**	**Site 2**	**Site 1**
6/03/08	2	8	8	10
6/11/08	26	88	84	80
6/17/08	130	110	**270**	50
6/19/08	20	**250**	60	55
6/25/08	170	50	50	20

Upon evaluation of the geometric mean, there were no criteria exceeded.

Table 5: 2008 E. Coli descriptive statistics

	***E. Coli.* (col/100 ml)**		
	Min	Max	Geometric Mean
Site 4	2	170	29.67
Site 3	8	250	62.69
Site 2	8	270	55.87
Site 1	10	80	33.78

B.4 Phosphorus

Total Phosphorus

According to the New Jersey 2004 and 2006 Integrated Water Quality Monitoring and Assessment Report, segments of the Black River do no meet the criterion for total phosphorus. This impairment is based on sampling data exceeding the 0.1 mg/L phosphorus water quality standard for streams. A TMDL for the Raritan River Watershed including Black River is currently being prepared by NJDEP to address this impairment.

Table 6: Total Phosphorus, mg/L

Date	Site 4	Site 3	Site 2	Site 1
6/11/08	0.03	0.09	0.03	**0.12**
6/17/08	0.03	0.08	0.06	0.06

The measured phosphorus levels in 2008 approached the maximum criteria at Site 3, but did not show an exceedance, as the 2007 data did. On June 11, 2008, the phosphorus level at Site 1 exceeded the criteria. Exceedances of the criteria at Site 1 were not observed in the sampling conducted in 2007.

Dissolved Orthophosphate

Orthophosphate is one component of total phosphorus, and it is the form of phosphorus that is most readily available for plant uptake. Orthophosphate concentrations reported are detailed in Table 7.

Table 7: 2008 Dissolved Orthophosphate Concentration

Date	Site 4	Site 3	Site 2	Site 1
6/11/08	0.02	0.03	0.05	0.06
6/17/08	0.03	0.02	0.05	0.05

It is important to note that often the predominant component of observed total phosphorus is ortho-phosphorus except for Site 1 and 3 on June 11, 2008. Since rainfall was not significant prior to the June 11, 2008 sampling event, it is unlikely that stormwater runoff had any impact on the total phosphorus concentrations at these locations.

B.5 TSS

Two standards for total suspended solids (TSS) exist for FW2-TM and FW2-NT classified waters. The level of total suspended, unfilterable, solids allowed before exceeding the stricter standards for the trout maintenance waters is 24 mg/L. All samples taken on the Black River, in 2007 and 2008, fell well under this allowable standard. Results from the 2008 sampling events can be seen in Table 8.

Table 8: Concentration of Total Suspended Solids, mg/L

Date	Site 4	Site 3	Site 2	Site 1
6/11/08	Non detect	2.5	2.5	4.0
6/17/08	Non detect	Non detect	4.0	3.5

B.6 pH

The pH level of all waters should be within a range of 6.5 to 8.5 Standard Units. Values less than 7 are considered "acidic," and values over 7 are considered "basic." A value of 7 would be considered neutral.

The 2008 measurements taken on the Black River can be found in the table below.

Table 9: 2008 Measured pH values

Date	Site 4	Site 3	Site 2	Site 1
6/03/08	8.23	6.89	**6.34**	6.92
6/11/08	**8.59**	7.48	NA	6.87
6/17/08	8.22	6.96	**6.27**	6.69
6/19/08	7.42	**6.23**	**6.09**	**5.99**
6/25/08	7.55	**6.47**	**5.88**	**6.39**

In the data collected in 2007, 22 of the 40 total samples taken fell below the minimum pH level, showing the greater tendency toward an acidic condition. In the 2008 round of data, 8 out of the 20 samples were found to be more acidic, while one data point fell slightly over the maximum criteria and would be considered basic.

B.7 Temperature

There are two standards applied to the various classifications of water in the Black River for temperature. For FW2-TP and FW2-TM waters, there should be "no thermal alterations which would cause temperatures to exceed 20°C (68°F) summer seasonal average." The FW2-NT waters would be held to a standard of "no thermal alterations which would cause temperatures to exceed 30°C (86°F) summer seasonal average." Portions of the Black River have been noted to be impaired for temperature, according to the 2004 and 2006 Integrated Report.

Only the main stem of the stream that passes through Subbasin One, to the outlet of the delineated Black River Watershed, would need to adhere to the standard of 20°C (68°F) summer seasonal average. All other data reported for the outlets of Subbasins 4 through 2 would need to adhere to the standard of 30°C (86°F) summer seasonal average.

In the sampling for September and October of 2007, the temperature at Site 1 was found to fall below the maximum allowable levels except on one occasion, where the temperature was slightly elevated. (See Figure 1).

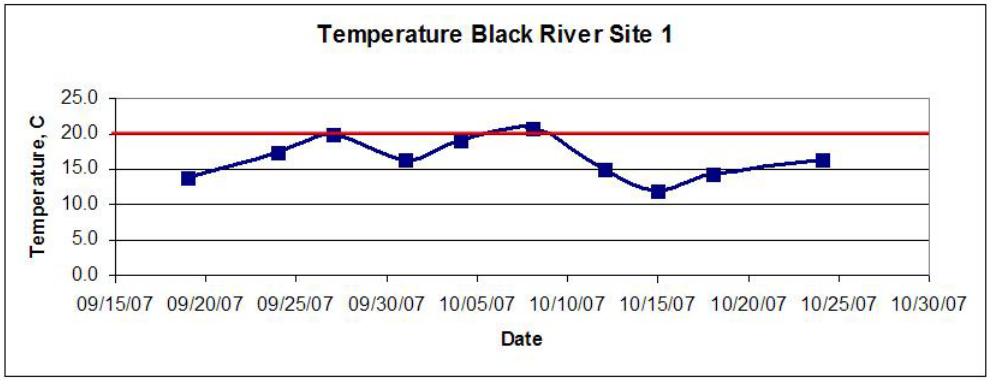

Figure 1: 2007 Temperature Measurements

During the summer month that the 2008 sampling events took place, the temperature exceeded the standard on one occasion, 6/11/08.

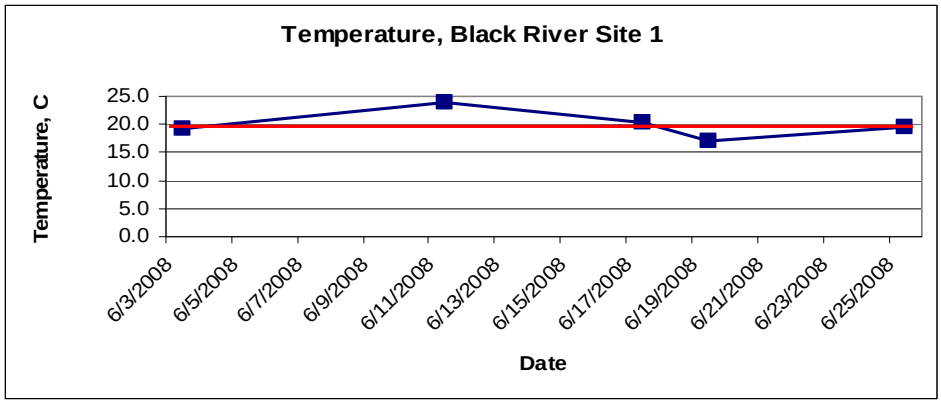

Figure 2: 2008 Temperature Measurements

B.8 Dissolved Oxygen

Dissolved oxygen concentrations fluctuate over the 24-hour day, with concentrations increasing with photosynthesis during daylight and decreasing during respiration at night. A typical fluctuation shows the highest concentration of dissolved oxygen occurring in the hours around dusk, and a minimum concentration around dawn. Dissolved oxygen concentration is highly dependent on water temperature, being lower at higher temperatures.

According to the surface water quality standards, both FW2-TM and FW2-NT waters posses a standard based on a 24-hour average, and a one time point minimum. For the trout maintenance (FW2-TM) section of the Black River, the standard is a 24-hour average of not less than 6.0 mg/L and no less than 5.0 mg/L at any time. The standard for the non-trout (FW2-NT) section (Subbasin 2 and above) is a 24-hour average of no less than 5.0 mg/L but not less than 4.0 mg/L at any time.

Data collected on the Black River for the 2008 sampling series can be found in Table 10.

Table 10: Oxygen concentration (mg/L)

Date	Site 4	Site 3	Site 2	Site 1
	FW2-NT	FW2-NT	FW2-NT	FW2-TM
6/03/08	NA	7.77	5.10	7.09
6/11/08	6.68	6.60	NA	6.90
6/17/08	7.44	6.92	NA	6.59
6/19/08	9.20	8.88	**3.42**	8.16
6/25/08	8.32	8.08	**3.12**	7.64

Site 2 showed a slight tendency toward low dissolved oxygen in 2007 and continued to show lower than desired concentrations in 2008, as indicated above in Table 10.

C. Biological Assessment

A survey of the benthic macroinvertebrate community within the Black River Watershed was conducted by the Rutgers Cooperative Extension Water Resources Program on June 18, 2008 in accordance with a Quality Assurance Project Plan (QAPP). The sampling and data analysis procedures were conducted in accordance with the Rapid Bioassessment Protocol procedures used by the NJDEP Bureau of Freshwater and Biological Monitoring, which are based on USEPA's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (Barbour et al., 1999). Benthic macroinvertebrates were collected at two locations as described below.

Station	Description	Coordinates
BR1	Lamington River at Old Route 24 at Coopers Mill Park; AMNET #AN0358	40º 00'80.97"N 73º 43'54.67"W
BR3	Ironia Road in Chester Township; AMNET #AN0356	40º 04' 28.14"N 73º 39' 12.33"W

A detailed data summary of the biological assessment can be found in Attachment A.

The NJDEP Bureau of Biological & Freshwater Monitoring maintains three Ambient Biomonitoring Network (AMNET) stations within the Black River Watershed (i.e., Stations AN0356, AN0357, and AN0358) (NJDEP, 1995; NJDEP, 2000; NJDEP, 2008b). Station AN0356 corresponds to Station BR3, and Station AN0358 corresponds to Station BR1. Station AN0357 is on Tanners Brook and was not sampled as part of this 2008 biological assessment. In 1994, 1999, and 2004, Station AN0356 was assessed as being moderately impaired by NJDEP. Habitat conditions were found to be suboptimal in 1999 and 2004. The 2008 assessment by the RCE Water Resources Program demonstrates that the biological condition remains as moderately impaired at this site on the Black River, and the habitat conditions remain as suboptimal. In 1994 and 1999, Station AN0358 was assessed as being non-impaired, and in 2004 a decline in biological condition to moderately impaired was noted at this site. Habitat conditions in 1999 and 2004 were found to be optimal. The 2008 assessment by the Rutgers Cooperative Extension Water Resources Program demonstrates that the biological condition improved to a non-impaired status, and the habitat condition remains as optimal.

D. Discussion

Bacteria

In the data acquired in September and October of 2007 there was a distinguishable water quality standard exceedance after storm events. In 2008 there were no storms, but concentrations of fecal coliform exceeded standards once for a single sample and also for the geometric average at Site 3. Although there no longer exists water quality criterion for fecal coliform, this data indicates the need to identify sources of waste from wildlife, pets or humans and to reduce that source.

The concentrations of *E. coli* showed two single sample exceedances of the water quality criteria. The two exceedances fell on different days at different sites, one at Site 2 and one at Site 3. These two sites are located around a large wildlife area and are typically wide, slow flow areas.

The original Black River Watershed and Restoration Plan calculated percent reductions that could be applied to this drainage area and the additional testing performed in 2008 does not change this recommendation.

Phosphorus
In the 2007 data, phosphorus levels were a concern at Site 2 which was downstream of the discharge from a wastewater treatment plant. In the 2008 data, this area did not contain any water quality exceedances for total phosphorus. This does not discount the possible input from the wastewater treatment plant, but a problem was not apparent from this set of water quality data.

A single sample out of the 2008 data at Site 1 exceeded the water quality standard of 0.1 mg/L total phosphorus with the level of 0.12 mg/L. This elevated reading did not occur after a storm event and therefore would not be attributed to stormwater runoff. Given that this site experiences a more turbulent flow, resuspension of the stream sediment may be a causal factor in the elevated phosphorus concentration.

TSS
The levels of TSS detected over the course of this study have been found to fall well within acceptable guidelines. However, since minimal data have been collected following a storm event, this data cannot be conclusive as to the potential sediment disturbances or stormwater source input that may be created after a rainfall.

pH
Water quality standards call for the pH of natural waters to fall between 6.5 and 7.4 standard units. Several pH readings in the Black River fell below the 6.5 level. Most fishes, including trout, are generally not seriously affected by a pH between 6.0 and 7.0. However, as pH values dip below 6.0, problems with the range of freshwater biota become noticeable. As the acidity level increases (i.e., the pH decreases), the food base will fall off, and spawning success and egg survival of fishes will decline (Cincotta, 2002). Several pH readings fell below the 6.5 level, with two readings below the 6.0 standard units for pH. In the 2007 data, there were several pH readings below 6.5 and two below the 6.0 level.

These low pH readings could be indicative of a stressor to the biota of the Black River and a more thorough evaluation of the pH should be performed. This more intense analysis should include a continuous monitoring with approved, well maintained equipment.

This study did not find any sources of acidic input. However, precipitation could be the carrier of lower pH waters and may be considered a diffuse source. Many waters of the Northeast hold a buffering capacity that protects the waters from this input. The buffering capacity of the Black River Watershed has not been determined as a part of this study, but may be useful to understand in the future.

Temperature

Temperature readings taken over the course of this study have indicated that temperature may not be optimal for the trout maintenance section of the stream. During both the 2007 and the 2008 sampling events, there was a time where the standard water quality temperature was exceeded. It must also be noted that these measurements were generally taken in the morning when temperatures are expected to be relatively low.

In a 2008 paper published in the North American Journal of Fisheries Management, it was determined that brook trout were almost never found in watersheds where impervious land cover exceeded 4%, as assessed from the 2001 National Land Cover Dataset (2001 NLCD; Stranko, et al., 2008). The single exception was a stream that displayed consistently low water temperatures. The Black River Watershed is estimated to have 6% impervious surface (as calculated from NJDEP 2002 Land Use/Land Cover GIS data layer).

An impervious coverage of 6% is relatively low for New Jersey suburban areas, but it does fall above this upper limit of stress on brook trout noted in this study. As recommended in the original Black River Plan, canopy protection and restoration along with the promotion of infiltration to safeguard baseflow will be an important mitigating factor in reducing the stress on the biological community.

DO

Dissolved oxygen measurements are most useful when continually determined over the course of a day, with the lowest readings occurring before sunrise and the highest concentrations occurring in the evening. This phenomenon would be indicative of the cycle of respiration and photosynthesis. Omni Environmenatal Corporation provided such data for the Raritan River Basin Nutrient TMDL study, as discussed in the original Black River Plan.

The 2008 site and time specific data collected by the Rutgers Cooperative Extension Water Resources Program indicated some low dissolved oxygen readings at Site 2. Stream characteristics at Site 2, such as minimal slope, slow flow, and a broad floodplain contribute to the stream having a longer contact time with the sediments, which may exhibit a large sediment oxygen demand, thereby resulting in reduced dissolved oxygen levels.

These few readings provide a limited understanding of the complete dynamics of dissolved oxygen. It does appear, however, that levels of dissolved oxygen at Site 2 may be a concern for the biota and may indicate the need for a larger temporal analysis.

Biological Sampling

The benthic macroinvertebrate community occurring within the vicinity of BR3 is apparently under some type of stress as evidenced by low taxa richness and poor representation of EPT taxa. Based on the calculated Family Biotic Index, the types of organisms found are indicative of good water quality, but the index value suggests that some organic pollution is probable at the site (Hilsenhoff, 1988). A permitted wastewater treatment plant is located just upstream of BR3. In

addition, the habitat assessment revealed suboptimal habitat conditions at BR3, which may also account for the impaired condition of the benthic macroinvertebrate community at this site.

Biological assessments have become an important tool for managing water quality to meet the goal of the Clean Water Act (i.e., to maintain the chemical, physical, and biological integrity of the nation's water). However, although biological assessments are a critical tool for detecting impairment, they do not identify the cause or causes of the impairment. The U.S. Environmental Protection Agency (USEPA) developed a process, known as the Stressor Identification (SI) process, to accurately identify any type of stressor or combination of stressors that might cause biological impairment (USEPA, 2000). The SI process involves the critical review of available information, the formation of possible stressor scenarios that may explain the observed impairment, the analysis of these possible scenarios, and the formation of conclusions about which stressor or combination of stressors are causing the impairment. The SI process is iterative, and in some cases additional data may be needed to identify the stressor(s). In addition, the SI process provides a structure or a method for assembling the scientific evidence needed to support any conclusions made about the stressor(s). When the cause of a biological impairment is identified, stakeholders are then in a better position to locate the source(s) of the stressor(s) and are better prepared to implement the appropriate management actions to improve the biological condition of the impaired waterway. The SI process is recommended as the next step toward improving the biological condition within the Black River Watershed, particularly in the vicinity of Station BR3.

E. Conclusion

The Black River Watershed is a valuable resource to the surrounding community. In some documented instances, the designated uses for this stream are not being met and therefore require the formation of a plan that will solve those problems. The original Black River Watershed Restoration and Protection Plan (August 2008) attempted to qualify and quantify the water quality issues and the potential solutions.

The purpose of this addendum was to introduce water quality data taken at a time of year when water temperatures are expected to be higher. It was particularly necessary to determine the effect of temperature on the bacteria levels in the stream. It was also necessary to perform the biological assessment during a month when these assessments have been performed in the past for comparison purposes.

Although the data did show variability, this did not appear to be driven by temperature differences. This additional data did provide the stakeholders with a more broad view of the characteristics of the watershed and some of the potential stresses it may face.

The results of the analysis of this additional data confirm the findings and recommendations of the original Black River Watershed Restoration and Protection Plan.

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ATTACHMENT A

THE BLACK RIVER WATERSHED RESTORATION AND PROTECTION PLAN
DATA SUMMARY – BIOLOGICAL ASSESSMENT
OCTOBER 2008

THE BLACK RIVER WATERSHED RESTORATION AND PROTECTION PLAN

DATA SUMMARY- BIOLOGICAL ASSESSMENT

OCTOBER 2008

Introduction

The Black River Watershed is part of the North Branch Raritan River Watershed, located within New Jersey's Watershed Management Area 8 (WMA 8). The Black River Watershed covers 21 square miles in the western portion of Morris County, New Jersey. The main stem of the stream, including the Tanners Brook tributary, is approximately 13 miles long. When all mapped tributaries are included, the total stream length extends to over forty miles. The stream winds its way from the headwaters in Mine Hill and Roxbury Township, through Randolph Township, Chester Township and Washington Township. The northwest section of Chester Borough also contributes to the drainage area of the watershed. Land uses within the watershed are comprised of approximately 36% forest, 35% urban, and 20% wetlands.

According to the 2004 and 2006 New Jersey Integrated Water Quality Monitoring and Assessment Reports (NJDEP, 2004; NJDEP, 2006), segments of the Black River do not meet the criteria for the aquatic life designated use and are documented as impaired for temperature, total phosphorus, aquatic life, and fecal coliform. In addition, the entire length of the Black River, together with its major tributary, Tanners Brook, is under a TMDL Implementation Priority for fecal coliform which calls for a 90% reduction in the wasteload allocation of fecal coliform. Due to the aquatic life impairment listing, a biological assessment of the Black River Watershed was proposed as part of the development of the Black River Watershed Restoration and Protection Plan. The following is a data summary of the biological assessment conducted by the Rutgers Cooperative Extension (RCE) Water Resources Program early in June of 2008.

Biological Data Collection

A survey of the benthic macroinvertebrate community within the Black River Watershed was conducted by the RCE Water Resources Program on June 18, 2008 in accordance with a Quality Assurance Project Plan (QAPP). The sampling and data analysis procedures were conducted in accordance with the Rapid Bioassessment Protocol procedures used by the NJDEP Bureau of Freshwater and Biological Monitoring, which are based on USEPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers* (Barbour et al., 1999). Benthic macroinvertebrates were collected at two locations as described below and identified in Figure 1.

Station	Description	Coordinates
BR1	Lamington River at Old Route 24 at Coopers Mill Park; AMNET #AN0358	40º 00'80.97"N 73º 43'54.67"W
BR3	Ironia Road in Chester Township; AMNET #AN0356	40º 04' 28.14"N 73º 39' 12.33"W

Samples were collected using a multi-habitat sampling approach, which minimizes habitat or substrate variation between sampling sites and includes all likely functional feeding groups of benthic macroinvertebrates in the stream. Given the nature of the substrate and the flow conditions at Location BR1, a Surber Square Foot Bottom Sampler was used to collect three grab type samples from the most productive habitat of the stream (i.e., riffle/run areas). At Location BR3, given the substrate and the flow conditions, samples were collected by jabbing a standard aquatic D-frame dip net in productive and stable habitats (i.e., snags, banks, macrophytes, and the bottom substrate) a total of 20 times. Samples were sorted and processed in the field using a U.S. Standard No. 30 sieve, composited (i.e., the contents from the grab samples from each location or the contents from the jabs were combined into a single container), and preserved in 80% ethanol for later subsampling, identification, and enumeration.

A composite collection of a variety of coarse particulate organic matter (CPOM) forms (e.g., leaves, needles, twigs, bark, or fragments of these) was collected. It is difficult to quantify the amount of CPOM to be collected in terms of weight or volume given the variability of its composition. Collection of several handfuls of material is usually adequate, and the material is typically found in depositional areas, such as in pools and along snags and undercut banks. The CPOM sample was processed using a U.S. Standard No. 30 sieve and was added to the composite of the grab/jab samples for each location.

A 100-organism subsample of the benthic macroinvertebrate composite sample from each sampling location was taken in the laboratory according to the methods outlined in the Rapid Bioassessment Protocol used by the NJDEP Bureau of Freshwater & Biological Monitoring (Barbour et al., 1999). With the exception of any chironomids and oligochaetes, benthic macroinvertebrates were identified to genus. Chironomids were identified to subfamily as a minimum, and oligochaetes were identified to family as a minimum. Standard taxonomic

references were used and included Merritt and Cummins, 1988; Pennak, 1989; Peckarsky, *et al*., 1990; and Thorp and Covich, 1991.

A habitat assessment was conducted in accordance with the methods used by the NJDEP Bureau of Freshwater & Biological Monitoring for high gradient streams (NJDEP, 2008a). The habitat assessment, which has been designed to provide a measure of habitat quality, involves a visual based technique for assessing stream habitat structure. The findings from the habitat assessment are used to interpret survey results and identify obvious constraints on the attainable biological potential within the study area.

Results

Physicochemical Characteristics:

The stream width at Station BR1 was approximately 23 feet. The stream depth averaged 1.0 foot in riffle/run areas and was greater than 2.5 feet in some pool areas. The stream velocity ranged from 0.3 ft/sec to 3.85 ft/sec and averaged 2.15 ft/sec. The canopy was completely closed at this location. The inorganic substrate at Station BR1 consisted mostly of boulders and cobbles. Although minimal, the organic substrate was comprised mainly of detritus in the form of sticks and new fall. No sediment odors or oils were noted. The water was slightly turbid, and no water odors or surface oils were found. The water temperature was 18.2˚C; the pH was 6.12 SU; the dissolved oxygen was 7.19 mg/L, and the concentration of total dissolved solids was180 mg/L. In addition the water was noticeably brown in color, not unlike the color of water typically found in the Pine Barrens.

The stream width at Station BR3 was approximately 31 feet. The stream depth averaged 1.1 feet in run areas and was greater than 2.5 feet in some pool areas. The stream velocity ranged between 0.03 ft/sec and 0.53 ft/sec and averaged 0.37 ft/sec. Unlike Station BR1, the canopy was completely open at this location, and large stands emergent aquatic plants, pondweed, and waterweed were noted throughout. The inorganic substrate at Station BR3 consisted mostly of cobbles, gravel, and coarse sand. The organic substrate was dominated by detritus in the form of sticks and leaves, with some muck-mud in depositional/pool areas. No sediment odors or oils were noted. The water was slightly turbid, and no water odors or surface oils were noted. The water temperature was 18.3˚C; the pH was 7.12 SU, the dissolved oxygen was 7.62 mg/L, and the concentration of total dissolved solids was 290 mg/L. In addition,

Station BR3 was found to be located at the upstream portion of Lake Lillian. The habitat at this location was more characteristic of a lentic type habitat, rather than the lotic habitat found at Station BR1.

In the vicinity of Station BR1, the predominant surrounding land use was primarily forest, whereas in the vicinity of Station BR3 there was a mix of wetlands and rural residential. Local watershed erosion was noted as being minimal at both locations, and obvious sources of local watershed nonpoint sources of pollution were found to include runoff from roadways and trails.

Habitat Assessment:

The habitat assessment is designed to provide an estimate of habitat quality based upon qualitative estimates of selected habitat attributes. The assessment involves the numerical scoring of ten habitat parameters to evaluate instream substrate, channel morphology, bank structural features, and riparian vegetation. Each parameter is scored and summed to produce a total score which is assigned a habitat quality category of optimal (excellent), suboptimal (good), marginal (fair), or poor. Table 1 outlines the habitat scoring criteria for high gradient streams by the NJDEP Bureau of Freshwater & Biological Monitoring. Sites with optimal habitat conditions have total scores ranging from 160 to 200; sites with suboptimal habitat conditions have total scores ranging from 110 to 159; sites with marginal habitat conditions have total scores ranging from 60 to 109, and sites with poor habitat conditions have total scores less than 60. The scores for Stations BR1 and BR3 are summarized in Table 2. With scores of 187 and 122, BR1 and BR3 were found to have optimal and suboptimal habitat conditions, respectively.

Benthic Macroinvertebrates:

The results of the benthic macroinvertebrate survey are presented in Table 3. These results are organized by the order, the family, and then by the generic taxonomic levels. The number of taxa and individuals collected from each sampling location is also summarized in Table 3. A total of 21 different taxa of benthic macroinvertebrates was collected within the study area, representing three phyla (i.e., flatworms, mollusks, and arthropods). The arthropods, in particular the insects, were the most strongly represented in terms of the number of different taxa present. A total of 14 insect families was represented.

To evaluate the biological condition of the sampling locations, several community measures were calculated from the data presented in Table 3 and included the following:

1. Taxa Richness: Taxa richness is a measure of the total number of benthic macroinvertebrate families identified. A reduction in taxa richness typically indicates the presence of organic enrichment, toxics, sedimentation, or other factors.

2. EPT (Ephemeroptera, Plecoptera, Trichoptera) Index: The EPT Index is a measure of the total number of Ephemeroptera, Plecoptera, and Trichoptera families (i.e., mayflies, stoneflies, and caddisflies). These organisms typically require clear moving water habitats.

3. %EPT: Percent EPT measures the numeric abundance of the mayflies, stoneflies, and caddisflies within a sample. A high percentage of EPT taxa are associated with good water quality.

4. % CDF (percent contribution of the dominant family): Percent CDF measures the relative balance within the benthic macroinvertebrate community. A healthy community is characterized by a diverse number of taxa that have abundances somewhat proportional to each other.

5. Family Biotic Index: The Family Biotic Index measures the relative tolerances of benthic macroinvertebrates to organic enrichment based on tolerance scores assigned to families ranging from 0 (intolerant) to 10 (tolerant) (Hilsenhoff, 1988).

This analysis integrates several community parameters into one easily comprehended evaluation of biological integrity referred to as the New Jersey Impairment Score (NJIS). The NJIS has been established for three categories of water quality bioassessment for New Jersey streams: non-impaired, moderately impaired, and severely impaired. A non-impaired site has a benthic community comparable to other high quality “reference” streams within the region. The community is characterized by maximum taxa richness, balanced taxa groups, and a good representation of intolerant individuals. A moderately impaired site is characterized by reduced macroinvertebrate taxa richness, in particular the EPT taxa. Changes in taxa composition result in reduced community balance and intolerant taxa become absent. A severely impaired site is one in which the benthic community is significantly different from that of the reference streams. The macroinvertebrates are dominated by a few taxa which are often very abundant. Tolerant taxa are typically the only taxa present.

The scoring criteria used by the NJDEP Bureau of Freshwater & Biological Monitoring are outlined in Table 4. This scoring system is based on comparisons with reference streams and

a historical database consisting of 200 benthic macroinvertebrate samples collected from New Jersey streams. While a low score indicates "impairment," the score may actually be a consequence of habitat or other natural differences between the subject stream and the reference stream. Non-impaired sites have total scores ranging from 24-30, moderately impaired sites have total scores ranging from 9 to 21, and severely impaired sites have total scores ranging from 0 to 6. Impairment scores for Stations BR1 and BR3 are provided in Tables 5A and 5B, respectively. Station BR1 is assessed as being non-impaired, and Station BR3 is assessed as being moderately impaired.

Discussion

The NJDEP Bureau of Biological & Freshwater Monitoring maintains three Ambient Biomonitoring Network (AMNET) stations within the Black River Watershed (i.e., Stations AN0356, AN0357, and AN0358) (NJDEP, 1995; NJDEP, 2000; NJDEP, 2008b). Station AN0356 corresponds to Station BR3, and Station AN0358 corresponds to Station BR1. Station AN0357 is on Tanners Brook and was not sampled as part of this 2008 biological assessment. In 1994, 1999, and 2004, Station AN0356 was assessed as being moderately impaired by NJDEP. Habitat conditions were found to be suboptimal in 1999 and 2004. The 2008 assessment by the RCE Water Resources Program demonstrates that the biological condition remains as moderately impaired at this site on the Black River, and the habitat conditions remain as suboptimal. In 1994 and 1999, Station AN0358 was assessed as being non-impaired, and in 2004 a decline in biological condition to moderately impaired was noted at this site. Habitat conditions in 1999 and 2004 were found to be optimal. The 2008 assessment by the RCE Water Resources Program demonstrates that the biological condition improved to a non-impaired status, and the habitat condition remains as optimal.

The benthic macroinvertebrate community occurring within the vicinity of BR3 is apparently under some type of stress as evidenced by low taxa richness and poor representation of EPT taxa. Based on the calculated Family Biotic Index, the types of organisms found are indicative of good water quality, but the index value suggests that some organic pollution is probable at the site (Hilsenhoff, 1988). A permitted wastewater treatment plant is located just upstream of BR3. In addition, the habitat assessment revealed suboptimal habitat conditions at

BR3, which may also account for the impaired condition of the benthic macroinvertebrate community at this site.

Recommendations

Biological assessments have become an important tool for managing water quality to meet the goal of the Clean Water Act (i.e., to maintain the chemical, physical, and biological integrity of the nation's water). However, although biological assessments are a critical tool for detecting impairment, they do not identify the cause or causes of the impairment. The U.S. Environmental Protection Agency (USEPA) developed a process, known as the Stressor Identification (SI) process, to accurately identify any type of stressor or combination of stressors that might cause biological impairment (USEPA, 2000). The SI process involves the critical review of available information, the formation of possible stressor scenarios that may explain the observed impairment, the analysis of these possible scenarios, and the formation of conclusions about which stressor or combination of stressors are causing the impairment. The SI process is iterative, and in some cases additional data may be needed to identify the stressor(s). In addition, the SI process provides a structure or a method for assembling the scientific evidence needed to support any conclusions made about the stressor(s). When the cause of a biological impairment is identified, stakeholders are then in a better position to locate the source(s) of the stressor(s) and are better prepared to implement the appropriate management actions to improve the biological condition of the impaired waterway. The SI process is recommended as the next step toward improving the biological condition within the Black River Watershed, particularly in the vicinity of Station BR3.

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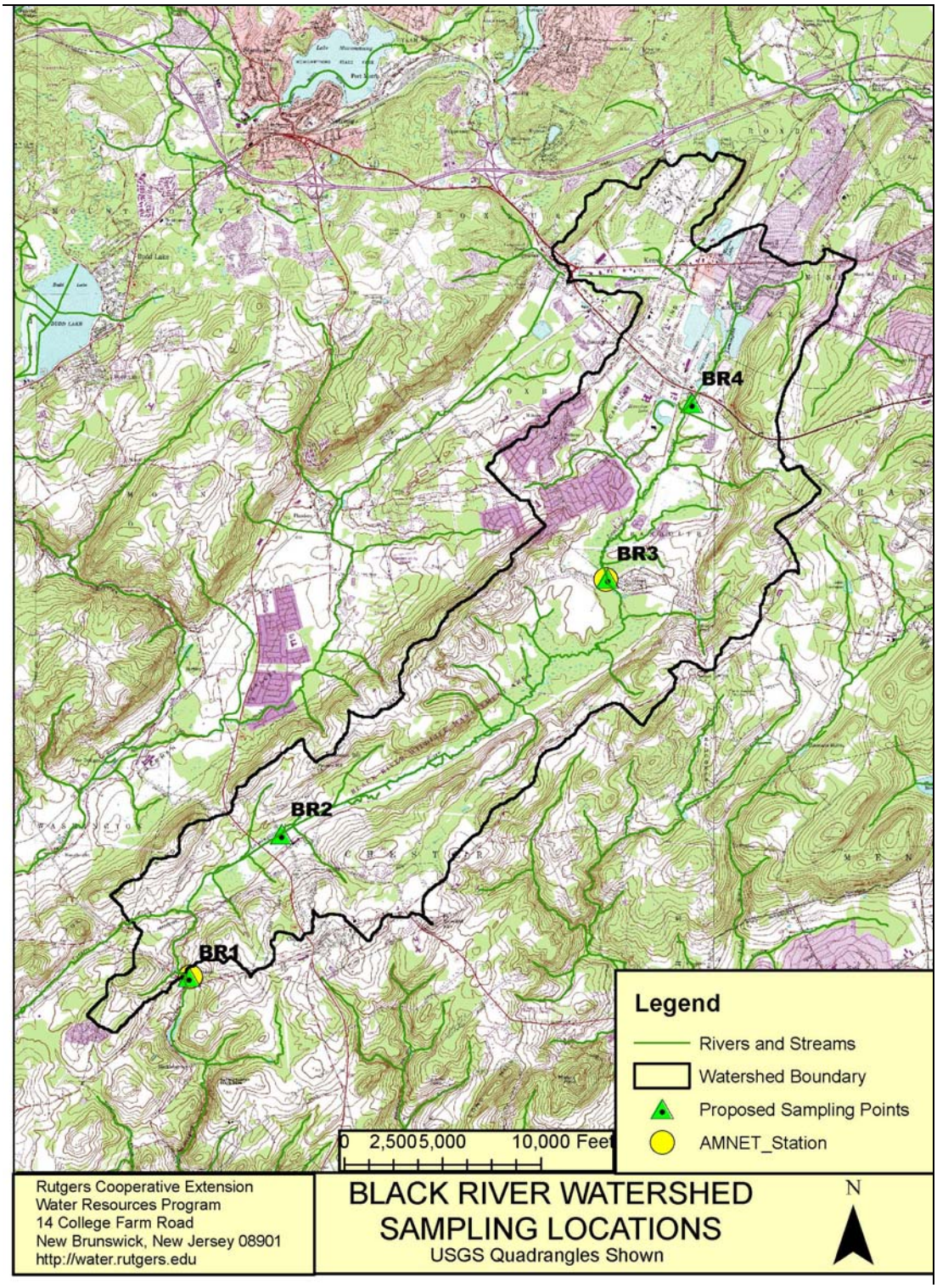

FIGURE 1. Sampling Locations

TABLE 1. Scoring Criteria for Habitat Assessment

Table 4 — **HABITAT ASSESSMENT FOR *HIGH* GRADIENT STREAMS**

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i. e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regimes	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is < 0.3 m/s, deep is > 0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity / depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (< 20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills > 75% of the available channel; or < 25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream < 7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of > 25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. < 5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone > 18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone < 6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

HABITAT SCORES	VALUE
OPTIMAL	160 — 200
SUB-OPTIMAL	110 — 159
MARGINAL	60 — 109
POOR	< 60

TABLE 2. Habitat Assessment Results

Habitat Parameter	Scores	
	BR1	**BR3**
1. Epifaunal Substrate/Available Cover	18	13
2. Embeddedness	20	13
3. Velocity/Depth Regime	13	3
4. Sediment Deposition	20	8
5. Channel Flow Status	20	18
6. Channel Alteration	20	13
7. Channel Sinuosity	18	3
8a. Bank Stability (Left Bank)	10	10
8b. Bank Stability (Right Bank)	10	10
9a. Vegetative Protection (Left Bank)	10	10
9b. Vegetative Protection (Right Bank)	9	10
10a. Riparian Vegetative Zone Width (Left Bank)	10	7
10b. Riparian Vegetative Zone Width (Right Bank)	9	4
Total Score	*187*	*122*
Condition Category	*Optimal*	*Sub-optimal*

TABLE 3. Results of the Benthic Macroinvertebrate Sampling

Taxa:	***Station BR1***	***Station BR3***
Tricladida (flat worms)		
Planariidae		
Dugesia sp.	4	
Limnophila (snails)		
Physidae		
Physa sp.		7
Amphipoda (scuds or side swimmers)		
Gammaridae		
Gammarus sp.	17	73
Isopoda (pill bugs)		
Asellidae		
Caecidotea sp.		10
Ephemeroptera (mayflies)		
Baetidae		
Baetis sp.	2	
Plecoptera (stoneflies)		
Perlidae		
Acroneuria sp.	2	
Odonata (damselflies/dragonflies)		
Coenagrionidae		
Enallagma sp.		3
Trichoptera (caddisflies)		
Brachycentridae		
Micrasema sp.	2	
Glossosomatidae		
Glossosoma sp.	7	
Hydropsychidae		
Cheumatopsyche sp.		2
Hydropsyche sp.	28	
Philopotamidae		
Chimarra sp.	22	
Rhyacophilidae		
Rhyacophila sp.	1	

TABLE 3. Results of the Benthic Macroinvertebrate Sampling (continued)

Taxa:	***Station BR1***	***Station BR3***
Uenoidae		
Neophylax sp.	2	
Coleoptera (beetles)		
Elmidae		
Dubiraphia sp.	1	
Optioservus sp.	1	
Stenelmis sp.	7	5
Psephenidae		
Psephenus sp.	2	
Scirtidae		
Cyphon sp.	1	
Diptera (true flies)		
Chironomidae		
Tanypodinae	1	
Tipulidae		
Antocha sp.	1	
Tipula sp.	1	
Total # taxa:	***18***	***6***
Total # individuals:	***102***	***100***

TABLE 4. Scoring Criteria for Rapid Bioassessments in New Jersey Streams

	Non-impaired	***Moderately Impaired***	***Severely Impaired***
Biological Condition Score:	***6***	***3***	***0***
Biometrics:			
1. Taxa Richness	>10	10-5	4-0
2. EPT Index	>5	5-3	2-0
3. %CDF	<40	40-60	>60
4. %EPT	>35	35-10	<10
5. Family Biotic Index	<5	5-7	>7
Biological Condition:	Total Score		
Non-impaired	24-30		
Moderately impaired	9-21		
Severely impaired	0-6		

TABLE 5A. Calculation of Biological Condition for Station BR1

Taxa	*Tolerance Value*	*Location BR1 Number of Individuals*
Planariidae	4	4
Gammaridae	4	17
Baetidae	4	2
Perlidae	1	2
Brachycentridae	1	2
Glossosomatidae	0	7
Hydropsychidae	4	28
Philopotamidae	3	22
Rhyacophilidae	0	1
Uenoidae	3	2
Elmidae	4	9
Psephenidae	4	2
Scirtidae	5	1
Chironomidae	6	1
Tipulidae	3	2
Taxa Richness		15
EPT Index		8
%CDF		27% Hydropsychidae
%EPT		65%
Family Biotic Index		3.34 excellent water quality; organic pollution unlikely
NJIS Rating		30
Biological Condition		Non-Impaired

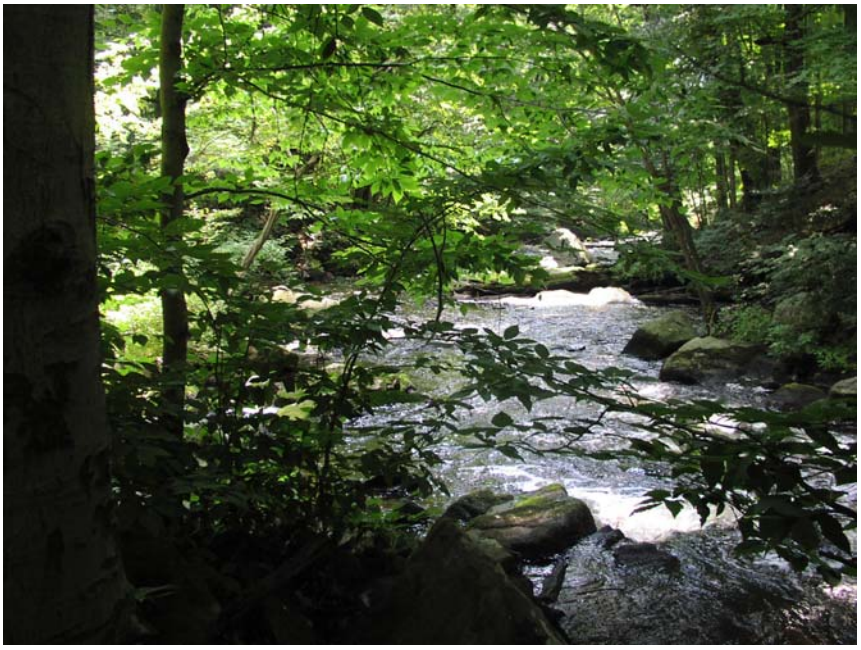

TABLE 5B. Calculation of Biological Condition for Station BR3

Taxa	*Tolerance Value*	*Location BR3 Number of Individuals*
Physidae	8	7
Gammaridae	4	73
Asellidae	8	10
Coenagrionidae	9	3
Hydropsychidae	4	2
Elmidae	4	5
Taxa Richness		6
EPT Index		1
%CDF		73% Gammaridae
%EPT		2%
Family Biotic Index		4.83 good water quality; some organic pollution probable
NJIS Rating		9
Biological Condition		Moderately Impaired