Coldwater Conservation Plan

Upper Bushkill Creek Watershed

Bushkill & Moore Townships
Northampton County, Pennsylvania

2009

Prepared for:

Bushkill Stream Conservancy

Prepared by:

Hanover Engineering Associates, Inc.

Funded by:

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Delaware & Lehigh National Heritage Corridor

Dedication

This plan is proudly dedicated to Sandra T. Merwarth whose leadership and vision for the Bushkill Steam Conservancy have profoundly influenced and improved education, preservation, and restoration efforts focusing on the natural, cultural, and historical resources within the Bushkill Creek Watershed.

Sandy's service to the Bushkill Stream Conservancy and our local watershed communities and partners will be greatly missed, but her many contributions will have forever improved the Bushkill Creek, its tributaries, and its watershed. We wish Sandy the very best in all of her future endeavors.

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INTRODUCTION

Purpose of Study

The implementation of the Upper Bushkill Creek Watershed Coldwater Conservation Plan is a primary goal of the Bushkill Stream Conservancy (BSC) and many of its partners. The Upper Bushkill Creek Watershed, for purposes of this study, is defined as the watersheds of Sobers Run and Bushkill Creek from the point of their confluence within Jacobsburg State Park. The watershed for the upper reaches of the Bushkill Creek from this point is approximately 14 square miles, with nearly equal portions in Bushkill and Moore Townships. Sobers Run, which includes the West Branch Sobers Run, is one of the largest tributaries to Bushkill Creek, and its lower reach is a focal point within Jacobsburg State Park. The watershed of Sobers Run is approximately 10 square miles, with approximately 5 square miles consisting of the watershed of West Branch Sobers Run. These streams provide high quality recreational and aesthetic values within the Upper Bushkill Creek Watershed, and they supply clean, cool water to the lower reaches of the Bushkill Creek which supports coldwater fish species through a suburban landscape and into the City of Easton. The combination of the exceptional water quality from the upper reaches and the limestone geology in the lower reaches of the Bushkill Creek have long supported a Class A Wild Trout designation. The Bushkill Stream Conservancy and its partners have made the preservation of the unique fishery a top priority, with a strong focus on protection and restoration in the headwater areas which have suffered the least impact by land development in recent years.

All of the streams within the Upper Bushkill Creek Watershed area are listed as High Quality – Cold Water Fishes, with exception of the uppermost reaches of Sobers Run (to its crossing at Kromer Road) which has been re-designated as Exceptional Value in Chapter 93 of Title 25 of the Pennsylvania Code. The watersheds for all of the streams begin along the Appalachian Trail atop the Kittatinny, or Blue Mountain, Ridge. Vast wetlands and vernal pool areas form at the base of the Kittatinny Ridge, providing critical habitat for numerous rare, threatened, and endangered plant and animal species, including the federally listed bog turtle. In fact, nearly the entire headwaters area has been deemed as special protection areas by The Nature Conservancy within three areas known as Rissmiller's Woods, Moorestown Wetlands, and Knecht's Ponds. The wetland and vernal pond areas within Knecht's Ponds and Rissmiller's Woods, as well as other areas along the foot of the Blue Mountain, form numerous rivulets which eventually feed the main streams channels throughout the Upper Bushkill Creek Watershed. All of these streams support reproduction of wild brown and native brook trout and provide exceptional water quality, habitat, recreational, and aesthetic values. The primary goal of the proposed project is to maximize the level of protection of all of these waterways and to protect their unique and exceptional values from land-use change impacts.

The historical land-use in the Upper Bushkill Creek Watershed has been primarily agricultural, including both livestock and crop farming, with some rural residential and village areas. There were also several mills along the Bushkill Creek to support local agriculture. The vast wetlands and water resources in this headwater area to the larger Bushkill Creek, however, have historically discouraged farming practices within the wet, riparian areas, as well as residential development. Therefore, most of the riparian lands remained in tact as part of large woodland tracts with minimal impact for logging and pasturing. Today, these riparian woodlands serve as highly valuable buffers for water quality and habitat impacts from a rapidly changing landscape. Existing development within the Upper Bushkill Creek Watershed has been serviced by on-lot

water (springs and wells) and septic, with limited centralized water becoming available in recent years.

Urban sprawl, population growth, and greatly improved transportation systems in recent years have shifted land-use throughout our region, converting the relatively poor agricultural lands within the Upper Bushkill Creek Watershed into residential development. While the riparian woodlands contain regulated wetlands and waterways, the majority of these areas is commonly deemed as non-regulated, poorly drained soils, allowing land development with a reasonable amount of earthmoving and filling. The result of such ongoing activities is a tremendous loss of riparian woodlands and the protection that they afford local streams and wetlands which feed Sobers Run and Bushkill Creek.

Residential developments also impact the streams further with stormwater, malfunctioning septic system leachate, and direct discharges of "treated" wastewater from individual lot wasterwater treatment facilities (replacement systems, only). To date, there has not been any centralized wastewater treatment within the Upper Bushkill Creek Watershed, but as new technologies emerge and costs continue to decline for smaller "package" treatment plants and other alternative treatment systems, the threat to local streams remains a valid concern. Replacement of old and failing septic systems on smaller lots with individual lot wastewater treatment systems that have direct stream discharges is also a primary concern, especially along the foot of the Blue Mountain where soils are particularly problematic for using conventional on-lot septic systems. Stormwater discharges, which also cause considerable non-point source pollution to local streams, are an inherent part of every subdivision development. Additionally, direct impacts to the streams, wetlands, and vernal ponds are beginning to occur for the installation of roads, driveways, lot clearing, and other land development activities.

In an effort to control the level of impact to Sobers Run and Bushkill Creek, the Bushkill Stream Conservancy and its partners have engaged in several significant projects in recent years, including development of the Upper Bushkill Creek Watershed and Sobers Run Coldwater Conservation Plans, Greenway Plans, Open Space Programs, and Township Official Maps to provide protection of riparian buffers and remaining riparian woodlands. These initiatives all focus on the protection of local streams, ponds, vernal ponds, and wetlands, but additional measures are still required to maximize protection and maintain or improve upon current conditions.

Following completion of the initial Sobers Run Coldwater Conservation Plan, Sobers Run and West Branch Sobers Run were officially named, and the uppermost reaches of Sobers Run were designated as Exceptional Value in Chapter 93 of Title 25 of the Pennsylvania Code. The results of the Sobers Run Coldwater Conservation Plan prompted the Bushkill Stream Conservancy to consider the potential of the remaining headwater areas of the uppermost sections of Bushkill Creek which have very similar characteristics and composition. It was also determined that additional study of Sobers Run, including West Branch Sobers Run were warranted, due to limited data collection and adverse weather conditions occurring during the initial study.

This plan and its recommendations include information and provisions necessary to maximize the protection of the coldwater fishery and exceptional water quality of Bushkill Creek and Sobers Run, as well as to protect their riparian corridors from further impacts associated with imminent land-use change and development.

Goals of the study

The following have been determined the primary goals of this Upper Bushkill Creek Watershed Coldwater Conservation Plan study:

1. Determine if streams meet characteristics necessary to qualify for upgrade in water quality designation under Chapter 93.
2. Determine if streams still support native brook trout, and to what extent.
3. Determine fish species distribution
4. Determine the general condition of the streams with regard to support of coldwater fisheries.
5. Develop recommendations for watershed and stream water quality protection and restoration, as well as coldwater habitat improvement and management.
6. Develop recommendations for protection of native brook trout, as well as naturally reproducing populations of wild brown trout.

Sport Fishing History

When considering the development of a Coldwater Conservation Plan for the Upper Bushkill Creek Watershed, one must certainly take into account the role of trout fishing for sport. Bushkill Creek, Sobers Run and West Branch Sobers Run have long been a special local sport fisheries, especially for the keen flyfisher looking to get away from the mainstream fishery provided along lower sections of the Bushkill Creek which offer higher flows, public stocking, Class A Wild Trout waters, and considerable public access.

CURRENT TROUT WATER CLASSIFICATIONS

Bushkill Creek

Class A Wild Trout Streams (Brown Trout)

Section: 1.3 mi - Lower Tatamy Boro Line Downstream to Private Bridge off S.R. 2019

- Managed as Special Regulations Designation: Class A Wild Trout
- Requires current PA Fishing License & Trout/Salmon Permit (if over 16-yrs of age)
- Season: Regional Opening Day of Trout Season (March 29 at 8 a.m. through Sept. 1)
  - Minimum length limit: 7-inches
  - Creel limit: 5

  Extended Season (Jan. 1 through Feb. 29 and Sept. 2 through Dec. 31)
  - Minimum length limit: 7-inches
  - Creel limit: 3

1.1 mi - Dam at Binney-Smith Downstream to 13th Street Bridge in Easton

- Managed as Special Regulations Designation: Catch & Release, Artificial Lure Only
- Requires current PA Fishing License & Trout/Salmon Permit (if over 16-yrs of age)
- Season: Open to fishing year-round (no closed season)

Approved Trout Waters

Section: All Remaining Sections of Bushkill Creek

- Managed as Special Regulations Designation: Approved Trout Waters
- Requires current PA Fishing License & Trout/Salmon Permit (if over 16-yrs of age)
- Season: Regional Opening Day of Trout Season (March 29 at 8 a.m. through Sept. 1)
  - Minimum length limit: 7-inches
  - Creel limit: 5

  Extended Season (Jan. 1 through Feb. 29 and Sept. 2 through Dec. 31)
  - Minimum length limit: 7-inches
  - Creel limit: 3

Sobers Run

Not Classified

Section: All Sections of Sobers Run

- No Special Regulations Designation
- Requires current PA Fishing License & Trout/Salmon Permit (if over 16-yrs of age)
- Season: Regional Opening Day of Trout Season (March 29 at 8 a.m. through Sept. 1)
  - Minimum length limit: 7-inches
  - Creel limit: 5

West Branch Sobers Run

Not Classified

Section: All Sections of West Branch Sobers Run

- No Special Regulations Designation
- Requires current PA Fishing License & Trout/Salmon Permit (if over 16-yrs of age)
- Season: Regional Opening Day of Trout Season (March 29 at 8 a.m. through Sept. 1)
  - Minimum length limit: 7-inches
  - Creel limit: 5

WATERSHED CHARACTERISTCS

Location

The Upper Bushkill Creek Watershed (part of State Water Plan Sub-basin 1F) is located within Bushkill and Moore Townships, Northampton County, Pennsylvania. Named streams within the Upper Bushkill Creek Watershed include Bushkill Creek, Sobers Run, and the West Branch Sobers Run. Both Sobers Run and West Branch Sobers Run were officially named within the past three to four years, and therefore are not always listed as part of currently available maps and documents.

The streams within the Upper Bushkill Creek Watershed originate from a collection of spring seeps, wetlands, and vernal ponds at the base of the Blue Mountain Ridge in the northern portion of Bushkill Township, Northampton County. Scores of small streams forming across this area quickly join together to form the main channels of the three named streams which in turn meet within Jacobsburg State Park.

Sub-watersheds

The Upper Bushkill Creek Watershed, including the Sobers Run Watershed, is approximately 25 square miles, considering the downstream-most point as the confluence with Sobers Run located within Jacobsburg State Park. This area represents approximately 31% of the total watershed area of the larger, 80 square mile Bushkill Creek Watershed. The Sobers Run Watershed, including the 5.0 square mile West Branch Sobers Run Watershed, is approximately 9.5 square miles. The watershed areas of the main stem of Sobers Run upstream and downstream of the confluence with the West Branch are approximately 3.9 and 0.5 square miles, respectively.

Ownership

The headwater lands throughout the Upper Bushkill Creek Watershed are publicly owned State Gamelands (No. 168) along the Blue Mountain Ridge. A 1.3 mile reach of the main stem of Sobers Run lies entirely within Jacobsburg State Park and Environmental Education Center, as does approximately 0.7 miles of Bushkill Creek (upstream of the confluence with Sobers Run). The remaining upstream reaches of Bushkill Creek, Sobers Run, and West Branch Sobers Run are entirely within privately owned land.

Most privately owned tracts along the streams are relatively large, as most have not yet been subdivided for development. According to township officials, most of the riparian landowners have a great appreciation for all that the streams offer, and therefore, they do wish to not develop these lands or further impact the streams. Old farms within the watershed, however, have been and continue to be sold for residential and other land development, as farming in the region is not profitable enough to compete with rising land values for such development.

During recent years, a series of public meetings was held in partnership with Jacobsburg Environmental Education Center, Bushkill Township, and Bushkill Stream Conservancy. Presentations were given on various aspects of conservation and preservation specifically

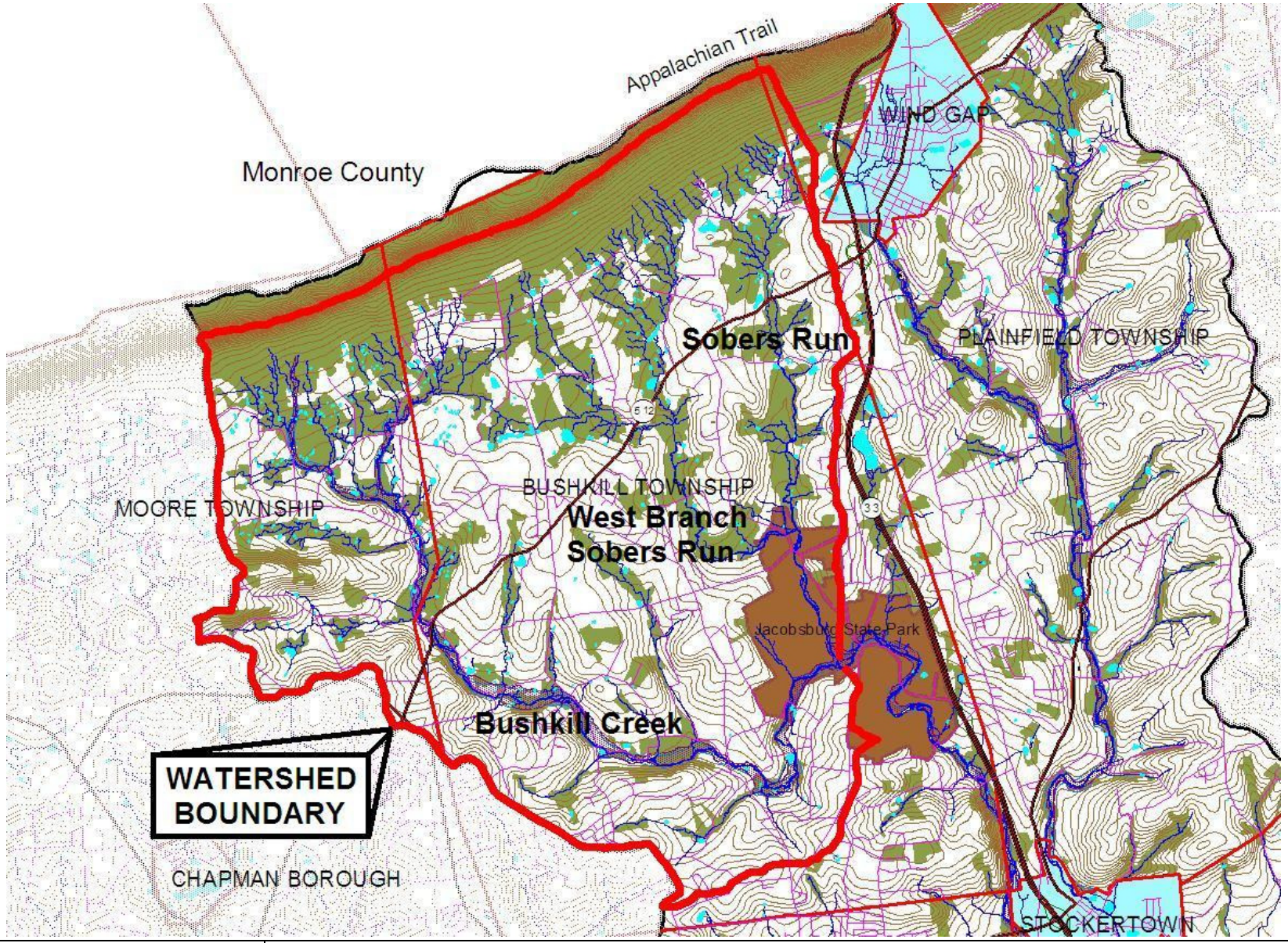


FIGURE 1

Upper Bushkill Creek Watershed Map
(base mapping from LVPC, 2004)

targeted towards the stream corridors which connect Jacobsburg State Park with the Blue Mountain Ridge to the north. The presentation series was advertised in local newspapers and in the Bushkill Township Newsletter, and individual invitations were extended to significant landowners. The outcome of the public meetings supported the fact that local homeowners and landowners generally supported the conservation and protection measures presented and discussed. Since this time, both Moore and Bushkill Townships have approved collection of Open Space funds through voter approved referenda. Both Townships' funding targets preservation of natural areas and farmlands. Bushkill Township has developed and approved an Open Space Plan and has a functioning Open Space Program administered through its Environmental Advisory Council. Moore Township is in the process of developing and Open Space Plan and has established a Farmland Preservation Board which will administer their Program once the Plan has been completed and approved.

BIOLOGICAL STUDIES

Pennsylvania Fish & Boat Commission

The Upper Bushkill Creek and Sobers Run were surveyed by the Pennsylvania Fish and Boat Commission during the mid- to late-1970s. Coldwater fish species (stocked and wild) were present in both survey areas, with brook trout observed in the surveyed section of Bushkill Creek.

Sobers Run 1979 Fish Survey

A stretch north of the LR 48087 bridge produced 64 brown trout (*Salmo trutta*) with lengths between 75mm and 300mm, along with a diverse assemblage of other fish species. The main stem of Sobers Run within Jacobsburg State Park and Environmental Education Center was electrofished in 1979. A 300 meter stretch north of the LR 48087 bridge produced 64 brown trout (*Salmo trutta*) with lengths between 75mm and 300mm, along with a diverse assemblage of other fish species. The following table list fish species observed in each stream:

FISH SPECIES OF SOBERS RUN (PAFBC, 1979)
American eel, *Anguilla rostrata*
Bluegill, *Lepomis macrochirus*
Blacknose dace, *Rhinichythys atratulus*
Brown trout, *Salmo trutta*
Common shiner, *Notropis cornutus*
Creek chub, *Semotilus atromaculatus*
Cutlips minnow, *Exoglossum maxillingua*
Largemouth bass, *Micropterus salmoides*
Longnose dace, *Rhinichythys cataractae*
Margined madtom, *Noturus insignis*
Redbreast sunfish, *Lepomis auritus*
Tessellated darter, *Etheostoma olmstedi*
White sucker, *Catastomus commersoni*

Note: Brook trout (*Salvelinus fontinalis*) have been reported by local anglers to occur in the headwater streams of Sobers Run, but were not observed in the 1979 survey by the Pennsylvania Fish & Boat Commission.

Bushkill Creek (Upper) 1976 Fish Survey

During July of 1976, the Pennsylvania Fish & Boat Commission conducted a survey within Section 02 of Bushkill Creek, extending from Bushkill Center Road (SR 4025) bridge near Copella (RM 20.00) downstream to Filetown Road (SR 1006) bridge Belfast Junction (RM 11.2).

FISH SPECIES OF UPPER BUSHKILL CREEK (PAFBC, 1976)
American Eel, *Anguilla rostrata*
Blacknose Dace, *Rhinichthys atratulus*
Bluegill, *Lepomis macrochirus*
Brook Trout, *Salvelinus fontinalis*
Brook Trout – Hatchery, *Salvelinus fontinalis*
Brown Bullhead, *Ameiurus nebulosus*
Brown Trout, *Salmo trutta*
Brown Trout – Hatchery, *Salmo trutta*
Common Shiner, *Luxilus cornutus*
Creek Chub, *Semotilus atromaculatus*
Cutlip Minnow, *Exoglossum maxillingua*
Golden Shiner, *Notemigonus crysoleucas*
Johnny Darter, *Etheostoma nigrum*
Largemouth Bass, *Micropterus salmoides*
Longnose Dace, *Rhinichthys cataractae*
Margined Madtom, *Noturus insignis*
Pumpkinseed, *Lepomis gibbosus*
Rainbow Trout, *Oncorhynchus mykiss*
Rainbow Trout – Hatchery, *Oncorhynchus mykiss*
Redbreast Sunfish, *Lepomis auritus*
Redfin Pickerel, *Esox americanus*
Satinfin Shiner, *Cyprinella analostana*
Spottail Shiner, *Notropis hudsonius*
Tessellated Darter, *Etheostoma olmstedi*
White Sucker, *Catostomus commersonii*

Pennsylvania Department of Environmental Protection

In recent years, the Pennsylvania Department of Environmental Protection has conducted macroinvertebrate monitoring throughout the Upper Bushkill Creek Watershed, including Sobers Run (and West Branch Sobers Run which was recently officially named). Work on Sobers Run was conducted during 2005 and work on the remaining stations along the upper reaches of Bushkill Creek, upstream of Jacobsburg State Park was conducted during 2006. The results of this monitoring are discussed below, with data summaries included as appendices to this report.

Sobers Run 2005 Macroinvertebrate Monitoring

During April and November 2005, monitoring was conducted on Sobers Run and West Branch Sobers Run at several strategically located stations. The results of this sampling effort are included as Appendix A. Marcoinvertebrate species collected and identified in Sobers Run included:

SOBERS RUN BENTHIC MACROINVERTEBRATE SPECIES*
BUSHKILL TOWNSHIP, NORTHAMPTON COUNTY, PA (PADEP, APRIL 19, 2005)

MAYFLIES		TRUE FLIES	
		Ceratopogonidae	***Probezzia***
Baetidae	***Baetis***	Chironomidae	***sp.***
Ephemerellidae	***Drunella***	Empididae	***Chelifera***
	Ephemerella		***Clinocera***
	Serratella		***Hemerodromia***
Heptageniidae	***Epeorus***	Simuliidae	***Prosimulium***
	Stenonema		***Simulium***
Isonychiidae	***Isonychia***		***Stegopterna***
Leptophlebiidae	***Paraleptophlebia***	Tipulidae	***Antocha***
STONEFLIES			***Dicranota***
Chloroperlidae	***Sweltsa***		***Hexatoma***
Leuctridae	***Leuctra***		***Limonia***
Nemouridae	***Amphinemura***		***Tipula***
Perlidae	***Acroneuria***	**BEETLES**	
Perlodidae	***Isoperla***	Dryopidae	***Helichus***
	Remenus	Elmidae	***Dubiraphia***
Pteronarcyidae	***Pteronarcys***		***Microcylloepus***
CADDISFLIES			***Optioservus***
Brachycentridae	***Micrasema***		***Oulimnius***
Glossosomatidae	***Agapetus***		***Promoresia***
Hydropsychidae	***Cheumatopsyche***		***Stenelmis***
	Diplectrona	Psephenidae	***Ectopria***
	Hydropsyche		***Psephenus***
Hydroptilidae	***Stactobiella***	Ptilodactylidae	***Anchytarsus***
Philopotamidae	***Chimarra***	**MISC. INSECT TAXA**	
	Dolophilodes	Cordulegasteridae	***Cordulegaster***
Polycentropodidae	***Polycentropus***	Corydalidae	***Nigronia***
Rhyacophilidae	***Rhyacophila***	Gomphidae	***Lanthus***

* Non-insect taxa included Cambaridae *cambarus*, Hydracarina sp., and Oligochaeta sp.

This sampling indicated that the uppermost reaches of the main stem of Sobers Run to its headwaters at the foot of the Blue Mountain Ridge qualified as Exceptional Value (EV) classification in Chapter 93 based on the biological criteria. Sampling at the other stations indicated that the primary tributary, West Branch Sobers Run, and the remainder of the main stem of Sobers Run nearly qualified for EV classification, missing by only a few percentage points with the methodology used for the sampling date.

It should be noted that the PADEP sampling on April 19, 2005 was completed following severe weather and highly erosive streamflow conditions. Considerable bed scour was observed at the stations on the western branch tributary. Consequently, additional macroinvertebrate sampling following more stable and normal conditions may help to improve biological monitoring scores enough to qualify for the EV classification.

Bushkill Creek (Upper) 2006 Macroinvertebrate Monitoring

During 2006, macroinvertebrate monitoring was conducted seven (7) stations along the reaches of Bushkill Creek upstream of Jacobsburg State Park. Results of this monitoring are included in Appendix B.

This sampling indicated that the uppermost reaches of the Bushkill Creek to its headwaters at the foot of the Blue Mountain Ridge would likely qualify as Exceptional Value (EV) classification in Chapter 93 based on the biological criteria. Sampling at the other more-downstream stations indicated a more likely biological classification as High Quality – Cold Water Fishes (HQ-CWF). Actual determination on water quality classification using the 2006 data is not possible, however, since there was no "reference reach" monitoring conducted as part of this initial evaluation work. Therefore, additional macroinvertebrate monitoring by the Pennsylvania Department of Environmental Protection, including an appropriate reference reach, would be required to make a final determination on the exact classifications at the various stations and stream reaches.

Lance Leonhardt – Bushkill Stream Conservancy

2007-08 Fish Survey

Fish surveys were conducted from July through October 2007 at seven (7) sampling sites on two (2) tributaries and the main stem of the Bushkill Creek, and at six (6) sampling sites on the east and west branches of Sobers Run, a tributary of Bushkill Creek, located in Northampton County, Pennsylvania. The purpose of the surveys was to confirm the presence of brook trout (*Salvelinus fontinalis*) in the Bushkill Creek Watershed and document the fish species assemblages at the sampling site locations. See Appendix D - Fish Survey Report, Bushkill Creek and Sobers Run, Northampton County, PA.

A total of thirty-five (35) brook trout individuals, ranging in total length from 60 to 245 mm (2.4-9.7 in.), were found at four (4) sampling sites on Bushkill Creek. A total of eight (8) brook trout individuals, ranging in total length from 65 to 320 mm (2.5-13.0 in.), were found at two (2) sampling sites on Sobers Run.

A total of nineteen (19) fish species were identified during the surveys on Bushkill Creek and Sobers Run, with eighteen (18) fish species identified at the sampling sites on Bushkill Creek, and seventeen (17) fish species identified at the sampling sites on Sobers Run.

Length-frequency distributions of brook trout individuals collected during the surveys indicate reproduction is occurring in small, self-sustaining brook trout populations in both Bushkill Creek and Sobers Run. (Adapted from Leonhardt, 2008)

2008 Macroinvertebrate Survey

Macroinvertebrate sampling was conducted March 29, 2008, at two sites on the upper Bushkill Creek, Northampton County, PA. See Appendix C - Macroinvertebrate Survey Report, Upper Bushkill Creek, Northampton County, PA. Sampling Sites #1 and #2 corresponded to the same locations on Bushkill Creek found to support naturally-reproducing populations of brook trout by a fish survey conducted in 2007.

Macroinvertebrate sampling and assessment followed Pennsylvania Department of Environmental Protection (PA DEP) protocols. Using PA DEP's Benthic Index of Biotic Integrity (IBI) for Wadeable Freestone Streams as an evaluative tool, the collected and sub-sampled macroinvertebrate assemblage from Site #1 scored 80.1 on the IBI. The collected and subsampled macroinvertebrate assemblage from Site #2 scored 78.97. An IBI score of 80 or greater is the benchmark required for consideration of High Quality/Exceptional Value (HQ/EV) Aquatic Life Use (ALU) antidegradation designations.

Using the Biological Condition Gradient (BCG) for Freestone (Non-Calcareous) Streams of Pennsylvania, a tier or biological condition class was determined using the macroinvertebrate assemblage for each sampling site. Site #1 had the required characteristics of a Tier 2 condition described as outstanding condition waters having a natural condition with minimal ecosystem changes. Site #2, missing one Tier 2 qualification rule, was designated a Tier 3, or good condition waters.

Macroinvertebrate indicator species were used to classify each site's community type based on the genus-level macroinvertebrate communities defined by the Pennsylvania Aquatic Community Classification Project. Although each site had representative species indicators of several community types, the genus-level stream community "High Quality Small Stream" best describes both Site #1 and Site #2.

The presence of high quality macroinvertebrates, reflected in the IBI and BCG Tier results, and the occurrence of naturally-reproducing brook trout populations at the assessed sites may warrant further evaluation of portions of the upper Bushkill Creek by PA DEP biologists for possible consideration of Exceptional Value (EV) designated use. (Adapted from Leonhardt, 2008)

Patricia Thornton Bradt

During 1972-73, Dr. Patricia Bradt conducted macroinvertebrate and fish surveys on the Bushkill Creek at its crossing by Clearfield Road (Station 1), along with limited streamflow discharge monitoring (see Appendix F). Approximately 200 linear feet of stream channel were electro-fished using standard methods, yielding primarily Cyprinids and white suckers, along with nine brown trout and six eels. The local Pennsylvania Fish Commission Waterways Patrolman, John Weaver, determined that at least two of the brown trout resulted from natural reproduction in Bushkill Creek. Macroinvertebrate monitoring was conducted 31 times during the 2-year study period (at Station 1), which produced relative low numbers of organisms respective to other stations on Bushkill Creek, but the highest diversity index and highest mean diversity index. On the date of surveying and monitoring, the flow was approximately 8 inches deep and 30 feet wide, and the riparian corridor was wooded on both sides with notable shading of the channel. The minimum streamflow discharge, as measured and recorded during August 1972 as part of a concurrent study by Lafayette College, was 1.97 cfs, following a mean flow of 10 cfs during July 1972.

CHEMICAL STUDIES

Lafayette College

Lafayette College conducted a year long monitoring program on the main stem of Sobers Run within Jacobsburg State Park during 2000. No data were available for the upper reaches of Bushkill Creek upstream of Jacobsburg State Park. Chemical data, along with limited physical data for Sobers Run, are presented in the following table:

Summary of Water Quality Data for 2000

Sample Location	Sample Date	Anion Concentrations (mg/L)					Cation Concentrations (mg/L)						Field Parameters				
		F^-	Cl^-	NO_3^-	PO_4^{-3}	SO_4^{-2}	Li^+	Na^{+2}	NH_4^+	K^+	Mg^{+2}	Ca^{+2}	Temp. (°C)	pH	Cond. (uS/cm)	Turb. (NTU)	D.O. (mg/L)
7	3/18/2000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	4/15/2000	0.04	9.53	10.06	ND	18.51	ND	4.10	ND	0.83	3.09	12.13	NA	NA	NA	NA	NA
7	5/24/2000	0.05	4.68	2.99	ND	16.10	ND	3.70	ND	1.13	2.64	12.32	NA	NA	NA	NA	NA
7	6/14/2000	0.04	5.84	5.22	ND	16.11	ND	4.37	ND	1.16	3.31	14.23	14.5	6.60	110	3	10
7	7/17/2000	0.04	6.79	4.73	ND	27.03	ND	4.41	ND	1.09	3.83	16.67	18.0	7.19	134	7	11
7	8/16/2000	0.02	7.10	13.10	ND	11.64	0.86	8.08	0.13	2.06	5.63	19.84	18.1	7.48	138	0.75	10
7	9/16/2000	0.04	6.10	6.44	ND	16.00	ND	5.16	ND	1.70	4.04	16.92	14.8	6.72	138	1.5	12
7	10/15/2000	0.01	6.53	10.38	ND	10.59	ND	3.96	0.06	1.17	4.00	14.72	15.9	6.90	140	0.7	10
7	11/19/2000	0.02	6.61	7.97	ND	19.30	ND	3.63	ND	0.99	3.82	15.06	4.5	7.20	140	0.5	12
7	12/18/2000	0.03	3.77	13.66	ND	20.81	ND	2.98	ND	1.54	3.18	13.25	2.0	7.30	124	8	14

NA = not analyzed
ND = not detected

Nutrient concentrations during the 2000 study period were relatively low with nitrogen and phosphorus at or near non-detect for all monitoring events. Other chemical parameters were also relatively low, with respectively little variability amongst seasons. Water temperature reached an observed maximum of 18.1°C during August, which is well below temperatures shown to be stressful for coldwater fish. Respectively, the dissolved oxygen remained very high, even during the most stressful summer months, with a minimum observed concentration of 10 mg/L which is several times higher than concentrations known to be stressful for coldwater fish. pH values were near neutral for all monitoring events, and both conductivity and turbidity values were relatively low and well within ranges for high quality and exceptional value streams in our region.

Retired and Senior Volunteer Program

The Retired and Senior Volunteer Program (RSVP) conducts annual monitoring throughout the Bushkill Creek Watershed, with three stations located within the Upper Bushkill Creek Watershed study area for this project. Chemical parameters include pH, dissolved oxygen, water temperature, air temperature, alkalinity, nitrates, and phosphates, using Lamotte kits and a hand-held YSI Dissolved Oxygen and Temperature meter, accordingly. Bushkill Creek is monitored immediately upstream of the crossing by East Douglasville Road near the boundary of Jacobsburg State Park. Sobers Run is monitored at the crossing by Kromer Road, above the confluence with West Branch Sobers Run. West Branch Sobers Run is monitored at 123 Belfast Road (Marsh property). Data for 2007 at the three monitoring stations are presented in tabular and graphic formats in Appendix G.

Water quality was excellent during 2007 at all three stations. Nutrient concentrations were relatively low, with phosphates being “non-detect” during all monitoring events.* The relatively low algal and periphytin growth observed within the streams is consistent with the low nutrient concentrations. Turbidity was also “non-detect” during all monitoring events. Alkalinity was

also relatively low, but normal for free-stone and shaley streams within the region and high enough to provide sufficient buffering capacity and neutral pH values. Dissolved oxygen concentrations were all very high, even during the warmer conditions during mid-summer. Water temperatures during mid-summer were generally within the range which would support trout (coldwater fishes), with the highest temperature of 23^{o}C recorded at the West Branch Sobers Run station on June 21. The highest temperatures recorded for Sobers Run and Bushkill Creek stations were 22^{o}C and 20^{o}C on June 21 and July 19, respectively.

** The minimum detection limit for phosphates using the Lamotte kit is too high for most normal background phosphate concentrations, and therefore, the result of "non-detect" does not allow for detailed analysis for this parameter.*

TEMPERATURE MONITORING

Temperature monitoring was conducted at nine (9) stations throughout the upper watershed during the 2008 growing season, from early May through late September of 2008, using in-stream data loggers to collect hourly temperature readings. Onset® temperature loggers were installed in-stream at each station and were downloaded quarterly. Temperature plots for all nine stations are presented in Appendix E.

The data indicate that temperatures were generally sufficient at Stations 2, 3, 5, 8, and 9, primarily the most upstream stations in the headwater areas. At the remain stations, temperatures were generally within ranges that brook trout may survive, but commonly exceeded the 66.2F (noted as yellow dashed line on graphs in Appendix E) at which reproducing populations have been found to decline, and in some cases exceeded the 75F at which point trout mortality increases substantially.

This article is the second in a series of articles on the major topics of concern in the Commission's theme, "Conserve 2000." This feature explains the global, regional and local aspects of the topic of fish habitat with the state fish, the brook trout, as the focal point. Because the brook trout is a Pennsylvania native, we can readily see the effects of human activity on this species and its habitat over several hundred years.

Habitat and the Brook Trout

by Walt Dietz

Have you ever caught a wild brook trout? If you have, you were probably awed by its orange belly, red spots and the green markings on its back. It's one of Pennsylvania's most colorful fish. But you probably didn't catch it just anywhere. Wild brook trout need the coldest and cleanest water, like that which flows in a small stream beneath a shady forest. Today, most of these shaded streams can be found only in the forested mountains. That's because much of our landscape has been opened up to agriculture and development. Can you imagine what the state might have been like 400 years ago? Pennsylvania was entirely forested then and nearly every stream had a wild brook trout in it.

Before the 1600s, wild brook trout were widely distributed throughout the state. They could be found in just about every watershed, including the Ohio, Allegheny, Susquehanna and Delaware. Pennsylvania provided the perfect habitat for the native brook trout because of the forests.

The area that became Pennsylvania includes nearly 29 million acres. Very few clearings could be found before the 1600s, except for those made by natural events or Native Americans. No wonder it was named Pennsylvania. "Penn," for William Penn, the Quaker leader who purchased the land from the Indians, and sylvania, which is Latin for "woods."

This blanket of forest was important to the health of streams and rivers. Tall hemlocks, white pine and a variety of deciduous trees shaded the valleys. Shade kept the water temperatures cold. Trees protected the banks from erosion. Gravel stream bottoms were clean and unsilted. There was plenty of food and shelter among the submerged tree roots. The conditions were perfect for brook trout survival and reproduction.

Changing landscape

The landscape changed when European settlers arrived and began to cut the forests in the 1600s and 1700s. This activity changed the habitat of the native brook trout. There seemed to be an endless supply of trees at that time. There were so many trees that the first settlers looked at the forests as a hindrance. They cut timber for fuel, homes, furniture and tools. Still, the early settlers hardly had an effect on the state's endless forest.

Large amounts of timber were not really cut until the early 1700s. Europeans had already overexploited their own resources. They sought to develop the New World and use its abundant

resources. Pennsylvania timber became a valuable commodity. It fed a growing country and a global economy, but not without consequences to our local forests and waters.

Shipbuilding was the first industry to take advantage of the state's trees. England needed timber to build ships, so the White Pine Act of 1722 was created. It reserved all the white pines for the British Navy. Lumber was used to make hulls. "Spars," long white pine logs, were used for masts. Can you imagine the size of a tree needed for the main ship mast? The minimum size was 96 feet tall and 15 inches in diameter at the top. A spar's size made it hard to transport. That's why the first trees to be cut were those closest to major riverbanks-not good for the health of aquatic habitats. The banks of eastern rivers like the Delaware and the Susquehanna became the first targets. Trees were felled by hand and the logs were pulled to the water by oxen. Logs were then floated to Baltimore and Philadelphia. Lumber and spars were shipped back to England and made into ships. Those ships were later used against America during the revolutionary war and for exploration of new frontiers. Imagine the importance that Pennsylvania trees had in the world's economy and history

Industrial heritage

The new country's population was growing in the early 1800s. And forest resources were needed to meet its demands. This is when large-scale timbering began. Wood became an important part of America's industrial heritage. The iron, tanning and lumber industries all relied on forests.

In the early 1800s, Pennsylvania became an important source of iron. Making iron required wood for charcoal. It was the fuel used to melt iron ore. Most of the forests had already been cut near the river valleys for the shipbuilding industry. So the mountainsides of central Pennsylvania became the next focus. Iron ore was present and trees were abundant. Iron furnaces were established and entire communities would be built up around them.

By 1860, there were 150 iron furnaces in Pennsylvania. They required over 1.5 million acres of trees per year. That's a lot of trees cut down to produce a lot of iron. This iron fed a growing nation and a growing world. That's right: Pennsylvania iron was an important part of the global economy. Take the small town of Axemann in Centre County, for example. It once produced iron ax heads that were shipped all over the world.

The landscape around iron furnaces was eventually stripped bare of trees. Only open clear cuts were left.

The tanning industry also relied heavily on the use of trees. Tree bark provided the tannin that was used to "tan" animal hides. The best source for tannin was the bark of eastern hemlocks. The best place to find plenty of hemlocks was northeast Pennsylvania. Counties like Monroe and Pike became the location of several important tanneries. Buffalo hides were brought from the West to these tanneries. By the mid-1800s, the Pocono region became the second largest leather producer in America. That's how places like Tannersville, in Monroe County, got its name. Eventually the areas around the tanneries also ran out of trees. By the 1800s, much of the landscape in northeastern Pennsylvania was deforested.

The lumber industry took advantage of the central portion of the state. This area was still heavily forested. But transporting large logs from these remote areas was a problem. The solution was

splash dams. They were built on small mountain streams to impound and stop the flow of water. Trees were pulled to the empty streambed, the dam was opened and water pushed the trees to the next dam. Can you imagine the effect that splash dams had on brook trout habitat? The trees could be transported from remote areas to major rivers, like the Susquehanna and Allegheny.

Booms were constructed on the rivers to catch and hold the logs. Logs were then formed into huge "rafts" and floated downriver to Williamsport, Philadelphia, Harrisburg and even as far away as New Orleans.

Pennsylvania's lumber industry also had an important place in history. Take, for instance, Williamsport, which had many sawmills. It became the world's largest lumber producer by 1880.

Stream and river habitats

By the late 1800 to early 1900s, almost all areas of Pennsylvania had been cut at least once. Forest cutting up to this time was not really managed with sustainability in mind. Environmental effects were not considered. The effect of logging on streams and rivers was not even considered. Loggers would move on to a new area once the trees were cut. The result was that our stream and river habitats were degraded. So was the water quality. Without trees for shade, water temperatures rose. The higher temperatures became too stressful for brook trout. There was no vegetation to hold the soil. Erosion washed silt into prime spawning habitat. The silt covered the gravel and made it impossible for brook trout to reproduce. The aquatic insects that brook trout feed on could not survive. Shelter in the form of tree roots was lost. The result was that native brook trout populations were depleted from much of their original range.

Depleted fish populations brought about concern. The aristocracy of the New World enjoyed sport fishing, but there were no fish! Their solution to the problem was to stock new fish. There was little thought about restoring or improving habitat. They believed that stocking fish would bring back good populations. It also gave them an opportunity to duplicate the species that they once caught in their homeland -- Europe. So they brought in carp during the mid-1800s. Smallmouth bass were introduced from the Potomac River. They were released into the Delaware and Susquehanna rivers during the 1870s. Brown trout from Europe were introduced in the late 1800s.

Rainbow trout were eventually transferred from western North America to the East Coast. Brown, rainbow and brook trout were raised in hatcheries and then released into the wild.

Little did they know that they were providing a source of competition for the native brook trout. When they co-exist in the same habitat, brown trout compete with brook trout for resources.

Lessons from the past

Today things are much different. We have learned many lessons from the past. The way we go about managing and protecting Pennsylvania's forests and waters has improved. Forestry practices have changed and many important habitat management methods have been learned over the years. Landscape ecology is evaluated before cutting forests. In most cases, forests are no longer clear-cut. Cutting rotations are ecologically based and managed more carefully.

Timbered areas are replanted after trees are removed. Some mature trees are left standing to act as a seed stock for new trees. Vegetation buffers are left along streambanks and roads. Buffers minimize the effects of logging operations. These techniques result in healthier forests. They also result in better water quality.

The way in which we manage fisheries in Pennsylvania has also changed. The Fish & Boat Commission follows a plan for streams and rivers that are cold enough to hold trout. Waters are grouped as "wild" or "hatchery-supported." There are several criteria that fisheries biologist use. A wild trout fishery must also be able to sustain a naturally reproducing population of wild trout. It must provide adequate habitat. These waters are labeled "Class A Wild Trout Waters" and are not stocked. In this way, wild brook trout are managed more like a renewable natural resource.

Streams that cannot support wild trout are stocked with hatchery-raised trout. Stocking provides the opportunity for anglers to catch a trout, in a stream that would normally not allow them to reproduce on their own. Chances are there is a hatchery-supported trout stream only minutes from your home.

Riparian buffers

Habitat protection and enhancement play an important support role in fisheries management. A focal point for protecting and enhancing aquatic habitats is riparian buffers. A riparian buffer is a zone of trees and vegetation between water and an upland area. Riparian buffers are important to the health of a stream. They shade the water, stabilize banks and intercept surface runoff. Studies show that water temperature is 10 degrees cooler in streams that are lined with buffers. They purify runoff by trapping sediment, fertilizers and pollution. They even provide food in the form of leaf litter for aquatic insects. The insects in turn are food for forage fish and trout. Ultimately, we can improve fish populations if we protect and enhance riparian buffers.

The Commission, along with other agencies, also protects habitat through laws and regulations. People who want to alter a stream or river in any way must apply for a special permit. The request is reviewed to make sure that the habitat will not be degraded. The Commission enforces habitat protection laws that are broken.

The Commission is also involved with many stream and river enhancement projects through its Adopt-a-Stream Program. This program is one of the ways in which individuals and organizations can help. It's a cooperative effort that improves and protects aquatic and riparian habitats. The program provides assistance for those willing to donate time and effort toward waterway protection and enhancement. Projects might include fish habitat restoration, stream corridor management and stabilization projects.

Environmental conditions in Pennsylvania are much improved. Our forests and waters have rebounded thanks to the efforts of many agencies, organizations and individuals. Hardwood forests now cover nearly 60 percent of the Commonwealth. These forests protect more than 25,000 miles of streams and provide clean water for aquatic animals. Around 13,000 miles of streams are clear and cold enough to support trout. Wild brook trout populations have also improved. Their numbers and dispersal in watersheds isn't what it was before the 1600s. Nevertheless, they can once again be found over much of the terrain they once inhabited.

(Rettew, 2004)

The above article by Walt Dietz provides good background information on what land-use conditions must have been like in the Upper Bushkill Creek Watershed.

General recommendations supported by the Pennsylvania Fish and Boat Commission for small wild trout streams include:

1. The Pennsylvania Fish and Boat Commission should continue to manage wild brook trout fisheries under conventional, statewide angling regulations with no stocking.

2. The Pennsylvania Fish and Boat Commission should continue to sample the wild trout populations to monitor the effects of stream sedimentation and low flow on trout abundance, and to learn more about natural variations in brook trout abundance.

3. Corrective measures should be taken to reduce man-related sources of sedimentation in the drainage basin. Stream sedimentation conditions have clearly worsened in recent years due to increased development within the Upper Bushkill Creek Watershed.

4. Efforts by Bushkill and Moore Townships and the Pennsylvania Department of Transportation to address problems associated with runoff and erosion from roads adjacent to the stream through the Department of Environmental Protection's Dirt and Gravel Road Program should be pursued. Additionally, other drainage improvements and roadway management practices should be undertaken as necessary to prevent further sedimentation from roadways within the Upper Bushkill Creek Watershed.

CONCLUSIONS

1. Many of the headwater streams within the Upper Bushkill Creek Watershed appear to meet the regulatory criteria and definitions for Exceptional Value streams under Chapter 93 of Title 25 of the Pennsylvania Code. Macroinvertebrate samples collected for Sobers Run yielded results which met or exceeded the biological standards required for Exceptional Value designation. Due to severe storms and excessively high streamflows, additional monitoring would be necessary for the Sobers Run stations (including West Branch Sobers Run) to more accurately determine the most appropriate Chapter 93 water quality designation. Macroinvertebrate samples collected at the stations along the Bushkill Creek upstream of Jacobsburg State Park best classified the stream reaches as High Quality Coldwater, but that the results of the sampling warrant further sampling and consideration by the Pennsylvania Department of Environmental Protection for possible upgrade to Exceptional Value classification. Comparison to an appropriate "reference reach" would be necessary for a final determination.

2. Sobers Run, including the West Branch Sobers Run, meets the regulatory criteria and definitions as an Exceptional Value stream under Chapter 93 of Title 25 of the Pennsylvania Code. Portions of the Sobers Run main stem (upstream of Kromer Road in Bushkill Township) meet the biological and water quality standards, while other sections qualify as having significant local resource value.

3. The entire Upper Bushkill Creek Watershed is not currently as well-protected by local land-use regulations (e.g. municipal ordinances) as it should be from future impacts of land-use change and development. Natural resource protection improvements are planned as part of the Nazareth Area Council of Governments Multi-municipal Comprehensive Plan, but are not yet developed or enacted.

4. The greatest threat to the wetlands and watercourses in the Upper Bushkill Creek Watershed is from imminent land-use change and development, even in accordance with current zoning, land development, and other municipal ordinances. Stormwater runoff (quantity and quality) likely represents the greatest threat from such development, but other impacts such as well water withdrawals, surface water intakes, use of pesticides, use of fertilizers, and other point and non-point source impacts commonly associated land development and sprawl also represent serious concerns. Stormwater runoff introduces sediments, nutrients, and other pollutants from adjacent land. Increased runoff volumes cause streambank and streambed erosion which further introduces unnecessary sediments and nutrients.

5. The existing wooded riparian corridors along headwater wetlands, feeder streams, and riparian corridors protect the streams from thermal impacts by creating a dense shaded canopy. These riparian woodlands also help to filter pollutants from stormwater runoff from agricultural and urban land-uses in adjacent cleared areas. Therefore, the riparian woodlands should be protected to the maximum extent possible from degradation.

6. Headwater areas at the base of the Blue Mountain Ridge, where high and seasonally high water tables exist and feeder streams originate, there are many existing residential units on smaller lots with substandard and/or failing septic systems. To exacerbate this problem, most lots are too small to accommodate conventional replacement septic systems, relegating owners to install on-lot treatment systems, many which have stream discharges for treated effluent. Nutrients and pathogens associated with effluent discharges represent future impacts to the water quality and coldwater habitat currently supported by the streams within the Upper Bushkill Creek Watershed.

7. Future surface water and groundwater withdrawals for community water systems, water wholesaling, and other uses represent considerable potential threats for the health of local wetlands and streams, especially the smaller streams which have been found to support sustaining populations of wild native brook trout.

8. Sustaining native brook trout populations have been observed in headwater streams throughout the Upper Bushkill Creek Watershed through a formal professional study (see Appendix D). The healthiest populations were observed in old growth forest areas with timber estimated to be 100 to 200 years old, or older.

9. An overall assessment of the available data indicates that preservation and restoration of riparian woodlands must be a priority to maintain and improve coldwater habitats. Conservation easements are recommended for all riparian areas throughout the Upper Bushkill Creek Watershed, with provisions that limit, and preferably prohibit, vegetation cutting and other disturbance to natural conditions. Municipal ordinances, which may include considerable conservation provisions, may not prohibit forestry activities. Conservation easements, however, may be established with limitations or prohibition on forestry, vegetation clearing, and other disturbance to natural conditions (into perpetuity).

10. All stream sections where sustaining populations of native brook trout were observed were within mature, old-growth forest areas with considerable woody debris, such as fallen trees overhanging trees and shrubs.

11. The majority of land within the Upper Bushkill Creek Watershed, from the base of the Blue Mountain Ridge southward, is privately owned and subject to resource management and land-use in accordance with current regulations that do not provide for optimal resource protection. Land development occurring under these regulations, in the worst case scenario, would result in considerable water quality impacts and habitat loss for coldwater and other species.

12. The private ownership of lands within the Upper Bushkill Creek Watershed, combined with relatively difficult fishing conditions and limited fishing potential, should preclude heavy fishing pressure and should help protect native brook trout populations. Similarly, naturally reproducing brown trout populations in the lower portion of the Upper Bushkill Creek Watershed should experience similar protection.

13. The Upper Bushkill Creek Watershed contains several utility line rights-of-way for current and potential future water, gas, and electric utility lines. All such lines require considerable soils disturbance for installation and maintenance, and all result in intensive vegetation management with chemical herbicides and/or mechanical clearing. Installation and maintenance activities impact the local wetlands and streams through thermal, sediment, and nutrient pollution. PPL owns a currently undeveloped right-of-way for an above-ground powerline corridor which bisects the entire Upper Bushkill Creek Watershed. This right-of-way was recently contemplated for development, but was not selected in favor of a more cost-effective and less impactful route. PPL maintains the right, however, to reconsider the development, use, and maintenance of this right-of-way to meet future electric transmission needs.

14. The Upper Bushkill Creek Watershed contains three important natural areas which are directly associated with headwater streams and wetland areas, including Knecht's Ponds, Rissmiller's Woods, and the Moorestown Wetlands.

RECOMMENDATIONS

The following recommendations are made to best preserve and protect the Upper Bushkill Creek, including Sobers Run and West Branch Sobers Run, as high quality and exceptional value coldwater streams:

1. Upgrade the entire Sobers Run basin to Exceptional Value classification under section 4.2C (Outstanding national, state, regional, or local resource water) of Chapter 93 - Water Quality Standards, Title 25 of the Pennsylvania Code. This upgrade is necessary to best protect the stream from both point and non-point source discharges, as well as to best control encroachments on the stream channel. A petition has been completed and filed with the Pennsylvania Department of Environmental Protection, supporting the upgrade based on significance as an "outstanding national, state, regional or local resource water," with additional emphasis on the qualification of the uppermost reaches qualifying under the biological criteria and the lowermost reaches being within Jacobsburg State Park. Due to the lengthy petitioning process and the high development potential in the region, it is strongly recommended to also pursue the appropriate upgrades using the biological criteria through the local, Northeast Regional Office of the Pennsylvania Department of Environmental Protection (PADEP). **The petition was completed by the Delaware &**

Lehigh National Heritage Corridor, in cooperation with a partnership of Bushkill Stream Conservancy, Bushkill Township (EAC/Supervisors), Jacobsburg Environmental Education Center, Forks of the Delaware Trout Unlimited Chapter, Lafayette College (physical and chemical data), and Muhlenberg College (biological data), as well as other Conservancy partners. Upgrades based on biological criteria should be completed by the Pennsylvania Department of Environmental Protection.

2. Upgrade Bushkill Creek, from Jacobsburg State Park to the headwaters, to Exceptional Value classification under section 4.2C (Outstanding national, state, regional, or local resource water) of Chapter 93 - Water Quality Standards, Title 25 of the Pennsylvania Code. This upgrade is necessary to best protect the stream from both point and non-point source discharges, as well as to best control encroachments on the stream channel. This upgrade is also necessary to protect and preserve the Bushkill Creek within Jacobsburg State Park and Environmental Education Center, for which it is a focal point for environmental education, recreation, and wildlife habitat. A petition should be completed and filed with the Pennsylvania Department of Environmental Protection, supporting the upgrade based on significance as an "outstanding national, state, regional or local resource water," with additional emphasis on the qualification of the uppermost reaches qualifying under the biological criteria and the lowermost reaches being within Jacobsburg State Park. Due to the lengthy petitioning process and the high development potential in the region, it is strongly recommended to also pursue the appropriate upgrades using the biological criteria through the local, Northeast Regional Office of the Pennsylvania Department of Environmental Protection (PADEP). **The petition should be completed by the Delaware & Lehigh National Heritage Corridor, in cooperation with a partnership of Bushkill Stream Conservancy, Bushkill and Moore Townships (EAC/Supervisors), Jacobsburg Environmental Education Center, Forks of the Delaware Trout Unlimited Chapter, Lafayette College (physical and chemical data), and Muhlenberg College (biological data), as well as other applicable Conservancy partners. Upgrades based on biological criteria should be completed by the Pennsylvania Department of Environmental Protection. The Bushkill Stream Conservancy, in cooperation with Bushkill Township and Forks of the Delaware Trout Unlimited Chapter, should support any qualifying upgrades through formal petition or other appropriate measures.**

3. Conduct additional macroinvertebrate monitoring for all of the prior stations monitored on Sobers Run and West Branch Sobers Run during 2005 and 2006, including an appropriate reference reach, to make a final determination on the appropriate Chapter 93 water quality designations at the various stations and stream reaches. To the extent possible, monitoring should be conducted under normal conditions. Upgrades from High Quality – Cold Water Fisheries to Exceptional Value should be made, accordingly. **Monitoring should be conducted by the Pennsylvania Department of Environmental Protection. The Bushkill Stream Conservancy, in cooperation with Bushkill Township and Forks of the Delaware Trout Unlimited Chapter, should support any qualifying upgrades through formal petition or other appropriate measures.**

4. Conduct additional macroinvertebrate monitoring for all of the prior stations monitored on Bushkill Creek upstream of East Douglasville Road within Jacobsburg State Park during 2006, including an appropriate reference reach, to make a final determination on the appropriate Chapter 93 water quality designations at the various stations and stream reaches. To the extent possible, monitoring should be conducted under normal

conditions. Upgrades from High Quality – Cold Water Fisheries to Exceptional Value should be made, accordingly. **Monitoring should be conducted by the Pennsylvania Department of Environmental Protection. The Bushkill Stream Conservancy, in cooperation with Bushkill Township and Forks of the Delaware Trout Unlimited Chapter, should support any qualifying upgrades through formal petition or other appropriate measures.**

5. Educate riparian landowners and local citizens with regards to the resource values of the streams and the headwaters wetlands, spring seeps, and vernal ponds that form and feed the streams within the Upper Bushkill Creek Watershed. Such education, including the specific roles that the riparian landowners and local citizens play, will be a critical step towards achieving the necessary stewardship to protect the streams and wetlands into the future. **This task should be completed by Bushkill Stream Conservancy (Stream Keeper Program), Bushkill and Moore Township EACs, Forks of the Delaware Trout Unlimited Chapter, and Jacobsburg Environmental Education Center.**

6. Monitor and restore streams and riparian corridors within the entire Upper Bushkill Creek Watershed. **This task should be completed by the Bushkill Stream Conservancy, working in conjunction with Bushkill and Moore Townships and their respective EACs.**

7. Improve maintenance of trails within Jacobsburg State Park and implement Best Management Practices and proper maintenance for proposed trails connecting Jacobsburg State Park to the old rail line rights-of-way to the north (waterbars, blockades for vehicular traffic, limited use conditions, etc.). **This task should be completed by Jacobsburg Environmental Education Center/State Park (maintenance crew), along with possible assistance by area mountain bike and equestrian groups and individuals.**

8. Improve and restore riparian buffers along the streams within the Upper Bushkill Creek Watershed where buffers have been impacted by past clearing and development activities. The riparian buffer study and mapping prepared for the Upper Bushkill Creek Watershed by Heritage Conservancy should be used to target impacted riparian areas for restoration. **This task should be completed through the direction and supervision of Bushkill Stream Conservancy, Forks of the Delaware Trout Unlimited Chapter, and Bushkill and Moore Township EACs, as well as by respective landowners along the streams within the Upper Bushkill Creek Watershed. Landowner permission and funding should be secured by the Townships. Smaller restoration projects may be completed by qualified volunteers. Larger restoration projects may require paid professionals. Grant funding for such projects should be sought under the Pennsylvania Growing Greener Program, Lehigh Valley Greenways Initiative, and other potential sources.**

9. Correct the numerous streambank erosion problems along the streams within the Upper Bushkill Creek Watershed using a combination of structural and bioengineering. **This task should be completed through the direction and supervision of Bushkill Stream Conservancy, the Pennsylvania Fish & Boat Commission Habitat Specialist, Forks of the Delaware Trout Unlimited Chapter, and Bushkill Township EAC, as well as by respective landowners along the streams within the Upper Bushkill Creek Watershed. Grant funding for such projects should be sought under the**

Pennsylvania Growing Greener Program, Lehigh Valley Greenways Initiative, the Pennsylvania Fish & Boat Commission's "Adopt-a-Stream" Program, Trout Unlimited's "Embrace-a-Stream" Program, and other potential sources.

10. Adopt the most feasible, stringent stormwater management regulations as part of Act 167 stormwater management planning to protect the streams within the Upper Bushkill Creek Watershed from both water quality and quantity degradation problems. **This task should be completed by Bushkill Township EAC/Supervisors with technical assistance from the Lehigh Valley Planning Commission.**

11. Bushkill and Moore Townships should make appropriate changes within their Subdivision and Land Development Ordinance (SALDO) and Zoning Ordinance, as well as other environmental protection ordinances to best protect Bushkill Creek, Sobers Run, and West Branch Sobers Run from degradation. Zoning changes should be consistent with the Nazareth Area 2030 Multimunicipal Comprehensive Plan. **This task should be completed by the respective Townships' EACs, Planning Commissions and Boards of Supervisors, with technical assistance from the Lehigh Valley Planning Commission.**

12. The wetlands, vernal ponds, spring seeps, and other water features throughout the Upper Bushkill Creek Watershed should be mapped using hyperspectral imagery. This imagery may be use to create an invaluable Geographic Information Systems data layer that may be effectively used by the Bushkill Township Planning Commission and Environmental Advisory Council to review site development plans. **This task should be completed by Bushkill Stream Conservancy through grant funds sought through the Pennsylvania Growing Greener Program, Lehigh Valley Greenways Initiative, and other potential sources. Wetlands mapping produced should be provided to Bushkill and Moore Townships, as well as to Northampton County and the Lehigh Valley Planning Commission for use during review of land development plans.**

13. Bushkill Creek, Sobers Run, and West Branch Sobers Run should be monitored for all pertinent physical, chemical, and biological parameters. A minimum of three stations should be established on each stream; one on the main stems within Jacobsburg State Park and the others located further upstream along major tributaries. The stations established for temperature monitoring as part of this study may be optimal locations for long-term monitoring of general water quality and discharge conditions. Physical parameters should include temperature, flow (discharge), and dissolved oxygen. Chemical parameters should include phosphorus (dissolved and total), nitrogen series (ammonia, nitrate/nitrite, total Kjeldahl nitrogen, and total nitrogen), total suspended solids (and/or turbidity), pH, and conductivity. Biological parameters should include periphytin (attached algae), macrophytes (rooted aquatic vascular plants), macroinvertebrates (in accordance with EPA Rapid Bioassessment Protocol), and fish (every three to five years). Monitoring frequency for physical and chemical parameters should be monthly. Periphytin and macrophyte monitoring frequency should be at least one time, annually. Fish surveys should be completed as often as funding will permit to optimize the potential for management actions. **This task should be completed by volunteer monitorers from Lafayette College, Jacobsburg Environmental Education Center (working with other groups such as local high schools), Bushkill Stream Conservancy, Trout Unlimited, and the Retired Seniors Volunteer Program (RSVP). Chemical and physical parameters should be monitored Lafayette College**

with assistance from RSVP. Macroinvertebrate monitoring should be conducted by Jacobsburg State Park with assistance from local high schools and other groups. Periphytin and macrophyte monitoring should be completed by Bushkill Stream Conservancy volunteers and Jacobsburg Environmental Education Center staff. Fish surveys should be completed by the Pennsylvania Fish & Boat Commission. Data produced should be entered into a database maintained by Bushkill Stream Conservancy.

14. As is feasible, all 'greenways' and riparian buffers should be identified for preservation on the Bushkill and Moore Township Official Maps, respectively, and should be preserved through procurement of conservation easements (a.k.a. purchase of development rights) and fee-simple purchase, amongst other possible means for land preservation. Additionally, environmentally sensitive lands within the Knecht's Ponds, Rissmiller's Woods, and Moorestown Wetlands natural areas, as well as other natural areas within the Sobers Run watershed, should be identified and targeted for preservation through similar means. Open Space funds are available through both Townships' Open Space Programs, Northampton County's Open Space Program, and the Pennsylvania Department of Conservation and Natural Resources (including the Lehigh Valley Greenways). **This task should be undertaken by Bushkill and Moore Townships, with cooperation by Northampton County and the partners involved in the Lehigh Valley Greenways.**

15. The natural areas designated as Knecht's Ponds, Rissmiller's Woods, and Moorestown wetlands should be added to municipal Official Maps and designated for protection to the extent practicable under municipal land-use regulations. **This task should be undertaken by Bushkill and Moore Townships, led by their respective Environmental Advisory Councils.**

16. The entire Upper Bushkill Creek Watershed should be surveyed by qualified individuals for threatened and endangered species, and their critical habitats, in an effort to best protect the local environment from impacts associated with land-use and development. All survey work should be conducted in accordance with standard methodology and protocols so that all species are adequately protected as part of the survey work. Results from survey work should be provided to the Pennsylvania Natural Heritage Program as data collection and documentation proceeds. **This task should be undertaken by qualified and trained volunteers, with landowner permission secured for private properties. State Gamelands may be evaluated without formal permission. The Township and Bushkill Stream Conservancy should obtain qualifying grants to fund survey work by qualified botanists, if possible.**

17. Utility line corridors should be monitored for invasive exotic species two to three times annually. All occurrences should be promptly treated. **Monitoring, and possibly treatment, should be completed by Bushkill and Moore Township EACs, with permission secured from the pipeline companies. Assistance may be provided by trained volunteers from the Bushkill Stream Conservancy and other interest groups and individuals. If necessary, treatment should be provided by the pipeline companies.**

18. Municipalities should require monitoring and treatment plans and implementation to the extent possible as part of approvals required for installation of new utility lines and maintenance of existing lines. **That task should be undertaken by Bushkill and Moore Townships, with input on plan development by their respective EACs.**

19. Native brook trout restoration and habitat projects, including projects which would prevent upstream migration of brown trout into highly sensitive brook trout habitat, should be completed throughout the Upper Bushkill Creek Watershed, in collaboration with the Eastern Brook Trout Joint Venture, Pennsylvania Fish & Boat Commission, and Trout Unlimited. **This task should be completed at the direction of the Forks of the Delaware Trout Unlimited Chapter with assistance from Bushkill Stream Conservancy and other watershed partners, including the Upper Bushkill Stocking Association. The Pennsylvania Fish & Boat Commission Areas 5 and 6 Fisheries Management Offices and the Coldwater Unit should be kept apprised of all proposed in-stream projects and activities (funding and assistance may also be available).**

20. Conduct trout redd surveys on stream segments of Bushkill Creek and Sobers Run using protocols set forth by the Pennsylvania Fish & Boat Commission. The primary purpose of redd surveys is to identify and protect critical spawning habitat. Suggested stream segments include Bushkill Creek sites #1 (brook trout) and #2 (mixed brook and brown trout), Sobers Run site #1 (brook trout) and Sobers Run at Jacobsburg Environmental Education Center (brown trout), as surveyed by Lance Leonhardt during 2007 (see Appendix D). **The surveys should be conducted by the Forks of the Delaware Trout Unlimited Chapter, with assistance from the Jacobsburg Environmental Education Center and Bushkill Stream Conservancy.**

21. Stakeholders within the Upper Bushkill Creek Watershed should evaluate the currently undeveloped PPL powerline right-of-way to determine the means necessary to protect riparian corridors and stream channels from thermal, sediment, and nutrient pollution which would otherwise result from new powerline installation and maintenance, as well as associated use impacts (e.g. all-terrain vehicle, mountain bike, equestrian use of powerline corridor). **This task should be completed by the Bushkill and Moore Township EACs, with input and assistance by Bushkill Stream Conservancy and other project partners.**

22. The use of synthetic pesticides within the Upper Bushkill Creek Watershed should be prohibited under municipal ordinances. **This task should be completed by Bushkill and Moore Townships with the necessary input and assistance by their respective EACs and by the Bushkill Stream Conservancy.**

23. Moore Township should form an Environmental Advisory Council (EAC) to assist with protection of headwater stream and wetlands, as well as riparian woodlands and other important natural areas which protect the water quality of Bushkill Creek and other streams and water resources within Moore Township. **This task should be completed by the Moore Township Board of Supervisors, with support provided by Bushkill Township, Bushkill Stream Conservancy, and other watershed partners.**

24. Moore Township should implement an Official Map similar to Bushkill Township's, including all riparian woodlands (using LVPC streams mapping) and 150 ft riparian buffers (along USGS mapped streams) designated for protection and/or restoration. **This task should be completed by Moore Township, with guidance, mapping, and support provided by their EAC. Assistance and guidance should also be provided by Bushkill Township, especially with regard to application and enforcement of the Official Map provisions.**

25. Bushkill and Moore Townships should adopt ordinances protecting the Appalachian Trail, as such measures would also help to protect headwater wetlands and streams throughout the Upper Bushkill Creek Watershed. **This task should be completed by Bushkill and Moore Townships with the necessary input and assistance by their respective EACs, and in conformance with State mandated regulations and guidance being developed for protection of the Appalachian Trail.**

26. Bushkill and Moore Townships should adopt the most stringent forestry management ordinances allowable to protect headwater wetlands and streams, as well as wooded riparian corridors from direct and indirect impacts commonly associated with forestry operations. At a minimum, approval of erosion and sedimentation pollution control plans by the Northampton County Conservation District should be required for all forestry operations. **This task should be completed by Bushkill and Moore Townships with the necessary input and assistance by their respective EACs.**

27. Bushkill and Moore Townships should focus Open Space funding on acquisition of conservation easements in headwater areas to better manage growth and development, and specifically to prevent future tree cutting, logging, and timber harvesting (under easement). **This task should be completed by Bushkill and Moore Townships, with guidance by their respective EACs and the Moore Township Farmland Preservation Board.**

28. Failing septic systems within the Upper Bushkill Creek Watershed should be replaced with the appropriate DEP approved replacement systems. Land-based application of treated effluent should be implemented whenever possible, with stream discharge being used only when no alternatives exist. Small constructed wetlands should be installed as part of stream discharges to allow final polishing of treated effluent before entering the stream channel. DEP has approved this practice as a non-regulated activity, therefore making it voluntary. Construction costs for the wetland component, as part of the overall system installation, are relatively low and could either be funded by the landowner or the Township. Grants should be sought whenever available to pay for installation. **This task should be completed by Bushkill and Moore Townships, with assistance, guidance, and input by the Township EACs.**

29. Stream clean-up projects should be conducted to the extent practicable. **This task should be completed by all watershed partners on an ongoing basis. At a minimum Earth Day activities should focus on a full day of stream clean-up on both public and private lands, with the necessary permission obtained. Events should be organized by the Bushkill Stream Conservancy, Pennsylvania Department of Conservation and Natural Resources, Forks of the Delaware Trout Unlimited Chapter, and the Township EACs.**

30. Reduce creel limits or increase minimum length requirements for salmonids. **This task should be spearheaded by the Forks of the Delaware Trout Unlimited Chapter and Bushkill Stream Conservancy with support from all other local partners. The Pennsylvania Fish and Boat Commission would need to evaluate proposed stream sections for qualification and implementation into a Special Regulation program deemed appropriate by the Commission to protect the resource while enhancing angling opportunities.**

31. Stream reaches north of Route 512 should be regulated as "catch-and-release" only. **This task should be spearheaded by the Forks of the Delaware Trout Unlimited Chapter and Bushkill Stream Conservancy with support from all other local partners. The Pennsylvania Fish and Boat Commission would need to evaluate proposed stream sections for qualification and implementation into a Special Regulation program deemed appropriate by the Commission to protect the resource while enhancing angling opportunities.**

32. Stocking of warmwater and coldwater fish species should be discouraged throughout the entire Upper Bushkill Creek Watershed. All reaches of the Bushkill Creek and its tributaries have been found to contain naturally reproducing wild trout species, and through better management a healthy sustaining population could be maintained while providing a high quality sport fishery. **This task should be completed at the direction of the Forks of the Delaware Trout Unlimited Chapter and Bushkill Stream Conservancy with support from all other local partners.**

33. Native brook trout populations should be protected by all feasible and practicable means. Remaining brook trout habitat is extremely fragile and is not likely to withstand additional impacts associated with land-use changes and development. **This task should be completed through input and action by several interest groups. Bushkill and Moore Townships should revise and enact strict ordinances which are protective of the streams and their headwater wetlands. Minimum 100-ft buffers are recommended for all stream channels (as measured from the Ordinary High Water Mark along streambanks) and wetlands (as measured from the professionally delineated wetlands boundary line).**

34. Whenever possible, existing ponds within the Upper Bushkill Creek Watershed should be breached and restored to streams with riparian corridors. Alternatively, surrounding riparian land should be restored to natural conditions, providing shade to ponds and lessening thermal impacts to receiving streams. **This task should be completed at the direction of the Bushkill Stream Conservancy and Trout Unlimited, with support by the respective Townships and other interest groups and individuals.**

35. Sub-watershed 420719 should be relisted as 'not extirpated' for wild native brook trout and a new CSI assessment should be requested. **This task should be completed at the direction of Trout Unlimited – Forks of the Delaware Chapter, with necessary survey work completed by the Pennsylvania Fish and Boat Commission, with support by the respective Townships and other interest groups and individuals.**

APPENDIX A

Sobers Run Macroinvertebrate Data

(Pennsylvania Department of Environmental Protection, 2005)

TABLE 1
STATION LOCATIONS
SOBERS RUN BASIN SURVEY (01F)
NORTHAMPTON COUNTY

STATION	LOCATION
1SR	Sobers Run (04646): 40 meters upstream of T615 bridge crossing. Bushkill Township, Northampton County Lat: 40 49 14.9 Long: 75 18 40.9 RMI: 2.88 Date: 4/19/05
2SR	Sobers Run (04646): 25 meters upstream of footbridge near confluence with Bushkill Creek. Bushkill Township, Northampton County Lat: 40 47 9.7 Long: 75 18 11.3 RMI: 0.11 Date: 4/19/05
1USR	Unt Sobers Run (04647): 250 meters upstream of SR0512 bridge crossing. Bushkill Township, Northampton County Lat: 40 49 3.0 Long: 75 19 51.9 RMI: 2.46 Date: 4/19/05
2USR	Unt Sobers Run (04647): 15 meters upstream of T611 bridge crossing Bushkill Township, Northampton County Lat: 40 48 17.4 Long: 75 19 34.0 RMI: 1.46 Date: 4/19/05
3USR	Unt Sobers Run (04648): 25 meters upstream of SR0512 bridge crossing. Bushkill Township, Northampton County Lat: 40 48 47.7 Long: 75 20 3.4 RMI: 0.36 Date: 4/19/05
R1	Wild Creek (03959) reference station: 75 m upstream of SR1001 bridge crossing. Penn Forest Township, Carbon County Lat: 40 56 24.6 Long: 75 35 5.4 RMI: 6.38 Date: 4/19/05

FIGURE 1. SOBERS RUN STATION LOCATIONS.

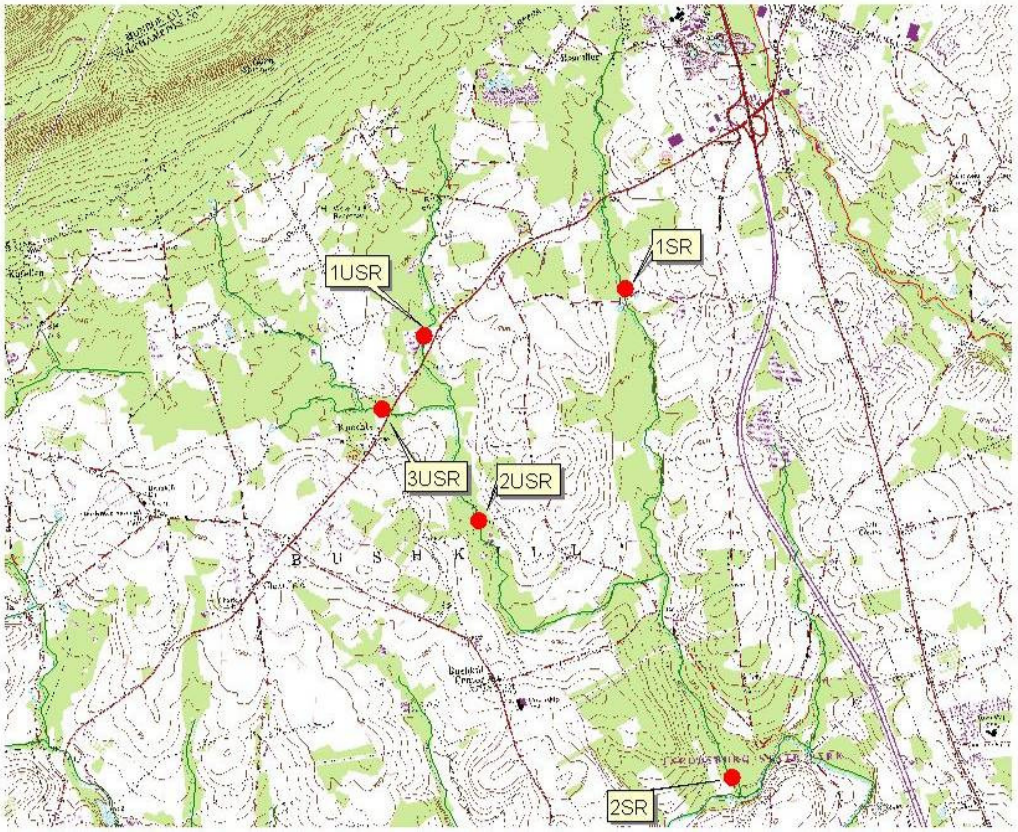


TABLE 2. SEMI-QUANTITATIVE BENTHIC MACROINVERTEBRATE DATA AND RBP METRIC COMPARISONS: SOBERS RUN WATERSHED, NORTHAMPTON COUNTY, APRIL 19, 2005.

		1WC (REF)	1SR	2SR	1USR	2USR	3USR
MAYFLIES							
Baetidae	***Baetis***	15	14	12	4	12	14
Ephemerellidae	***Drunella***		2	35	5	8	1
	Ephemerella	24	43	49	20	15	35
	Serratella	2					
Heptageniidae	***Epeorus***	11	26	9	3	3	4
	Stenonema	5	1	9	6	8	1
Isonychiidae	***Isonychia***			1			
Leptophlebiidae	***Paraleptophlebia***	6	2			1	8
STONEFLIES							
Chloroperlidae	***Sweltsa***	1					
Leuctridae	***Leuctra***	6	2		1	1	1
Nemouridae	***Amphinemura***	10	3	6	22	20	32
Perlidae	***Acroneuria***	3		6	1	1	1
Perlodidae	***Isoperla***	12	1	4		6	9
	Remenus				1		
Pteronarcyidae	***Pteronarcys***	3	1				
CADDISFLIES							
Brachycentridae	***Micrasema***	1				4	
Glossosomatidae	***Agapetus***				2		
Hydropsychidae	***Cheumatopsyche***	6			4	7	
	Diplectrona	1	6			1	
	Hydropsyche	9	3	7	8	14	1
Hydroptilidae	***Stactobiella***					2	
Philopotamidae	***Chimarra***				4	3	
	Dolophilodes	12			1	1	
Polycentropodidae	***Polycentropus***	1					
Rhyacophilidae	***Rhyacophila***	6	6	6	3	5	5
TRUE FLIES							
Ceratopogonidae	***Probezzia***		1			1	
Chironomidae	***sp.***	41	69	34	60	54	92
Empididae	***Chelifera***		1		1	1	1
	Clinocera			1		1	
	Hemerodromia			3	3	1	1
Simuliidae	***Prosimulium***	1	3	2	26	7	3
	Simulium	3	35	16	36	12	3
	Stegopterna				1		2
Tipulidae	***Antocha***					1	1
	Dicranota	4	1				1
	Hexatoma	4	1	1			
	Limonia					1	

	Tipula		1				
BEETLES							
Dryopidae	***Helichus***					1	
Elmidae	***Dubiraphia***					1	1
	Microcylloepus			1			
	Optioservus		1			4	
	Oulimnius	6		2	1	6	14
	Promoresia	6	1	1	1	9	
	Stenelmis					1	
Psephenidae	***Ectopria***			1			1
	Psephenus		2	5			
Ptilodactylidae	***Anchytarsus***	4					
MISC. INSECT TAXA							
Cordulegasteridae	***Cordulegaster***	1					
Corydalidae	***Nigronia***	5	1				
Gomphidae	***Lanthus***	1	3	2		2	2
NON-INSECT TAXA							
Cambaridae	***Cambarus***			2		1	1
Hydracarina	***sp.***	1	1			1	
Oligochaeta	***sp.***			1	1	2	1
Subsample Size		211	231	216	215	219	236
T Rich.		31	27	25	24	37	26
score (c/r)		n/a	87%	81%	77%	119%	84%
bc score		**8**	**8**	**8**	**7**	**8**	**8**
mEPT		15	11	9	12	15	10
score (c/r)		n/a	73%	60%	80%	100%	67%
bc score		**8**	**6**	**3**	**7**	**8**	**4**
mHBI		3.13	3.70	3.03	4.15	4.11	4.10
score (c-r)		n/a	0.57	-0.1	1.02	0.98	0.97
bc score		**8**	**8**	**8**	**4**	**4**	**5**
%Dom		19.4	29.9	22.7	27.9	24.7	39
score (c-r)		n/a	10.5	3.3	8.5	5.3	19.6
bc score		**8**	**8**	**8**	**8**	**8**	**2**
m %Mayfly		22.7	32	47.7	15.8	16	20.8
score (r-c)		n/a	-9.3	-25	6.9	6.7	1.9
bc score		**8**	**8**	**8**	**8**	**8**	**8**
TOTAL SCORE		**40**	**38**	**35**	**34**	**36**	**27**
Comparison to Reference		n/a	95%	88%	85%	90%	68%
Ch 93 Designated Use		EV	HQ	HQ	HQ	HQ	HQ
Existing Use		n/a	EV	HQ	HQ	HQ	CWF

TABLE 3. BIOLOGICAL CONDITION SCORING COMPARISONS, SOBERS RUN WATERSHED, NORTHAMPTON COUNTY, APRIL 19, 2005.

METRIC	STATIONS					
	1SR	2SR	1USR	2USR	3USR	R1
1. TAXA RICHNESS	27	25	24	37	26	31
Cand/Ref (%)	87	81	77	119	84	
Biol. Cond. Score	8	8	7	8	8	8
2. MOD. EPT INDEX	11	9	12	15	10	15
Cand/Ref (%)	73	60	80	100	67	
Biol. Cond. Score	6	3	7	8	4	8
3. MOD. HBI	3.70	3.03	4.15	4.11	4.10	3.13
Cand-Ref	0.57	-0.10	1.02	0.98	0.97	
Biol. Cond. Score	8	8	4	4	5	8
4. % DOMINANT TAXA	29.9	22.7	27.9	24.7	39	19.4
Cand-Ref	10.5	3.3	8.5	5.3	19.6	
Biol. Cond. Score	8	8	8	8	2	8
5. % MOD. MAYFLIES	32	47.7	15.8	16	20.8	22.7
Ref-Cand	-9.3	-25	6.9	6.7	1.9	
Biol. Cond. Score	8	8	8	8	8	8
TOTAL BIOLOGICAL CONDITION SCORE	38	35	34	36	27	40
% COMPARABILITY TO REFERENCE	**95**	**88**	**85**	**90**	**68**	N/A

Macroinvertebrate Sample Summary

version: 3.0 3/4/2009 12:14:40 PM

Assessment ID:	54450
Station ID:	20050419-1220-TLD (Latitude: 40.8212, Longitude: -75.3116)
Method:	6-Dframe Composite, 200 subsample
Location:	40 m ups of T615 bridge. Windgap Quad Bushkill Twp. Northampton Co.

Metrics:

Total # Organisms: 230	Hilsenhoff: 3.69	%EPT: 48	FCPRSH: 16
Taxa Richness: 26	Beck3: 25	Beck4: 27	Modified %EPT: 40
Modified Caddis: 2	EPT: 13	%Mayflies: 38	%Dominant: 30
Caddisfly Taxa: 3	Mayfly Taxa: 6	Modified EPT: 11	Modified %Mayflies: 32
%Intol-Limestone: 43	%Tol-Limestone: 0	%Intol-Freestone: 48	%Tol-Freestone: 52
Shannon Diversity: 2.22			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	14	6
1020600100	Epeorus	26	0
1020600700	Stenonema(old genus)	1	3
1020800200	Drunella	2	1
1020800300	Ephemerella	43	1
1021200500	Paraleptophlebia	2	1
1030200700	Lanthus	3	5
1040100100	Pteronarcys	1	0
1040400100	Amphinemura	3	3
1040500200	Leuctra	2	0
1040801200	Isoperla	1	2
1060200400	Nigronia	1	2
1080400300	Diplectrona	6	0
1080400700	Hydropsyche	3	5
1080500100	Rhyacophila	6	1
1101000200	Psephenus	2	4
1101300600	Optioservus	1	4
1101300900	Promoresia	1	2
1120201500	Probezzia	1	6
1121200100	Chelifera	1	6
1121900400	Tipula	1	4
1121901100	Dicranota	1	3
1121901500	Hexatoma	1	2
1122100400	Prosimulium	3	2
1122100500	Simulium	35	6
1122200000	Chironomidae	69	6

Habitat:

1 Instream Cover:	15	2 Epifaunal Substrate:	17
3 Embeddedness:	18	4 Velocity/Depth Regimes:	14
5 Channel Alterations:	18	6 Sediment Deposition:	18
7 Frequency of Riffles:	18	8 Channel Flow Status:	16

9 Condition of Banks:	15	10 Bank Vegetation:	18	**Total**
11 Grazing or Disruptive:	19	12 Riparian Vegetation:	18	204

Impairment: no impairment data recorded

Insufficient? - Impaired? - Biology Impaired? -
Habitat Impaired? - Rock picks influenced? - Impact Localized? -
Designated Use needs reevaluation? -

Comments:

Land Use: 40 49' 14.9" 75 18' 40.9"
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 3/4/2009 12:19:41 PM

Assessment ID:	54453
Station ID:	20050419-1315-TLD (Latitude: 40.8178, Longitude: -75.3307)
Method:	6-Dframe Composite, 200 subsample
Location:	250 m ups of SR0512 bridge. Windgap Quad Bushkill Twp. Northampton Co.

Metrics:

Total # Organisms: 214	Hilsenhoff: 4.13	%EPT: 40	FCPRSH: 14
Taxa Richness: 23	Beck3: 24	Beck4: 22	Modified %EPT: 32
Modified Caddis: 4	EPT: 15	%Mayflies: 18	%Dominant: 28
Caddisfly Taxa: 6	Mayfly Taxa: 5	Modified EPT: 12	Modified %Mayflies: 16
%Intol-Limestone: 43	%Tol-Limestone: 0	%Intol-Freestone: 49	%Tol-Freestone: 51
Shannon Diversity: 2.33			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	4	6
1020600100	Epeorus	3	0
1020600700	Stenonema(old genus)	6	3
1020800200	Drunella	5	1
1020800300	Ephemerella	20	1
1040400100	Amphinemura	22	3
1040500200	Leuctra	1	0
1040700400	Acroneuria	1	0
1040800900	Remenus	1	2
1080100100	Chimarra	4	4
1080100200	Dolophilodes	1	0
1080400600	Cheumatopsyche	4	6
1080400700	Hydropsyche	8	5
1080500100	Rhyacophila	3	1
1080600200	Agapetus	2	0
1101300800	Oulimnius	1	5
1101300900	Promoresia	1	2
1121200100	Chelifera	1	6
1121200500	Hemerodromia	3	6

1122100400	Prosimulium	26	2
1122100500	Simulium	36	6
1122100600	Stegopterna	1	6
1122200000	Chironomidae	60	6

Habitat:

1 Instream Cover:	16	2 Epifaunal Substrate:	16	
3 Embeddedness:	18	4 Velocity/Depth Regimes:	16	
5 Channel Alterations:	20	6 Sediment Deposition:	18	
7 Frequency of Riffles:	16	8 Channel Flow Status:	16	
9 Condition of Banks:	13	10 Bank Vegetation:	16	**Total**
11 Grazing or Disruptive:	15	12 Riparian Vegetation:	13	193

Impairment: no impairment data recorded

Insufficient? - Impaired? - Biology Impaired? -
Habitat Impaired? - Rock picks influenced? - Impact Localized? -
Designated Use needs reevaluation? -

Comments:

Land Use: 40 49' 3.0" 75 19' 51.9"
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 3/4/2009 12:20:56 PM

Assessment ID:	54456
Station ID:	20050419-1425-TLD (Latitude: 40.8132, Longitude: -75.3347)
Method:	6-Dframe Composite, 200 subsample
Location:	25 m ups of SR0512 bridge. Windgap Quad Bushkill Twp. Northampton Co.

Metrics:

Total # Organisms: 234	Hilsenhoff: 4.07	%EPT: 48	FCPRSH: 13
Taxa Richness: 24	Beck3: 19	Beck4: 20	Modified %EPT: 41
Modified Caddis: 1	EPT: 12	%Mayflies: 27	%Dominant: 39
Caddisfly Taxa: 2	Mayfly Taxa: 6	Modified EPT: 10	Modified %Mayflies: 21
%Intol-Limestone: 44	%Tol-Limestone: 0	%Intol-Freestone: 51	%Tol-Freestone: 49
Shannon Diversity: 2.10			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	14	6
1020600100	Epeorus	4	0
1020600700	Stenonema(old genus)	1	3
1020800200	Drunella	1	1
1020800300	Ephemerella	35	1
1021200500	Paraleptophlebia	8	1
1030200700	Lanthus	2	5
1040400100	Amphinemura	32	3
1040500200	Leuctra	1	0
1040700400	Acroneuria	1	0

1040801200	Isoperla	9	2
1080400700	Hydropsyche	1	5
1080500100	Rhyacophila	5	1
1101000400	Ectopria	1	5
1101300200	Dubiraphia	1	6
1101300800	Oulimnius	14	5
1121200100	Chelifera	1	6
1121200500	Hemerodromia	1	6
1121900700	Antocha	1	3
1121901100	Dicranota	1	3
1122100400	Prosimulium	3	2
1122100500	Simulium	3	6
1122100600	Stegopterna	2	6
1122200000	Chironomidae	92	6

Habitat:

1 Instream Cover:	15	2 Epifaunal Substrate:	15	
3 Embeddedness:	18	4 Velocity/Depth Regimes:	13	
5 Channel Alterations:	18	6 Sediment Deposition:	14	
7 Frequency of Riffles:	16	8 Channel Flow Status:	15	
9 Condition of Banks:	14	10 Bank Vegetation:	15	**Total**
11 Grazing or Disruptive:	14	12 Riparian Vegetation:	12	179

Impairment: no impairment data recorded

Insufficient? - Impaired? - Biology Impaired? -
Habitat Impaired? - Rock picks influenced? - Impact Localized? -
Designated Use needs reevaluation? -

Comments:

Land Use: 40 48' 47.7" 75 20' 3.4"
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 3/4/2009 12:22:31 PM

Assessment ID:	54447
Station ID:	20050419-1125-TLD (Latitude: 40.8050, Longitude: -75.3262)
Method:	6-Dframe Composite, 200 subsample
Location:	15 m ups of T611 bridge. Windgap Quad Bushkill Twp. Northampton Co.

Metrics:

Total # Organisms: 215	Hilsenhoff: 4.03	%EPT: 52	FCPRSH: 19
Taxa Richness: 34	Beck3: 28	Beck4: 28	Modified %EPT: 37
Modified Caddis: 6	EPT: 18	%Mayflies: 22	%Dominant: 25
Caddisfly Taxa: 8	Mayfly Taxa: 6	Modified EPT: 15	Modified %Mayflies: 16
%Intol-Limestone: 43	%Tol-Limestone: 0	%Intol-Freestone: 58	%Tol-Freestone: 42
Shannon Diversity: 2.85			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	12	6
1020600100	Epeorus	3	0
1020600700	Stenonema(old genus)	8	3
1020800200	Drunella	8	1
1020800300	Ephemerella	15	1
1021200500	Paraleptophlebia	1	1
1030200700	Lanthus	2	5
1040400100	Amphinemura	20	3
1040500200	Leuctra	1	0
1040700400	Acroneuria	1	0
1040801200	Isoperla	6	2
1080100100	Chimarra	3	4
1080100200	Dolophilodes	1	0
1080400300	Diplectrona	1	0
1080400600	Cheumatopsyche	7	6
1080400700	Hydropsyche	14	5
1080500100	Rhyacophila	5	1
1080700700	Stactobiella	2	2
1080900300	Micrasema	4	2
1101100200	Helichus	1	5
1101300200	Dubiraphia	1	6
1101300600	Optioservus	4	4
1101300800	Oulimnius	6	5
1101300900	Promoresia	9	2
1101301000	Stenelmis	1	5
1120201500	Probezzia	1	6
1121200100	Chelifera	1	6
1121200300	Clinocera	1	6
1121200500	Hemerodromia	1	6
1121900700	Antocha	1	3
1121901700	Limonia	1	6
1122100400	Prosimulium	7	2
1122100500	Simulium	12	6
1122200000	Chironomidae	54	6

Habitat:

1 Instream Cover:	15	2 Epifaunal Substrate:	14	
3 Embeddedness:	15	4 Velocity/Depth Regimes:	15	
5 Channel Alterations:	15	6 Sediment Deposition:	15	
7 Frequency of Riffles:	15	8 Channel Flow Status:	17	
9 Condition of Banks:	12	10 Bank Vegetation:	17	**Total**
11 Grazing or Disruptive:	18	12 Riparian Vegetation:	17	185

Impairment: no impairment data recorded

Insufficient? - Impaired? - Biology Impaired? -
Habitat Impaired? - Rock picks influenced? - Impact Localized? -
Designated Use needs reevaluation? -

Comments:

Land Use: 40 48' 17.4" 75 19' 34.0"
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 3/4/2009 12:23:40 PM

Assessment ID:	55236
Station ID:	20051102-1400-TLD (Latitude: 40.8017, Longitude: -75.3092)
Method:	6-Dframe Composite, 200 subsample
Location:	50 m upstream of junction with Unt 04647 on Jacobsburg S.P. property.

Metrics:

Total # Organisms: 216	Hilsenhoff: 3.40	%EPT: 66	FCPRSH: 17
Taxa Richness: 29	Beck3: 16	Beck4: 25	Modified %EPT: 63
Modified Caddis: 4	EPT: 17	%Mayflies: 8	%Dominant: 22
Caddisfly Taxa: 7	Mayfly Taxa: 6	Modified EPT: 14	Modified %Mayflies: 8
%Intol-Limestone: 64	%Tol-Limestone: 0	%Intol-Freestone: 81	%Tol-Freestone: 19
Shannon Diversity: 2.59			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020600100	Epeorus	1	0
1020600600	Stenacron	1	4
1020600700	Stenonema(old genus)	8	3
1020800300	Ephemerella	4	1
1020800400	Eurylophella	2	4
1021200500	Paraleptophlebia	1	1
1030200700	Lanthus	1	5
1030201000	Stylogomphus	2	4
1040300100	Taeniopteryx	31	2
1040300400	Strophopteryx	21	3
1040600100	Allocapnia	47	3
1040700400	Acroneuria	5	0
1080100100	Chimarra	7	4
1080100200	Dolophilodes	6	0
1080200100	Lype	1	2
1080300500	Polycentropus	1	6
1080400600	Cheumatopsyche	4	6
1080400700	Hydropsyche	2	5
1081000300	Apatania	1	3
1101000200	Psephenus	13	4
1101300600	Optioservus	4	4
1101300800	Oulimnius	1	5
1120201500	Probezzia	1	6
1121400600	Tabanus	1	5
1121900400	Tipula	3	4
1121901100	Dicranota	9	3
1121901500	Hexatoma	3	2
1122200000	Chironomidae	34	6
9020100000	Sphaeriidae	1	8

Habitat:

1 Instream Cover:	16	2 Epifaunal Substrate:	16	
3 Embeddedness:	16	4 Velocity/Depth Regimes:	17	
5 Channel Alterations:	20	6 Sediment Deposition:	15	
7 Frequency of Riffles:	16	8 Channel Flow Status:	15	
9 Condition of Banks:	15	10 Bank Vegetation:	18	**Total**
11 Grazing or Disruptive:	19	12 Riparian Vegetation:	19	202

Impairment: no impairment data recorded

Insufficient? - Impaired? - Biology Impaired? -
Habitat Impaired? - Rock picks influenced? - Impact Localized? -
Designated Use needs reevaluation? -

Comments:

Land Use:
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 3/4/2009 12:25:29 PM

Assessment ID:	54443
Station ID:	20050419-1000-TLD (Latitude: 40.7864, Longitude: -75.3033)
Method:	6-Dframe Composite, 200 subsample
Location:	25 m ups of footbridge near mouth. Windgap Quad Bushkill Quad Northampton Co.

Metrics:

Total # Organisms: 213	Hilsenhoff: 2.97	%EPT: 68	FCPRSH: 11
Taxa Richness: 23	Beck3: 17	Beck4: 19	Modified %EPT: 59
Modified Caddis: 1	EPT: 11	%Mayflies: 54	%Dominant: 23
Caddisfly Taxa: 2	Mayfly Taxa: 6	Modified EPT: 9	Modified %Mayflies: 48
%Intol-Limestone: 61	%Tol-Limestone: 0	%Intol-Freestone: 69	%Tol-Freestone: 31
Shannon Diversity: 2.47			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	12	6
1020500100	Isonychia	1	3
1020600100	Epeorus	9	0
1020600700	Stenonema(old genus)	9	3
1020800200	Drunella	35	1
1020800300	Ephemerella	49	1
1030200700	Lanthus	2	5
1040400100	Amphinemura	6	3
1040700400	Acroneuria	6	0
1040801200	Isoperla	4	2
1080400700	Hydropsyche	7	5
1080500100	Rhyacophila	6	1
1101000200	Psephenus	5	4

1101000400	Ectopria	1	5
1101300500	Microcylloepus	1	2
1101300800	Oulimnius	2	5
1101300900	Promoresia	1	2
1121200300	Clinocera	1	6
1121200500	Hemerodromia	3	6
1121901500	Hexatoma	1	2
1122100400	Prosimulium	2	2
1122100500	Simulium	16	6
1122200000	Chironomidae	34	6

Habitat:

1 Instream Cover:	16	2 Epifaunal Substrate:	18	
3 Embeddedness:	17	4 Velocity/Depth Regimes:	17	
5 Channel Alterations:	19	6 Sediment Deposition:	16	
7 Frequency of Riffles:	18	8 Channel Flow Status:	15	
9 Condition of Banks:	13	10 Bank Vegetation:	18	**Total**
11 Grazing or Disruptive:	20	12 Riparian Vegetation:	20	207

Impairment: no impairment data recorded

Insufficient? - Impaired? - Biology Impaired? -
Habitat Impaired? - Rock picks influenced? - Impact Localized? -
Designated Use needs reevaluation? -

Comments:

Land Use: 40 47' 9.7" 75 18' 11.3"
Impairment:

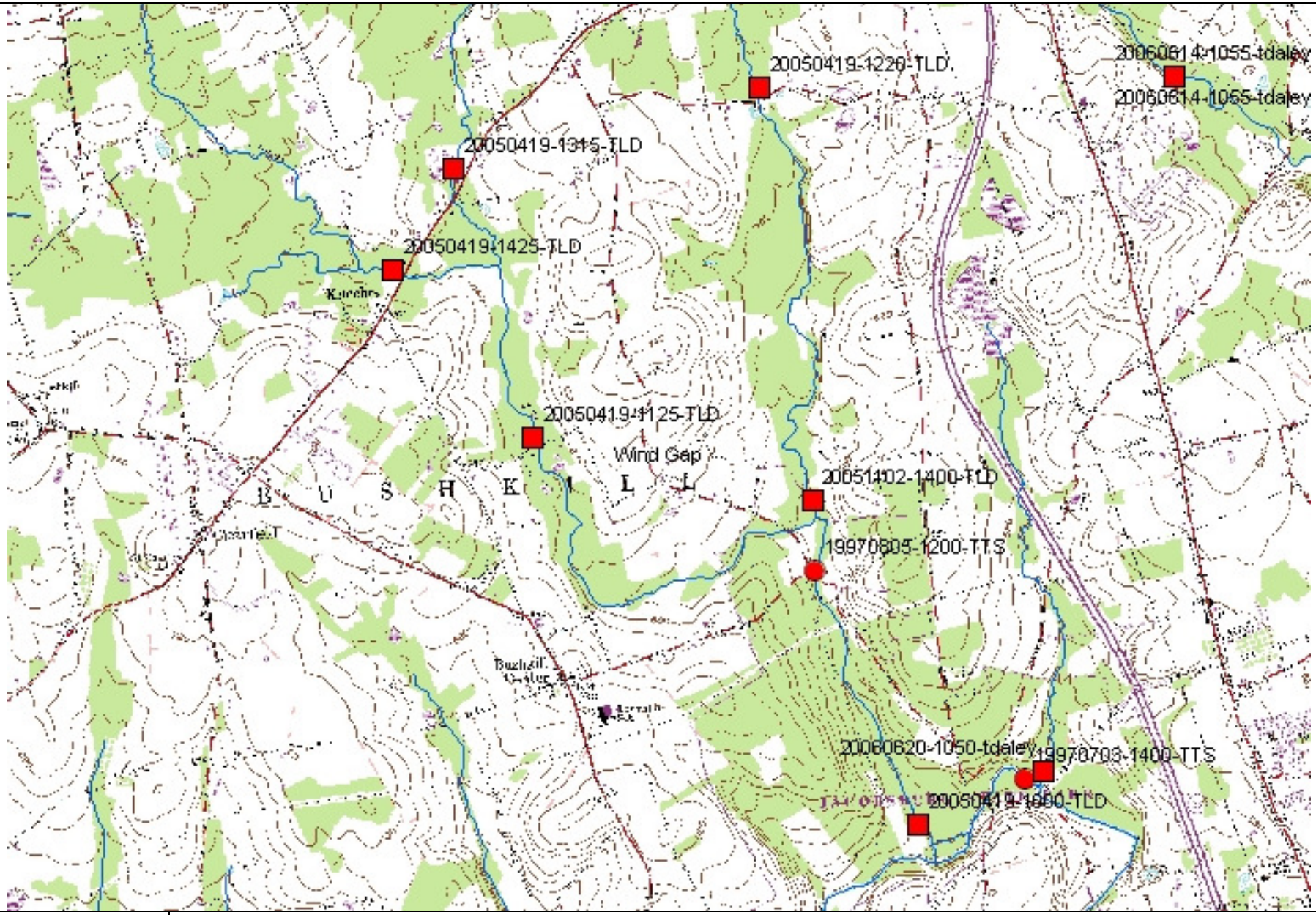


FIGURE	**Macroinvertebrate Monitoring Station Locations – Sobers Run Watershed** (Department of Environmental Protection, 2006)

Appendix B

Bushkill Creek Macroinvertebrate Data

Macroinvertebrate Sample Summary

version: 3.0 10/9/2008 9:50:59 AM

Assessment ID:	56693
Station ID:	20060620-1230-tdaley (Latitude: 40.7792, Longitude: -75.3102)
Method:	6-Dframe Composite, 200 subsample
Location:	75 m ups of T601 bridge (Douglasville Rd.) Windgap Quad Bushkill Twp. - Northampton Co.

Metrics:

Total # Organisms: 227	Hilsenhoff: 4.47	%EPT: 78	FCPRSH: 11
Taxa Richness: 26	Beck3: 14	Beck4: 21	Modified %EPT: 50
Modified Caddis: 1	EPT: 14	%Mayflies: 26	%Dominant: 28
Caddisfly Taxa: 4	Mayfly Taxa: 8	Modified EPT: 10	Modified %Mayflies: 17
%Intol-Limestone: 23	%Tol-Limestone: 11	%Intol-Freestone: 63	%Tol-Freestone: 37
Shannon Diversity: 2.42			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400100	Acentrella	1	4
1020400600	Centroptilum	1	2
1020500100	Isonychia	26	3
1020600300	Leucrocuta	1	1
1020600700	Stenonema(old genus)	2	3
1020800300	Ephemerella	1	1
1020800500	Serratella	6	2
1021000200	Caenis	21	7
1030200700	Lanthus	1	5
1040500200	Leuctra	3	0
1040700400	Acroneuria	9	0
1060200100	Corydalus	1	4
1060200400	Nigronia	1	2
1080100100	Chimarra	63	4
1080300500	Polycentropus	4	6
1080400600	Cheumatopsyche	31	6
1080400700	Hydropsyche	7	5
1100100100	Dineutus	3	4
1101000200	Psephenus	6	4
1101300600	Optioservus	6	4
1101300800	Oulimnius	1	5
1101300900	Promoresia	2	2
1121900700	Antocha	1	3
1122200000	Chironomidae	26	6
11000000000	Oligochaeta	2	10
15000000000	Hydracarina	1	7

Habitat:

1 Instream Cover:	15	2 Epifaunal Substrate:	16	
3 Embeddedness:	15	4 Velocity/Depth Regimes:	15	
5 Channel Alterations:	20	6 Sediment Deposition:	13	
7 Frequency of Riffles:	15	8 Channel Flow Status:	12	
9 Condition of Banks:	10	10 Bank Vegetation:	16	**Total**
11 Grazing or Disruptive:	19	12 Riparian Vegetation:	19	185

Impairment:

Insufficient?	Y	Impaired?	N/A	Biology Impaired?	N/A
Habitat Impaired?	N/A	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Comments:

Land Use:
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 10/9/2008 10:19:23 AM

Assessment ID:	56734
Station ID:	20060620-1510-tdaley (Latitude: 40.8044, Longitude: -75.3706)
Method:	2-Dframe Composite, 100 subsample
Location:	200 m ups of mouth. Windgap Quad Moore Twp. - Northampton Co.

Metrics:

Total # Organisms: 121	Hilsenhoff: 3.48	%EPT: 48	FCPRSH: 9
Taxa Richness: 21	Beck3: 15	Beck4: 18	Modified %EPT: 36
Modified Caddis: 3	EPT: 12	%Mayflies: 8	%Dominant: 26
Caddisfly Taxa: 5	Mayfly Taxa: 5	Modified EPT: 9	Modified %Mayflies: 6
%Intol-Limestone: 46	%Tol-Limestone: 0	%Intol-Freestone: 70	%Tol-Freestone: 30

Shannon Diversity: 2.46

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400100	Acentrella	3	4
1020400300	Baetis	3	6
1020600700	Stenonema(old genus)	1	3
1020800500	Serratella	1	2
1021200500	Paraleptophlebia	2	1
1030200700	Lanthus	2	5
1040500200	Leuctra	7	0
1040700400	Acroneuria	6	0
1080100100	Chimarra	9	4
1080100200	Dolophilodes	14	0
1080200100	Lype	1	2
1080400600	Cheumatopsyche	1	6
1080400700	Hydropsyche	10	5
1101300600	Optioservus	4	4

1101300800	Oulimnius	1	5
1101300900	Promoresia	2	2
1121900700	Antocha	1	3
1121901100	Dicranota	18	3
1121901500	Hexatoma	3	2
1122200000	Chironomidae	31	6
13040100100	Cambarus	1	6

Habitat:

1 Instream Cover:	15	2 Epifaunal Substrate:	14	
3 Embeddedness:	13	4 Velocity/Depth Regimes:	14	
5 Channel Alterations:	18	6 Sediment Deposition:	13	
7 Frequency of Riffles:	15	8 Channel Flow Status:	11	
9 Condition of Banks:	16	10 Bank Vegetation:	19	**Total**
11 Grazing or Disruptive:	18	12 Riparian Vegetation:	17	183

Impairment:

Insufficient?	Y	Impaired?	N/A	Biology Impaired?	N/A
Habitat Impaired?	N/A	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Comments:

Land Use:
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 10/9/2008 9:56:02 AM

Assessment ID:	56695
Station ID:	20060620-1232-tdaley (Latitude: 40.7791, Longitude: -75.3102)
Method:	2-Dframe Composite, 100 subsample
Location:	75 m ups of T601 bridge (Douglasville Rd.) Windgap QuadBushkill Twp. - Northampton Co.

Metrics:

Total # Organisms: 116	Hilsenhoff: 4.30	%EPT: 83	FCPRSH: 10
Taxa Richness: 23	Beck3: 12	Beck4: 18	Modified %EPT: 51
Modified Caddis: 3	EPT: 15	%Mayflies: 38	%Dominant: 16
Caddisfly Taxa: 6	Mayfly Taxa: 7	Modified EPT: 11	Modified %Mayflies: 22
%Intol-Limestone: 33	%Tol-Limestone: 17	%Intol-Freestone: 62	%Tol-Freestone: 38
Shannon Diversity: 2.57			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400100	Acentrella	1	4
1020500100	Isonychia	17	3
1020600300	Leucrocuta	1	1
1020600700	Stenonema(old genus)	3	3

1020800300	Ephemerella	1	1
1020800500	Serratella	3	2
1021000200	Caenis	18	7
1030200700	Lanthus	1	5
1040500200	Leuctra	6	0
1040700400	Acroneuria	6	0
1080100100	Chimarra	19	4
1080300500	Polycentropus	1	6
1080400600	Cheumatopsyche	15	6
1080400700	Hydropsyche	3	5
1080700000	Hydroptilidae	1	4
1080900300	Micrasema	1	2
1100100100	Dineutus	3	4
1101000200	Psephenus	3	4
1101300600	Optioservus	1	4
1101301000	Stenelmis	2	5
1122200000	Chironomidae	8	6
11000000000	Oligochaeta	1	10
15000000000	Hydracarina	1	7

Habitat:

1 Instream Cover:	15	2 Epifaunal Substrate:	16	
3 Embeddedness:	15	4 Velocity/Depth Regimes:	15	
5 Channel Alterations:	20	6 Sediment Deposition:	13	
7 Frequency of Riffles:	15	8 Channel Flow Status:	12	
9 Condition of Banks:	10	10 Bank Vegetation:	16	**Total**
11 Grazing or Disruptive:	19	12 Riparian Vegetation:	19	185

Impairment:

Insufficient?	Y	Impaired?	N/A	Biology Impaired?	N/A
Habitat Impaired?	N/A	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Comments:

Land Use:
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 10/9/2008 10:16:44 AM

Assessment ID:	56696
Station ID:	20060620-1420-tdaley (Latitude: 40.8042, Longitude: -75.3725)
Method:	6-Dframe Composite, 200 subsample
Location:	600 m ups of SR4019 bridge. Windgap Quad Moore Twp. - Northampton Co.

Metrics:

Total # Organisms: 206	Hilsenhoff: 3.41	%EPT: 58	FCPRSH: 17
Taxa Richness: 27	Beck3: 22	Beck4: 24	Modified %EPT: 41
Modified Caddis: 3	EPT: 14	%Mayflies: 17	%Dominant: 29
Caddisfly Taxa: 6	Mayfly Taxa: 4	Modified EPT: 10	Modified %Mayflies: 6

%Intol-Limestone: 46 %Tol-Limestone: 0 %Intol-Freestone: 56 %Tol-Freestone: 44
Shannon Diversity: 2.49

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	23	6
1020500100	Isonychia	9	3
1020600700	Stenonema(old genus)	1	3
1021200500	Paraleptophlebia	3	1
1030200700	Lanthus	1	5
1030400100	Cordulegaster	1	3
1040200200	Tallaperla	7	0
1040500200	Leuctra	22	0
1040700400	Acroneuria	11	0
1040700700	Perlesta	2	4
1060200400	Nigronia	1	2
1080100200	Dolophilodes	26	0
1080300500	Polycentropus	4	6
1080400300	Diplectrona	1	0
1080400600	Cheumatopsyche	1	6
1080400700	Hydropsyche	7	5
1080500100	Rhyacophila	2	1
1101000200	Psephenus	9	4
1101000400	Ectopria	1	5
1101300600	Optioservus	1	4
1101300800	Oulimnius	1	5
1120201500	Probezzia	2	6
1120900100	Atherix	1	2
1121901100	Dicranota	5	3
1121901500	Hexatoma	4	2
1122200000	Chironomidae	59	6
13040100100	Cambarus	1	6

Habitat:

1 Instream Cover:	15	2 Epifaunal Substrate:	15	
3 Embeddedness:	16	4 Velocity/Depth Regimes:	13	
5 Channel Alterations:	20	6 Sediment Deposition:	15	
7 Frequency of Riffles:	16	8 Channel Flow Status:	8	
9 Condition of Banks:	13	10 Bank Vegetation:	18	**Total**
11 Grazing or Disruptive:	19	12 Riparian Vegetation:	19	187

Impairment:

Insufficient? Y Impaired? N/A Biology Impaired? N/A
Habitat Impaired? N/A Rock picks influenced? N Impact Localized? N
Designated Use needs reevaluation? N

Comments:

Land Use:
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 10/9/2008 10:10:45 AM

Assessment ID:	56742
Station ID:	20060711-1050-tdaley (Latitude: 40.7773, Longitude: -75.3247)
Method:	2-Dframe Composite, 100 subsample
Location:	150 m ups of W. Douglasville Rd (T601) bridge. Windgap Quad Bushkill Twp. - Northampton Co.

Metrics:

Total # Organisms: 110	Hilsenhoff: 4.60	%EPT: 56	FCPRSH: 12
Taxa Richness: 24	Beck3: 9	Beck4: 14	Modified %EPT: 33
Modified Caddis: 2	EPT: 10	%Mayflies: 5	%Dominant: 21
Caddisfly Taxa: 5	Mayfly Taxa: 3	Modified EPT: 6	Modified %Mayflies: 3
%Intol-Limestone: 15	%Tol-Limestone: 2	%Intol-Freestone: 55	%Tol-Freestone: 45
Shannon Diversity: 2.51			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	2	6
1020600700	Stenonema(old genus)	1	3
1021600100	Tricorythodes	2	4
1030200700	Lanthus	4	5
1030300400	Boyeria	1	2
1040700100	Agnetina	1	2
1040700400	Acroneuria	1	0
1060200400	Nigronia	4	2
1080100100	Chimarra	23	4
1080100200	Dolophilodes	8	0
1080300500	Polycentropus	1	6
1080400600	Cheumatopsyche	19	6
1080400700	Hydropsyche	4	5
1101000200	Psephenus	1	4
1101000400	Ectopria	3	5
1101300200	Dubiraphia	1	6
1101300600	Optioservus	5	4
1101300800	Oulimnius	1	5
1121900400	Tipula	1	4
1121900700	Antocha	1	3
1122100500	Simulium	4	6
1122200000	Chironomidae	20	6
8030300000	Physidae	1	8
11000000000	Oligochaeta	1	10

Habitat:

1 Instream Cover:	13	2 Epifaunal Substrate:	16	
3 Embeddedness:	14	4 Velocity/Depth Regimes:	14	
5 Channel Alterations:	15	6 Sediment Deposition:	12	
7 Frequency of Riffles:	15	8 Channel Flow Status:	15	
9 Condition of Banks:	13	10 Bank Vegetation:	16	**Total**
11 Grazing or Disruptive:	13	12 Riparian Vegetation:	13	169

Impairment:

Insufficient?	Y	Impaired?	N/A	Biology Impaired?	N/A
Habitat Impaired?	N/A	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Comments:

Land Use:
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 10/9/2008 10:07:10 AM

Assessment ID:	56741
Station ID:	20060711-1145-tdaley (Latitude: 40.7902, Longitude: -75.3680)
Method:	2-Dframe Composite, 100 subsample
Location:	25 m ups of Bushkill Rd. (Sr4019) bridge. Windgap Quad Bushkill Twp. - Northampton Co.

Metrics:

Total # Organisms: 146	Hilsenhoff: 4.71	%EPT: 42	FCPRSH: 14
Taxa Richness: 22	Beck3: 11	Beck4: 14	Modified %EPT: 21
Modified Caddis: 2	EPT: 9	%Mayflies: 3	%Dominant: 24
Caddisfly Taxa: 4	Mayfly Taxa: 2	Modified EPT: 6	Modified %Mayflies: 1
%Intol-Limestone: 12	%Tol-Limestone: 1	%Intol-Freestone: 50	%Tol-Freestone: 50

Shannon Diversity: 2.34

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	3	6
1021200500	Paraleptophlebia	1	1
1030200700	Lanthus	12	5
1040500200	Leuctra	11	0
1040700400	Acroneuria	1	0
1040900600	Sweltsa	2	0
1060100100	Sialis	1	6
1080100100	Chimarra	15	4
1080400600	Cheumatopsyche	27	6
1080400700	Hydropsyche	1	5
1081001500	Pycnopsyche	1	4
1101000200	Psephenus	2	4
1101300200	Dubiraphia	1	6
1101300600	Optioservus	20	4
1101300800	Oulimnius	2	5
1101301000	Stenelmis	2	5
1121200500	Hemerodromia	1	6
1121900400	Tipula	1	4
1121901100	Dicranota	2	3
1122100500	Simulium	4	6
1122200000	Chironomidae	35	6
15000000000	Hydracarina	1	7

Habitat:

1 Instream Cover:	14	2 Epifaunal Substrate:	15	
3 Embeddedness:	14	4 Velocity/Depth Regimes:	14	
5 Channel Alterations:	18	6 Sediment Deposition:	12	
7 Frequency of Riffles:	16	8 Channel Flow Status:	16	
9 Condition of Banks:	14	10 Bank Vegetation:	18	**Total**
11 Grazing or Disruptive:	19	12 Riparian Vegetation:	18	188

Impairment:

Insufficient?	Y	Impaired?	N/A	Biology Impaired?	N/A
Habitat Impaired?	N/A	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Comments:

Land Use:
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 10/9/2008 10:15:42 AM

Assessment ID:	56740
Station ID:	20060711-1235-tdaley (Latitude: 40.7992, Longitude: -75.3703)
Method:	2-Dframe Composite, 100 subsample
Location:	100 m ups of Bushkill Rd. (SR4019) bridge. Windgap Quad Moore Twp. - Northampton Co.

Metrics:

Total # Organisms: 119	Hilsenhoff: 2.56	%EPT: 71	FCPRSH: 12
Taxa Richness: 23	Beck3: 25	Beck4: 24	Modified %EPT: 56
Modified Caddis: 4	EPT: 14	%Mayflies: 18	%Dominant: 24
Caddisfly Taxa: 4	Mayfly Taxa: 4	Modified EPT: 12	Modified %Mayflies: 3
%Intol-Limestone: 60	%Tol-Limestone: 1	%Intol-Freestone: 66	%Tol-Freestone: 34

Shannon Diversity: 2.44

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400800	Diphetor	15	6
1020500100	Isonychia	1	3
1020600700	Stenonema(old genus)	2	3
1021200300	Habrophlebiodes	3	6
1030200700	Lanthus	1	5
1040200200	Tallaperla	1	0
1040500200	Leuctra	29	0
1040700100	Agnetina	2	2
1040700400	Acroneuria	6	0
1040801200	Isoperla	1	2
1040900600	Sweltsa	11	0
1080100200	Dolophilodes	11	0
1080400300	Diplectrona	1	0
1080500100	Rhyacophila	1	1
1080910100	Lepidostoma	1	1

1101000200	Psephenus	5	4
1101300600	Optioservus	1	4
1101301000	Stenelmis	1	5
1121900700	Antocha	2	3
1121901500	Hexatoma	2	2
1122200000	Chironomidae	20	6
11000000000	Oligochaeta	1	10
13040100100	Cambarus	1	6

Habitat:

1 Instream Cover:	13	2 Epifaunal Substrate:	13	
3 Embeddedness:	15	4 Velocity/Depth Regimes:	13	
5 Channel Alterations:	18	6 Sediment Deposition:	12	
7 Frequency of Riffles:	16	8 Channel Flow Status:	15	
9 Condition of Banks:	15	10 Bank Vegetation:	16	**Total**
11 Grazing or Disruptive:	13	12 Riparian Vegetation:	12	171

Impairment:

Insufficient?	Y	Impaired?	N/A	Biology Impaired?	N/A
Habitat Impaired?	N/A	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Comments:

Land Use:
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 10/9/2008 9:58:47 AM

Assessment ID:	56743
Station ID:	20070103-1355-tdaley (Latitude: 40.7696, Longitude: -75.3159)
Method:	6-Dframe Composite, 200 subsample
Location:	upstream of SR4025 bridge. Wind Gap Quad Bushkill Twp. - Northampton Co.

Metrics:

Total # Organisms: 238	Hilsenhoff: 4.18	%EPT: 55	FCPRSH: 18
Taxa Richness: 28	Beck3: 23	Beck4: 27	Modified %EPT: 29
Modified Caddis: 4	EPT: 17	%Mayflies: 8	%Dominant: 24
Caddisfly Taxa: 6	Mayfly Taxa: 5	Modified EPT: 13	Modified %Mayflies: 5
%Intol-Limestone: 34	%Tol-Limestone: 1	%Intol-Freestone: 55	%Tol-Freestone: 45
Shannon Diversity: 2.54			

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	6	6
1020600100	Epeorus	1	0
1020800200	Drunella	1	1
1020800300	Ephemerella	9	1
1021200300	Habrophlebiodes	1	6
1030201000	Stylogomphus	1	4

1040300100	Taeniopteryx	2	2
1040300400	Strophopteryx	3	3
1040400500	Prostoia	5	2
1040600100	Allocapnia	7	3
1040700400	Acroneuria	6	0
1040801200	Isoperla	3	2
1060200400	Nigronia	1	2
1080100100	Chimarra	23	4
1080100200	Dolophilodes	5	0
1080400300	Diplectrona	2	0
1080400600	Cheumatopsyche	40	6
1080400700	Hydropsyche	13	5
1080500100	Rhyacophila	3	1
1101000200	Psephenus	3	4
1101300600	Optioservus	5	4
1101400100	Anchytarsus	4	5
1121900700	Antocha	1	3
1121901100	Dicranota	2	3
1122100400	Prosimulium	31	2
1122200000	Chironomidae	58	6
11000000000	Oligochaeta	1	10
15000000000	Hydracarina	1	7

Habitat:

1 Instream Cover:	13	2 Epifaunal Substrate:	14	
3 Embeddedness:	12	4 Velocity/Depth Regimes:	10	
5 Channel Alterations:	15	6 Sediment Deposition:	12	
7 Frequency of Riffles:	16	8 Channel Flow Status:	13	
9 Condition of Banks:	13	10 Bank Vegetation:	15	**Total**
11 Grazing or Disruptive:	16	12 Riparian Vegetation:	13	162

Impairment:

Insufficient?	Y	Impaired?	N/A	Biology Impaired?	N/A
Habitat Impaired?	N/A	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Comments:

Land Use:
Impairment:

Macroinvertebrate Sample Summary

version: 3.0 10/9/2008 10:18:00 AM

Assessment ID:	56697
Station ID:	20060620-1422-tdaley (Latitude: 40.8041, Longitude: -75.3722)
Method:	2-Dframe Composite, 100 subsample
Location:	600 m ups of SR4019 bridge.Wind Gap QuadMoore Twp. - Northampton Co.

Metrics:

Total # Organisms: 110 Hilsenhoff: 4.11 %EPT: 53 FCPRSH: 16

Taxa Richness: 26	Beck3: 24	Beck4: 25	Modified %EPT: 31
Modified Caddis: 4	EPT: 15	%Mayflies: 22	%Dominant: 33
Caddisfly Taxa: 7	Mayfly Taxa: 4	Modified EPT: 11	Modified %Mayflies: 11
%Intol-Limestone: 35	%Tol-Limestone: 0	%Intol-Freestone: 48	%Tol-Freestone: 52

Shannon Diversity: 2.57

Taxa:

Code	Standardized ID Level	Number	Tolerance
1020400300	Baetis	12	6
1020500100	Isonychia	7	3
1020800200	Drunella	1	1
1021200500	Paraleptophlebia	4	1
1030200700	Lanthus	1	5
1030201000	Stylogomphus	1	4
1040500200	Leuctra	5	0
1040700400	Acroneuria	4	0
1040801200	Isoperla	1	2
1040900600	Sweltsa	1	0
1060200400	Nigronia	2	2
1080100200	Dolophilodes	7	0
1080300500	Polycentropus	4	6
1080400600	Cheumatopsyche	2	6
1080400700	Hydropsyche	6	5
1080500100	Rhyacophila	2	1
1080600100	Glossosoma	1	0
1081100100	Neophylax	1	3
1101000200	Psephenus	4	4
1101000400	Ectopria	1	5
1120201500	Probezzia	1	6
1121900400	Tipula	2	4
1121901100	Dicranota	1	3
1121901500	Hexatoma	1	2
1122200000	Chironomidae	36	6
13040100100	Cambarus	2	6

Habitat:

1 Instream Cover:	15	2 Epifaunal Substrate:	15	
3 Embeddedness:	16	4 Velocity/Depth Regimes:	13	
5 Channel Alterations:	20	6 Sediment Deposition:	15	
7 Frequency of Riffles:	16	8 Channel Flow Status:	8	
9 Condition of Banks:	13	10 Bank Vegetation:	18	**Total**
11 Grazing or Disruptive:	19	12 Riparian Vegetation:	19	187

Impairment:

Insufficient?	Y	Impaired?	N/A	Biology Impaired?	N/A
Habitat Impaired?	N/A	Rock picks influenced?	N	Impact Localized?	N

Designated Use needs reevaluation? N

Comments:

Land Use:

Impairment:

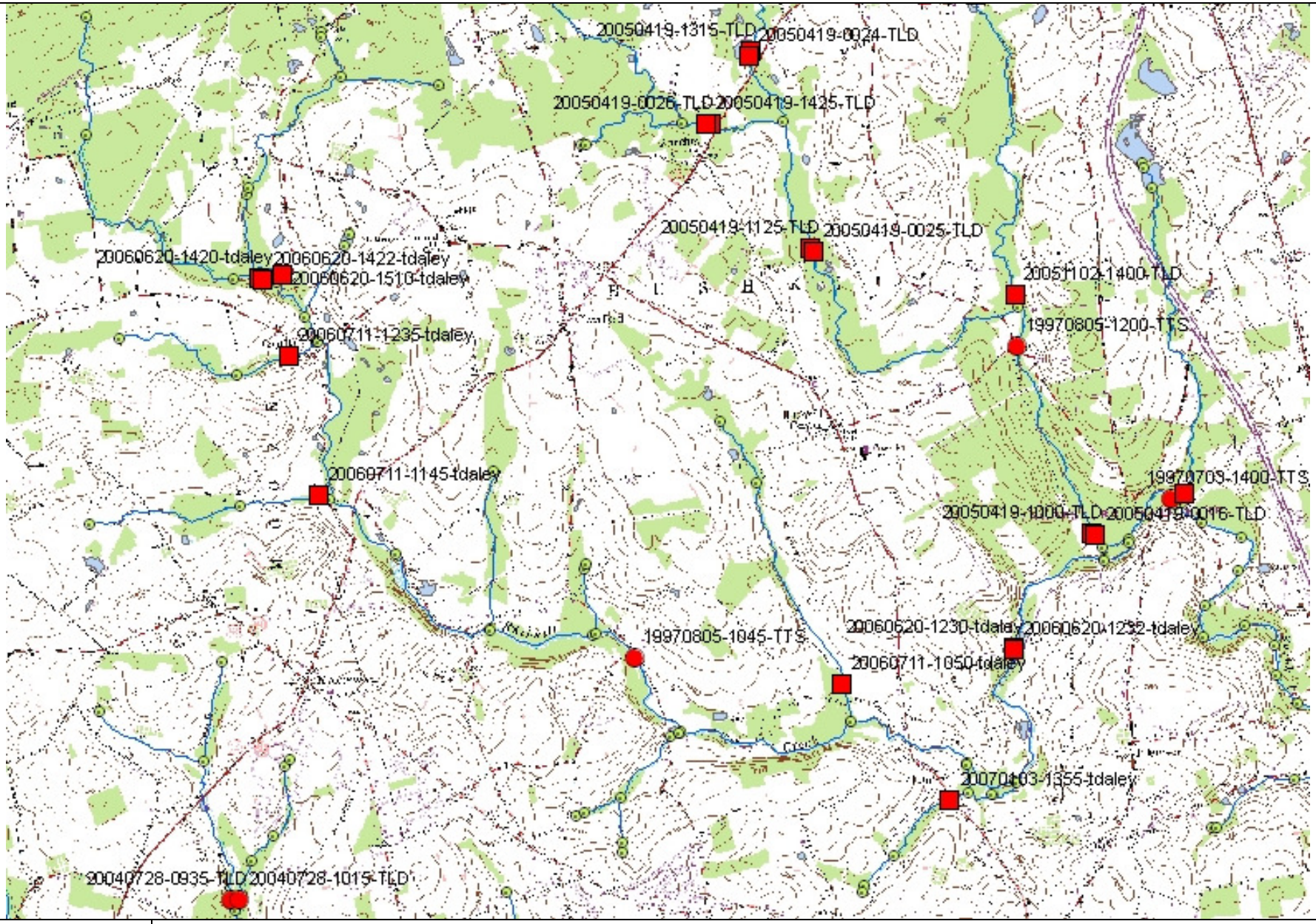


FIGURE	**Macroinvertebrate Monitoring Station Locations – Upper Bushkill Watershed** (Department of Environmental Protection, 2006)

Appendix C

Macroinvertebrate Survey Report
Upper Bushkill Creek

Macroinvertebrate Survey Report

Upper Bushkill Creek

Northampton County, PA

Submitted by Lance Leonhardt

To the Bushkill Stream Conservancy

August 11, 2008

Summary

Macroinvertebrate sampling was conducted March 29, 2008, at two sites on the upper Bushkill Creek, Northampton County, PA. The sampling sites, Site #1 and Site #2, corresponded to the same locations on Bushkill Creek found to support naturally-reproducing populations of brook trout by a fish survey conducted in 2007.

Macroinvertebrate sampling and assessment followed Pennsylvania Department of Environmental Protection (PA DEP) protocols. Using PA DEP's Benthic Index of Biotic Integrity (IBI) for Wadeable Freestone Streams as an evaluative tool, the collected and sub-sampled macroinvertebrate assemblage from Site #1 scored 80.1 on the IBI. The collected and sub-sampled macroinvertebrate assemblage from Site #2 scored 78.97. An IBI score of 80 or greater is the benchmark required for consideration of High Quality/Exceptional Value (HQ/EV) Aquatic Life Use (ALU) antidegradation designations.

Using the Biological Condition Gradient (BCG) for Freestone (Non-Calcareous) Streams of Pennsylvania, a tier or biological condition class was determined using the macroinvertebrate assemblage for each sampling site. Site #1 had the required characteristics of a Tier 2 condition described as outstanding condition waters having a natural condition with minimal ecosystem changes. Site #2, missing one Tier 2 qualification rule, was designated a Tier 3, or good condition waters.

Macroinvertebrate indicator species were used to classify each site's community type based on the genus-level macroinvertebrate communities defined by the Pennyslvania Aquatic Community Classification Project. Although each site had representative species indicators of several community types, the genus-level stream community "High Quality Small Stream" best describes both Site #1 and Site #2.

The presence of high quality macroinvertebrates, reflected in the IBI and BCG Tier results, and the occurrence of naturally-reproducing brook trout populations at the assessed sites may warrant further evaluation of portions of the upper Bushkill Creek by PA DEP biologists for possible consideration of Exceptional Value (EV) designated use.

Introduction

The water use designation of a stream has implications for its conservation and legal protection. Bushkill Creek, Northampton County and its tributaries are designated as HQ-CWF (High Quality Waters-Cold Water Fish) in The Pennsylvania Code Title 25, Section 93.9c. Drainage List C**.** HQ and Exceptional Value (EV) are special protection aquatic life designated uses requiring that new or expanded activities do not degrade existing water quality (Royer et al. 2007).

Water use designations of HQ and EV are, in part, determined by the benthic macroinvertebrate assemblage present at the stream reach scale. Benthic macroinvertebrates are animals with no backbone, such as insects, crustaceans, mollusks and annelids, visible to the naked eye, and living on the stream bottom.

The types of macroinvertebrates collected from a stream reach and their ecological characteristics may be used to assess a stream's biological condition, health, or biological integrity. This is because different types of macroinvertebrates vary in their tolerance to stream conditions, as does their response to stressors (physical, chemical, or biological factors that negatively impact populations).

For example, a more natural or native condition with biological integrity is generally indicated by a macroinvertebrate community having a greater proportion of intolerant, sensitive species (requiring healthy stream conditions to maintain populations) compared to tolerant species, able to maintain populations under stressed conditions. Conversely, a sample dominated by tolerant macroinvertebrates and containing few, if any, intolerant macoinvertebrates would generally indicate a greatly altered and impacted biological condition lacking biological integrity.

Linked to the biological condition of a system, biological integrity has been defined as "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a composition and diversity comparable to that of the natural habitats of the region" (Frey 1977). Biological integrity is expected in areas with no or minimal human influence (Karr and Chu 2000).

The use of macroinvertebrates as environmental indicators can allow for a direct quantification of changes in ecological attributes along a gradient of biological conditions, caused by increasing levels of stressors often associated with human activities (Davies and Jackson 2006).

Over the years, the Pennsylvania Department of Environmental Protection (PA DEP) has developed macroinvertebrate protocols for sampling and assessing a stream's biological condition. The most recent (November 2007) PA DEP macroinvertebrate assessment protocols developed for freestone streams is "A Benthic Index of Biotic Integrity for Wadeable Freestone Streams in Pennsylvania."

Utilizing this Index of Biological Integrity (IBI) to evaluate a stream's macroinvertebrate community, the PA DEP has set criteria for use attainment thresholds or benchmarks based on the numeric score of a stream's macroinvertebrate assemblage on the IBI.

The PA DEP has set IBI scoring benchmarks of $\geq$ 80 as a qualifier for special protection use status of High Quality (HQ) and Exceptional Value (EV). Several other factors in addition to IBI scores (reviewed in the results-discussion section of this report) are also considered in determining candidacy and to distinguish between EV and HQ uses. A score of $\geq$ 63 would support the use attainment benchmarks of Cold Water Fishery (CWF), Trout Stocked Stream (TSF), and Warm Water Fishery (WWF). Scores <63 indicate degraded streams (Chalfant 2007).

A preliminary Biological Condition Gradient (BCG) for Freestone (Non-Calcareous) Streams of Pennsylvania has also been recently developed by state biologists to identify the tier or biological condition class of a stream reach along a stressor gradient using macroinvertebrates. Six tiers describing the changes in aquatic community structure and function with increasing stress, range from tier 1 (undisturbed natural condition) to tier 6 (severely degraded condition).

Specific kinds of macroinvertebrates, as significant indicator species, can also classify stream communities, as was done by The Pennyslvania Aquatic Community Classification (PACC) Project to help describe "patterns in aquatic biodiversity for the purpose of prioritizing conservation activities and informing aquatic resource management" (Walsh et al. 2007a).

Using specific sets of statistically significant indicator species, the PACC describes the habitat, stream quality rating, community rarity, threats and conservation recommendations for 12 genus-level stream community types. Conservation recommendations for a community type can provide a useful guide for management decisions.

This survey documents the macroinvertebrate assemblages at two sites on the upper Bushkill Creek. The assemblages were used to assess the biological condition of the sites and determine whether the stream reaches sampled could potentially meet IBI scoring benchmarks required for EV candidacy, and, therefore, warrant future evaluation by PA DEP biologists.

Sampling Sites

Two stream reaches in the Upper Bushkill Creek watershed were selected for macroinvertebrate sampling and assessment. The two sampling sites (Site #1 and Site #2) corresponded to the same reaches in which naturally-reproducing brook trout (*Salvelinus fontinalis*) populations were found during a fish survey conducted on Bushkill Creek in 2007 (Leonhardt 2007).

Site #1 is located on the east (Katellen) branch, and site #2 on the west (Bender's Junction) branch of the upper Bushkill Creek (see Map 1).

The survey sampling sites, depending on definition, can be described as low to moderate gradient wadeable stream reaches (Site #1 ~ .9% gradient and Site #2 ~.6% gradient) having a series of riffle, run, and pool habitats. With primarily shale substrate, the stream reaches could be considered freestone. The substrate size at the sites ranged from mostly boulder and cobble, to pebble, gravel, with some sand and little silt.

Bushkill Creek Site #1 is a 2nd order stream (USGS quadrangle 7.5 minute series map) receiving water from a large, red maple-highbush blueberry swamp and flowing through mature secondary broadleaf deciduous forest.

Bushkill Creek site #2 is a 1st Order stream (USGS quadrangle 7.5 minute series map) flowing through mostly mature, secondary broadleaf deciduous forest, with sections lined by eastern hemlock and giant rhododendron.

Both sampling sites were slightly above base-flow during the time of sampling in late March, 2008. The two sampling sites were located on private land, requiring land owner permission prior to sampling.

Methods

Macroinvertebrate sampling was conducted March 29, 2008. Field sampling and lab methods followed the procedure for antidegradation surveys described in Appendix A of "A Benthic Index of Biotic Integrity for Wadeable Freestone Streams in Pennsylvania" (Chalfant 2007).

All macroinvertebrate samples at the sampling reaches, approximately 100 meters in length, were collected using a D-frame net with 500-micron mesh. Sample collection was spread out over the entire reach, with six of the best riffle habitat areas of different depths (fast and slow) and substrate types chosen for sampling.

At each of the six riffles per sampling reach, the substrate within an approximately one square meter area was disturbed immediately upstream of the net by kicking for about 1 minute to an approximate depth of 10 cm. The resulting six "D-frame efforts" for each sampling reach were composited into one sample container and preserved with 95% ethanol.

Prior to the sub-sampling, each composited sample from the sampling reach was rinsed in a standard USGS No. 35 sieve to remove fine materials and residual preservative. The composited sample was then placed in a 28-square gridded pan (Pan 1) 14" x 8" x 2" in size, and stirred after water was added to the depth of the sample. A 2" x 2" grid was randomly selected using a 28 random number set, and all debris and organisms were entirely removed from the grid with a tubular 4 $inch^2$ grid cutter and placed in a second gridded pan (Pan 2). All identifiable organisms from the grid were floated, entirely picked, counted, and sub-totaled. This procedure was repeated until 4 randomly selected grids had been sub-sampled and 200 organisms ($\pm$ 20%) were obtained from Pan 2.

Nearly all of the sub-sampled macroinvertebrates were identified to the genus-level with several individuals identified to the family level, the lowest level of taxonomy for which they could be confidently identified.

To assess the biological condition of the two sampling sites, the identified, macroinvertebrate taxa from the sub-samples were applied to the PA DEP's Benthic Index of Biotic Integrity (IBI) for Wadeable Freestone Streams, and the Biological Condition Gradient (BCG) for Freestone (Non-Calcareous) Streams of Pennsylvania. Stream community type evaluation was based on the presence of genus-level macroinvertebrate indicator species as defined by the Pennyslvania Aquatic Community Classification Project.

Results and Discussion

The macroinvertebrate sub-samples from Site #1 and Site #2 contained a total of 27 taxa each, with individual organisms totaling 219 in the Site #1 sub-sample and 177 in the Site #2 sub-sample. The two sites had 17 taxa that were the same, with 10 different taxa being found at each site for a combined total of 37 taxa identified from the two sites. A table for each site summarizing the macroinvertebrate taxa and their attributes can be found in Appendix A.

Using PA DEP's Benthic Index of Biotic Integrity (IBI) for Wadeable Freestone Streams as an evaluative tool, the collected and sub-sampled macroinvertebrate assemblage from Site #1 scored 80.1 on the IBI. The collected and sub-sampled macroinvertebrate assemblage from Site #2 scored 78.97. A table containing the IBI metric values and scores for Site #1 and #2 can be found in Appendix B-1.

The IBI consists of 6 metrics, each a measurable, ecologically-based attribute of macroinvertebrate populations that predictably change (numerically increasing or decreasing) in response to increased human-associated stressors. Summing the numeric scores of the metrics produces a single score representing the site's level of biological integrity. A table containing an explanation of the 6 metrics and their expected response to stressors is found in Appendix B-2.

The PA DEP has established use attainment thresholds or benchmarks based on IBI scores in assessing Aquatic Life Use (ALU) antidegradation designations such as High Quality (HQ) and Exceptional Value (EV) waters. An IBI score of 80 or greater is the antidegradation candidacy benchmark required as a qualifier for special protection status of EV and HQ (Chalfant 2007).

Other factors besides IBI scores are considered when determining antidegradation candidacy and to distinguish between EV and HQ uses. Chapter 93.4b.(b) of the Pennsylvania Code: *Qualifying as an Exceptional Value Water* states that a water qualifies as EV if it is a surface water of exceptional ecological significance or if it qualifies as an HQ water and meets one or more of several conditions, including "the water is an outstanding national, state, regional, or local water source."

To further assess the biological condition of the two sampling sites, the macroinvertebrate sub-samples were analyzed using the Biological Condition Gradient (BCG) for Freestone (Non-Calcareous) Streams of Pennsylvania (Gerritsen and Jessup 2007).

Incorporating a series of potential decision rules, the BCG identifies six conceptual resource condition tiers or biological condition classes of a stream reach along a general

stressor gradient ranging from a tier 1 native or natural condition, to a severely degraded tier 6 condition.

The biological condition required to support an ALU for a specific water body can be described in terms of BCG tiers (Davies and Jackson 2006). "For example, the biological condition associated with wild brook trout reproduction requires a very high-quality stream and may be defined as a narrow range of nearly natural BCG tiers, while the biological condition needed to support warm water recreational fisheries may span a broader range of conditions" (Chalfant 2007).

"The antidegradation candidacy benchmark of an IBI score greater than or equal to 80.0 approximates the separation between BCG tier 2 conditions and less pristine conditions" (Chalfant 2007). Because there is no clear consensus as to whether a pristine (no human impacts) tier 1 condition actually exists in Pennsylvania, accordingly, "the biological criterion for EV waters could be BCG Tier 2 or better" (Gerritsen and Jessup 2007).

Site #1 had the required characteristics of a Tier 2 condition, and Site #2, missing just one of the six Tier 2 qualification rules, but meeting all Tier 3 rules, was designated a Tier 3 condition. Tier 1 and Tier 2 have been described as "outstanding condition waters" having a native or natural condition with minimal ecosystem changes, and Tier 3 described as "good condition waters" (Gerritsen and Jessup 2007). Tables containing the BCG Tier Assessments for Site #1 and #2 can be found in Appendix C-1, and descriptions of BCG taxa attributes and BCG resource condition tiers can be found in Appendix C-2.

In addition to the presence of wild brook trout reproduction, high-quality streams in Pennsylvania can also be identified by the presence of macroinvertebrate indicator species in combination with habitat characteristics.

Macroinvertebrate indicator species from the two sampling sites were used to classify each site's community type based on the genus-level macroinvertebrate communities defined by the Pennyslvania Aquatic Community Classification Project (PACC). The PACC used statistically significant indicator values of macroinvertebrate taxa to assist in classifying 12 genus-level stream communities.

Although both sampling sites had representative macroinvertebrate species indicators of several potential PACC genus-level stream community types, the combination of expected community indicator species, and predicted average values for taxa richness, number of EPT (mayfly, stonefly and caddisfly) taxa, number of intolerant taxa, and stream/watershed characteristics best describe the two sites as a "High Quality Small Stream Community." The

PACC describes the High Quality Stream Community as a "strong indicator of a high quality, naturally functioning small stream system" (Walsh et al. 2007a).

It should be noted that the term "high quality" as used by the PACC depicts a stream community type found in reaches having little watershed disturbance, and should not be confused with the HQ Aquatic Life Use (ALU) antidegradation designation.

Two of the five main community indicators for the High Quality Small Stream Community were relatively abundant in both sub-samples: the mayfly *Epeorus,* having the highest significant indicator species value for the community, and *Rhyacophila,* a caddisfly (Walsh et al. 2007b).

The Site #1 sub-sample also had another of the main community indicators, *Pteronarcys*, a stonefly. Both *Epeorus* and *Pteronarcys* have an assigned pollution tolerance value of 0 (most intolerant value) by the PA DEP (Chalfant 2007) and a thermal preference for colder-cooler waters (Poff et al. 2006), a water temperature characteristic of the High Quality Small Stream Community.

Tables listing the significant indicator taxa for a High Quality Small Stream Community and several other stream community types, and the indicator taxa of these communities present in the two sub-samples can be found in Appendix D. Photos of *Epeorus*, *Pteronarcys*, and the mayfly *Ameletus*, another highly sensitive, cold-cool water macroinvertebrate (Poff et al. 2006) present in the Site #1 sub-sample, can be found in Appendix E.

The presence of a high proportion of intolerant, sensitive, macroinvertebrate taxa (reflected in the IBI, BCG Tier, and PACC stream community assessment results) and the occurrence of naturally-reproducing brook trout populations (recently added to the Pennsylvania Wildlife Action Plan as a species of greatest conservation need) indicates the existence of nearly natural biological conditions of high water quality and ecological significance at the two sampling reaches.

These findings may warrant further evaluation of portions of the upper Bushkill Creek by PA DEP biologists for possible consideration of Exceptional Value (EV) designated use.

Acknowledgements

I'd like to thank Mr. William Sweeney, Jacobsburg Environmental Education Center, for his assistance with the macroinvertebrate survey, and his time in acquiring landowner permission.

Literature Cited

Chalfant, B. 2007. A benthic index of biotic integrity for wadeable freestone streams in Pennsylvania. Pennsylvania Department of Environmental Protection.

Davies, S.P. and S.K. Jackson. 2006. The biological condition gradient: a descriptive model for interpreting change in aquatic systems. Ecological Applications 16(4):1251-1266.

Frey, D. 1977. Biological integrity, a historical approach. Pages 127-140 in R.K. Ballentine and L.J. Guarraia (editors). The Integrity of Water. Proceedings of a Symposium, March 10-12, 1975, U.S. Environmental Protection Agency, Washington, D.C.

Gerritsen, J. and B. Jessup. 2007. Identification of the biological gradient for freestone (non-calcareous) streams of Pennsylvania. Appendix G-Pennsylvania Tiered Aquatic Life Use Workshop Report. A benthic index of biotic integrity for wadeable freestone streams in Pennsylvania. Pennsylvania Department of Environmental Protection.

Karr, J.R., and E.W. Chu 1999. Restoring life in running waters: better biological monitoring. Island Press, Washington, D.C.

Leonhardt, L. 2007. Fish survey report Bushkill Creek and Sober's Run, Northampton County, PA. Bushkill Stream Conservancy.

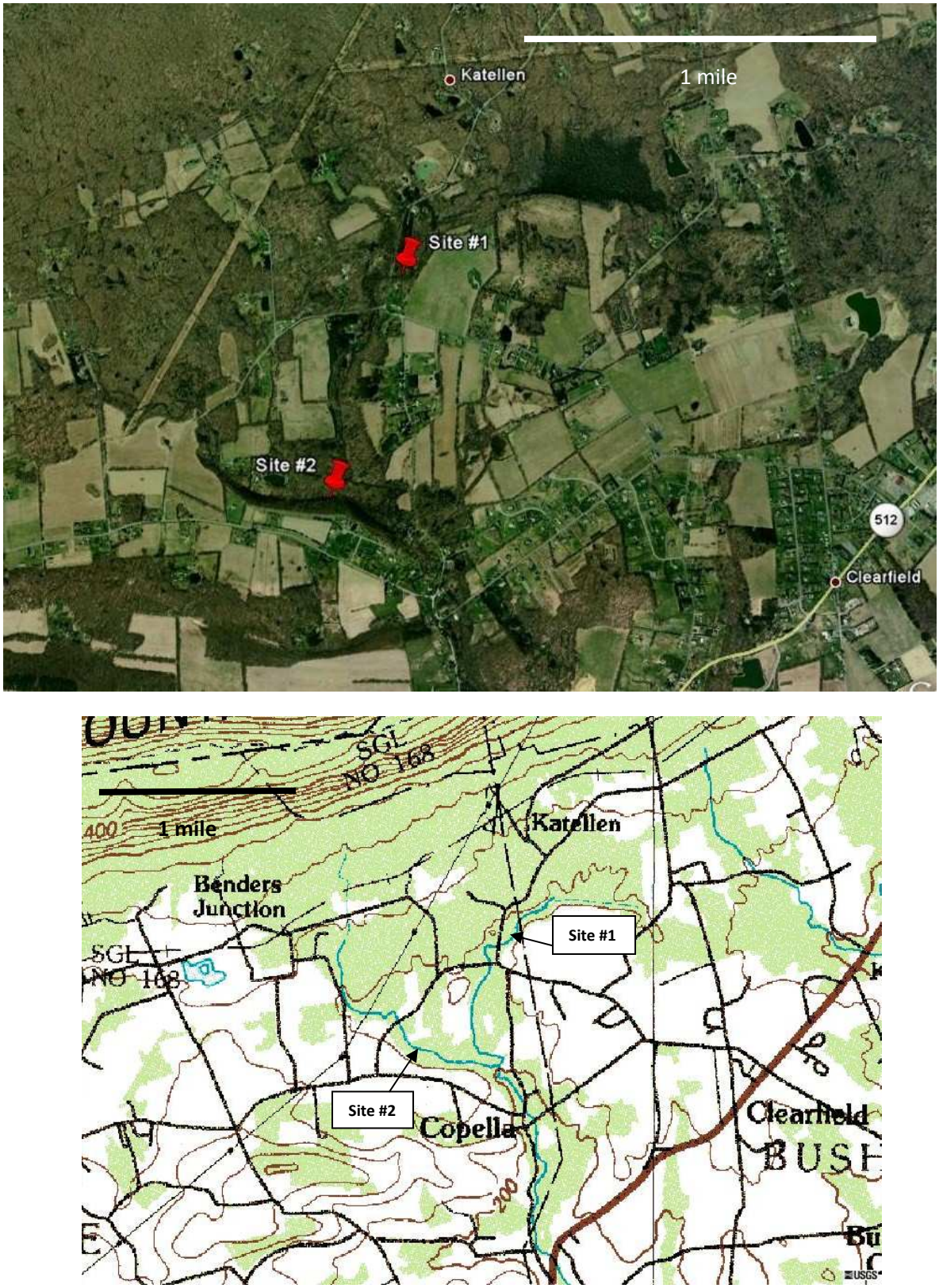
Poff, N. L., J.D. Olden, N.K.M. Viera, D.S. Finn, M.P. Simmons, and B.C. Kondratieff. 2006. Functional trait niches of North American lotic insects: traits-based ecological applications in light of phylogenetic relationships. Journal of the North American Benthological Society 25(4):730-755

Royer, M., B. Wendelgass, A. D. Steindler, E. Belser, F. Zerbe, J. Hoekstra, B. Smith, D. Nardone, L. Imgrund. 2007. The effects of special protection designation: a guide for communities. Pennsylvania Campaign for Clean Water

Walsh, M.C., J. Deeds, and B. Nightingale. 2007a. User's Manual and Data Guide to the Pennsylvania Aquatic Community Classification. Pennsylvania Natural Heritage Program, Western Pennsylvania Conservancy, Middletown, PA, and Pittsburgh, PA.

Walsh, M.C., J. Deeds, and B. Nightingale. 2007b. Classifying Lotic Systems for Conservation: Methods and Results of the Pennsylvania Aquatic Community Classification. Pennsylvania Natural Heritage Program, Western Pennsylvania Conservancy, Middletown, PA, and Pittsburgh, PA.

MAP 1: Upper Bushkill Creek Macroinvertebrate Survey Sampling Site Locations



(Image sources: Top Map: ***Google satellite image (USGS and PA DCNR)***. Bottom Map: ***USGS topographical map Wind Gap Quadrant)***

Appendix A

BUSHKILL CREEK SITE #1 March 29, 2008 MACROINVERTEBRATE SUB-SAMPLE Taxonomic Classification Class	Order	Family	Genus	Number of Individuals in Sample	Functional Feeding Group	Biological Condition Gradient Attribute	Hilsenhoff Pollution Tolerance Value (PA DEP Appendix E)	Tolerance Category I=Intolerant ≤ 5 T=Tolerant ≥ 6
INSECTA	Ephemeroptera	Heptageniidae	*Epeorus*	13	SC (scraper)	2	0	I
			Stenonema	3	SC	3	3	I
		Ephemerellidae	*Ephemerella*	5	CG (collector-gatherer)	3	1	I
		Leptophlebiidae	*Paraleptophlebia*	1	CG	2	4	I
		Ameletidae	*Ameletus*	2	CG	2	0	I
	Plecoptera	Perlidae	*Acroneuria*	22	PR (predator)	3	0	I
		Pteronarcidae	*Pteronarcys*	2	SH (shredder)	2	0	I
		Nemouridae	*Amphinemura*	1	SH	3	3	I
			Prostoia	3	SH	3	2	I
			Ostrocerca	1	SH	3	2	I
		Leuctridae	*Leuctra*	1	SH	3	0	I
	Tricoptera	Rhyacophilidae	*Rhyacophila*	8	PR	2	1	I
		Hydropsychidae	*Cheumatopsyche*	38	FC (filterer-collector)	4	6	T
			Hydropsyche	5	FC	4	5	I
		Philopotamidae	*Chimarra*	32	FC	4	4	I
			Dolophilodes	1	FC	2	0	I
		Uenoidae	*Neophylax*	7	SC	3	3	I
	Diptera	Tipulidae	*Hexatoma*	1	PR	3	2	I
			Tipula	1	SH	4	4	I
			Antocha	1	CG	4	3	I
		Chironomidae		1	CG	5	6	T
		Simuliidae	*Prosimulium*	61	FC	3	2	I
			Simulium	1	FC	4	6	T
		Tabanidae	*Tabanus*	1	PR	5	5	I
	Coleoptera	Elmidae	*Promoresia*	1	SC	3	2	I
	Odonata	Gomphidae	*Stylogomphus*	3	PR	4	4	I
	Megaloptera	Corydalidae	*Nigronia*	3	PR	3	2	I
TOTAL NUMBER of INDIVIDUALS IN SAMPLE				219				
TOTAL TAXA = 27								

BUSHKILL CREEK SITE #2 March 29, 2008 MACROINVERTEBRATE SUB-SAMPLE Taxonomic Classification Class	Order	Family	Genus	Number of Individuals in Sample	Functional Feeding Group	Biological Condition Gradient Attribute	Hilsenhoff Pollution Tolerance Value (Appendix E DEP)	Tolerance Category I=Intolerant ≤ 5 T=Tolerant ≥ 6
INSECTA	Ephemeroptera	Heptageniidae	*Epeorus*	27	SC (scraper)	2	0	I
		Ephemerellidae	*Ephemerella*	3	CG (collector-gatherer)	3	1	I
		Leptophlebiidae	*Paraleptophlebia*	2	CG	2	1	I
		Baetidae		1	CG	3	6	T
	(Oligoneuriidae)	Isonychiidae	*Isonychia*	1	CG	3	3	I
	Plecoptera	Perlidae	*Acroneuria*	5	PR (predator)	3	0	I
		Nemouridae	*Amphinemura*	1	SH (shredder)	3	3	I
			Prostoia	2	SH	3	2	I
		Chloroperlidae	*Haploperla*	1	PR	3	0	I
			Sweltsa	1	PR	3	0	I
		Perloididae		1	PR	2	2	I
		Taeniopterygidae	*Strophopteryx*	2	SH	3	3	I
	Tricoptera	Rhyacophilidae	*Rhyacophila*	4	PR	2	1	I
		Hydropsychidae	*Cheumatopsyche*	1	FC (filterer-collector)	4	6	T
		Polycentropodidae	*Polycentropus*	3	FC	4	6	T
		Philopotamidae	*Chimarra*	1	FC	4	4	I
		Uenoidae	*Neophylax*	2	SC	3	3	I
	Diptera	Tipulidae	*Hexatoma*	9	PR	3	2	I
			Tipula	2	SH	4	4	I
			Antocha	2	CG	4	3	I
			Dicranota	1	PR	4	3	I
		Chironomidae		1	CG	5	6	T
		Simuliidae	*Prosimulium*	100	FC	3	2	I
	Coleoptera	Psephenidae	*Psephenus*	1	SC	4	4	I
		Elmidae	*Promoresia*	1	SC	3	2	I
	Odonata	Gomphidae	*Lanthus*	1	PR	3	5	I
	Megaloptera	Corydalidae	*Nigronia*	1	PR	3	2	I
TOTAL NUMBER of INDIVIDUALS IN SAMPLE				177				
TOTAL TAXA = 27								

Appendix B-1

Bushkill Creek Site #1 Macroinvertebrate Sub-sample 3/29/08
Index of Biological Integrity[1] (IBI) Metric Values and Score

Metric	Standardized Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score (Maximum= 1.000)
Modified Beck's Index	Observed value/39	**28**	**.718**	**.718**
EPT Taxa Richness	Observed value/23	**17**	**.739**	**.739**
Total Taxa Richness	Observed value/35	**27**	**.771**	**.771**
Shannon Diversity Index	Observed value/2.90	**2.36**	**.814**	**.814**
Hilsenhoff Biotic Index	(10-observed)/ (10-1.78)	**2.77**	**.880**	**.880**
Percent Intolerant Individuals	Observed value/92.5	**81.7**	**.883**	**.883**
Average of adjusted standardized core metric scores x 100 = **IBI Score =**				**80.1**

[1]Index of Biotic Integrity for Wadeable, Freestone Streams in Pennsylvania

Bushkill Creek Site #2 Macroinvertebrate Sub-sample 3/29/08
Index of Biological Integrity[1] (IBI) Metric Values and Score

Metric	Standardized Equation	Observed Metric Value	Standardized Metric Score	Adjusted Standardized Metric Score (Maximum= 1.000)
Modified Beck's Index	Observed value/39	**24**	**.615**	**.615**
EPT Taxa Richness	Observed value/23	**17**	**.739**	**.739**
Total Taxa Richness	Observed value/35	**27**	**.771**	**.771**
Shannon Diversity Index	Observed value/2.90	**1.79**	**.617**	**.617**
Hilsenhoff Biotic Index	(10-observed)/ (10-1.78)	**1.81**	**.996**	**.996**
Percent Intolerant Individuals	Observed value/92.5	**96.6**	**1.044**	**1.000**
Average of adjusted standardized core metric scores x 100 = **IBI Score =**				**78.97**

[1]Index of Biotic Integrity for Wadeable, Freestone Streams in Pennsylvania

Appendix B-2

Index of Biological Integrity (IBI) for Wadeable, Freestone Streams in Pennsylvania
An explanation[1] of the IBI's 6 metrics and their expected response to stressors

Metric Name	Type of Metric	Description	Expected Response to Increasing Anthropogenic (Human-associated) Stress
Modified Beck's Index	Taxonomic Composition (relative abundance, identity, sensitivity, dominance)	A weighted count of taxa with pollution tolerance values of 0, 1, or 2 in a sub-sample.	Decrease
EPT Taxa Richness	Community Structure (taxonomic diversity)	A count of the number of taxa belonging to the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) in a sub-sample.	Decrease
Total Taxa Richness	Community Structure	A count of the total number of taxa in a sub-sample, or total taxa richness.	Decrease
Shannon Diversity Index	Taxonomic Composition	Measures taxonomic richness and evenness of individuals across taxa of a sub-sample.	Decrease
Hilsenhoff Biotic Index	Taxonomic Composition	Calculated as an average pollution tolerance value weighted by the number of individuals of each taxa in the sub-sample.	Increase
Percent Intolerant Individuals	Taxonomic Composition	The percentage of individuals with pollution tolerance values of five or less in a sub-sample.	Decrease

[1] Table terms and descriptions derived from Chalfant 2007

Appendix C-1

Biological Condition Gradient[2] (BCG) Tier Assessment
Bushkill Creek Site #1 Macroinvertebrate Sub-Sample 3/29/08

Characteristic	Site #1 Macroinvertebrate Data	Quantitative Tier Rule
Total Taxa	27	**Tier 2**: Total taxa >25 genera
Total Individuals	219	**Tier 2**: Total Individuals > 50% of target (200)
Taxa (II)	6	**Tier 2**: Taxa (II) > 33% of Taxa (III) (Bushkill Creek Site #1 = 50%)
Taxa (II + III)	18 (6 +12)	**Tier 2**: Taxa (II + III) > 50% of all taxa (Bushkill Creek Site #1 = 66.7%)
Abundance (II + III)	136	**Tier 2**: Abundance (II + III) > 50% of sample (Bushkill Creek Site #1 = 62.1%)
Individuals (V)	2	**Tier 2**: Individuals (V) < 25% (Bushkill Creek Site #1 = .91%)
BCG Resource Condition Tier		**Considered Tier 2 for Macroinvertebrates (All Tier 2 Quantitative Rules Apply)**

Biological Condition Gradient[2] (BCG) Tier Assessment
Bushkill Creek Site #2 Macroinvertebrate Sub-Sample 3/29/08

Characteristic	Site #2 Macroinvertebrate Data	Quantitative Tier Rule
Total Taxa	27	**Tier 2**: Total taxa >25 genera
Total Individuals	177	**Tier 2**: Total Individuals > 50% of target (200)
Taxa (II)	4	**Fails Tier 2**: Taxa (II) > 33% of Taxa (III) (Bushkill Creek Site #2 = 26.7%) **Passes Tier 3:** Taxa (II) >0 taxa
Taxa (II + III)	19 (4+15)	**Tier 2**: Taxa (II + III) > 50% of all taxa (Bushkill Creek Site #2 = 70.4%)
Abundance (II + III)	165	**Tier 2**: Abundance (II + III) > 50% of sample (Bushkill Creek Site #2 = 93.2%)
Individuals (V)	1	**Tier 2**: Individuals (V) < 25% (Bushkill Creek Site #2 = .56%)
Indicator Taxa	.56% 17 taxa	**Tier 3 Rules** Hydropsyche < 20% abundance EPT taxa > = 12 taxa
BCG Resource Condition Tier		**Considered Tier 3 for Macroinvertebrates (Failed one Tier 2 Rule; meets all Tier 3 rules)**

[2] **Appendix G - Pennsylvania Tiered Aquatic Life Use Workshop Report: "Identification of the Biological Condition Gradient for Freestone (Non-Calcareous) Streams of Pennsylvania" February 2007**

Appendix C-2

Biological Condition Gradient (BCG) Taxa Attribute and Resource Condition Tier Descriptions

BCG Taxa Attributes [2] **BCG Resource Condition Tiers[2]**

Taxa Type	Taxa Attribute		Resource Condition Tier	Tier Description
I	Endemic, Rare		1	Natural or native condition
II	Highly Sensitive		2	Minimal changes in biotic community structure and ecosystem function
III	Intermediate Sensitive		3	Evident changes in biotic community structure; minimal changes in ecosystem function
IV	Intermediate Tolerant		4	Moderate changes in biotic community structure; minimal changes in ecosystem function
V	Tolerant		5	Major changes in biotic community: moderate changes in ecosystem function
VI	Exotic, Invasive		6	Severe changes in biotic community structure: major loss of ecosystem function
x	unassigned			

[2] **Appendix G - Pennsylvania Tiered Aquatic Life Use Workshop Report: "Identification of the Biological Condition Gradient for Freestone (Non-Calcareous) Streams of Pennsylvania" February 2007**

Appendix D

Bushkill Creek Site #1 and Site #2 Sub-Samples 3/29/08 Significant Macroinvertebrate Indicator Species/Genus-Level Macroinvertebrate Stream Communities

High Quality Small Stream Community	Site #1	Site #2
Insecta Ephemeroptera Heptageniidae *Epeorus*	X	X
Insecta Plecoptera Perlodidae *Isoperla*		
Insecta Coleoptera Elmidae *Oulimnius*		
Insecta Plecoptera Pteronarcyidae *Pteronarcys*	X	
Insecta Trichoptera Rhyacophilidae *Rhyacophila*	X	X
Insecta Trichoptera Hydropsychidae *Diplectrona*		
Insecta Plecoptera Perlidae *Acroneuria*	X	X
Insecta Ephemeroptera Heptageniidae *Cinygmula*		
Insecta Plecoptera Chloroperlidae *Sweltsa*		X
Insecta Diptera Tipulidae *Hexatoma*	X	X
Insecta Ephemeroptera LeptophlebiidaeParaleptophlebia	X	X
Insecta Odonata Gomphidae *Lanthus*		X
Insecta Diptera Tipulidae *Dicranota*		X
Insecta Trichoptera Uenoidae *Neophylax*	X	X
Insecta Diptera Empididae *Chelifera*		
Insecta Trichoptera Hydropsychidae *Parapsyche*		
Insecta Coleoptera Psephenidae *Ectopria*		
Insecta Plecoptera Perlodidae *Yugus*		
Insecta Plecoptera Chloroperlidae *Haploperla*		X

High Quality Headwater Stream Community	Site #1	Site #2
Insecta Plecoptera Nemouridae *Amphinemura*	X	X
Insecta Trichoptera Lepidostomatidae *Lepidostoma*		
Insecta Plecoptera Leuctridae *Leuctra*	X	
Insecta Diptera Simuliidae *Prosimulium*	X	X
Insecta Diptera Tabanidae *Chrysops*		
Insecta Diptera Tipulidae *Limnophila*		
Insecta Trichoptera Limnephilidae *Pycnopsyche*		
Insecta Diptera Tipulidae *Pseudolimnophila*		
Insecta Odonata Cordulegastridae *Cordulegaster*		
Insecta Plecoptera Nemouridae *Ostrocerca*	X	
Insecta Diptera Tipulidae *Molophilus*		

X = present in sample

Note:
Indicator species for each stream community type listed down column from highest to lowest significant indicator values (from Walsh et al. 2007b).

Species present in samples designated as Cold stenothermal or cool eurythermal
All other species present in samples designated as Cool/warm eurythermal (from Poff et al. 2006).

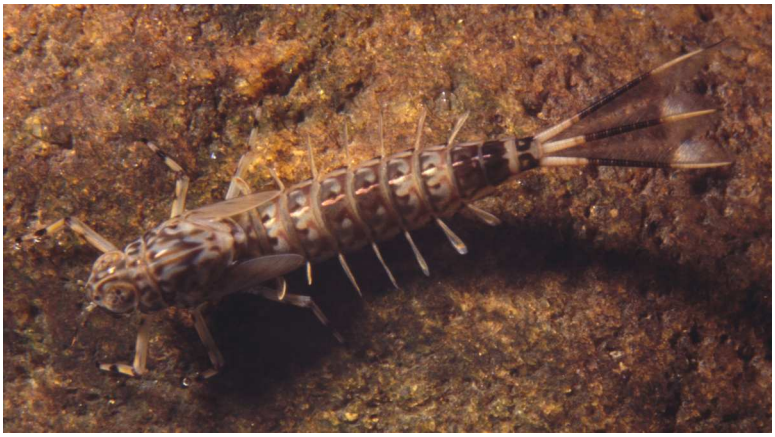
Forested Headwater Stream Community	Site #1	Site #2
Insecta Plecoptera Chloroperlidae *Alloperla*		
Insecta Diptera Tipulidae *Tipula*	X	X
Insecta Ephemeroptera Ameletidae *Ameletus*	X	

Common Small Stream Community	Site #1	Site #2
Insecta Ephemeroptera Heptageniidae *Stenonema*	X	
Insecta Coleoptera Psephenidae *Psephenus*		X
Insecta Trichoptera Philopotamidae *Chimarra*	X	X
Insecta Trichoptera Glossosomatidae *Glossosoma*		
Insecta Ephemeroptera Isonychiidae *Isonychia*		X
Insecta Trichoptera Hydropsychidae *Macrostemum*		
Insecta Megaloptera Sialidae *Sialis*		
Insecta Odonata Gomphidae *Stylogomphus*	X	
Insecta Megaloptera Corydalidae *Corydalus*		
Insecta Odonata Gomphidae *Arigomphus*		
Insecta Plecoptera Perlidae *Eccoptura*		

Appendix E

Upper Bushkill Creek Highly Sensitive Cold/Cool Water Macroinvertebrate Indicator Species

Mayfly larva: *Epeorus*



Mayfly larva: *Ameletus*

Stonefly larva: *Pteronarcys*

Photos: Lance Leonhardt

Appendix D

Fish Survey Report
Bushkill Creek & Sobers Run

Fish Survey Report

Bushkill Creek and Sober's Run

Northampton County, PA

Submitted by Lance Leonhardt

To the Bushkill Stream Conservancy

January 24, 2008

Summary

Fish surveys were conducted from July through October 2007 at seven sampling sites on two tributaries and the mainstem of the Bushkill Creek, and at six sampling sites on the east and west branches of Sober's Run, a tributary of Bushkill Creek, located in Northampton County, Pennsylvania. The purpose of the surveys was to confirm the presence of brook trout (*Salvelinus fontinalis*) in the Bushkill Creek Watershed and document the fish species assemblages at the sampling site locations.

A total of 35 brook trout individuals, ranging in total length from 60 to 245 mm (2.4-9.7 in.), were found at four sampling sites on Bushkill Creek. A total of 8 brook trout individuals, ranging in total length from 65 to 320 mm (2.5-13.0 in.), were found at two sampling sites on Sober's Run.

A total of 19 fish species were identified during the surveys on Bushkill Creek and Sober's Run, with 18 fish species identified at the sampling sites on Bushkill Creek, and 17 fish species identified at the sampling sites on Sober's Run.

Length-frequency distributions of brook trout individuals collected during the surveys indicate reproduction is occurring in small, self-sustaining brook trout populations in both Bushkill Creek and Sober's Run.

Introduction

The 80 square mile Bushkill Creek Watershed is located almost entirely within the Great Valley Section of the Ridge and Valley Physiographic Province, in Northampton County, Pennsylvania. Main watershed streams include the 21 mile Bushkill Creek, and its two main tributaries, Sober's Run and the Little Bushkill Creek.

The Bushkill Creek Watershed can be viewed as having an upper basin, of mainly non-carbonate shale bedrock, and a lower basin, of primarily limestone and dolomite bedrock. In the upper basin, water from springs on the southern slope of the Blue Mountain (Kittatinny Ridge) begin the headwaters that gather and flow south through the shales of the Ordovician-aged Martinsburg Formation. In this upper basin, with gently rolling terrain, stream pH ranges from 6.3 to 7.5, and stream flow varies considerably in response to precipitation, with rapid run-off and minimal underground drainage (Bradt 1974; Bradt 1999). By contrast, the lower basin, fed by numerous limestone springs, has less variable stream flow, and stream pH ranges from 7.2 to 8.9 (Bradt 1974; Bradt 1999).

Within the watershed, water temperatures are low enough (66^0F or about 19^0C in July and August) and dissolved oxygen levels high enough (minimum of 7 mg/l) for the Bushkill Creek and its tributaries to be designated as HQ-CWF (High Quality Waters and Cold Water Fish) in The Pennsylvania Code Title 25, Section 93.9c. Drainage List C**.**

Located in the upper basin of the watershed, the fish survey area included Bushkill Creek, from its headwaters to approximately 3 miles upstream of its entry into the Jacobsburg Environmental Education Center, and the east and west branches of Sober's Run, a tributary of Bushkill Creek. The purpose of the survey was to confirm the presence of brook trout in the survey area and document the fish species assemblages at the survey sites. The last officially confirmed report of brook trout in the Bushkill Creek Watershed was in 1976 by the Pennsylvania Fish and Boat Commission on a section of Bushkill Creek about .5 miles downstream of Copella (Stream Examination Report PFBC Bushkill Creek section 02, September 15, 1976).

Brook trout were the targeted fish species of the survey because of their ecological value. Brook trout require cold, clear, stream water for sustainable populations, and so, are ecological indicators of such conditions, which in Pennsylvania are usually provided by extensively forested habitat of high ecological integrity. Strong wild brook trout populations demonstrate that a coldwater stream or river ecosystem is healthy and that water quality is excellent. A decline in brook trout populations can serve as an early warning that the health of an entire system is at risk (EBTJV 2006).

Once found in nearly all of Pennsylvania's streams (MacCrimmon and Campbell 1969), brook trout have had their range reduced over the last 200 years to where only 1% of the state's subwatersheds now have intact brook trout populations (>90% of historical habitat occupied by self-reproducing brook trout) (EBTJV 2006). A subwatershed typically contains 25-75 miles of streams. In subwatersheds where self-sustaining populations were present, 39% have lost over half the habitat supporting brook trout, and 34% of Pennsylvania's subwatersheds have been documented as having brook trout being extirpated or no longer present (EBTJV 2006). A map created by Trout Unlimited in 2006 of Pennsylvania's brook trout status by subwatershed (map 1) shows Northampton County's Monocacy Creek and Martin's Creek as greatly reduced (1-50% historical habitat occupied by self-reproducing brook trout) and Bushkill Creek as being extirpated for brook trout.

As Pennsylvania's only native stream salmonid the brook trout is a coldwater species dependent on waters colder than 24^0C or 75.2^0F, making summer stream temperatures an important factor influencing their distribution and abundance (MacCrimmon and Campbell 1969). The apparent upper limit for the natural occurrence of self-sustaining populations is about 19^0C or 66.2^0F, with the optimum temperature range for growth reported at 10-19^0C or 50-66.2^0F (Hokanson *et al.* 1973).

Although brook trout are generally more acid tolerant than other salmonid species, with brook trout in Pennsylvania reported to have inhabited a bog stream with a pH less than 4.75 (Dunson and Martin 1973), their optimal pH range is reported to be 6.5-8.0 (Creaser 1930; Raleigh 1982). Stream alkalinity levels (the amount of dissolved calcium carbonate) has been associated with brook trout growth, with higher alkalinity increasing the probability of a stream supporting harvestable-length ($\geq$7 in.) brook trout (Kocovsky and Carline 2006) and having greater annual net brook trout production (Cooper and Scherer 1967).

Stream fertility has also been related to size at first maturity. Brook trout inhabiting softwater, infertile, freestone streams in Pennsylvania have been found to grow slowly and mature at a small size; while those in hardwater, fertile, limestone streams grow fast and mature at the same age, but at a larger size (Cooper and Scherer 1967).

In both infertile and fertile streams wild brook trout are relatively short-lived, with few living more than four or five years and none more than six years in one study (Cooper 1967). Sexual maturity has been reported to be attained by the majority of brook trout in infertile Pennsylvania streams at age 2 (3rd year of life), although many males and females mature at age 1 (2nd year of life) (Wydoski and Cooper 1966). Most of these individuals mature, spawn, and

die before reaching six inches in total length, with spawning occurring each year from September to early November (Wydoski and Cooper 1966).

In general, brook trout populations have been found to respond most negatively to factors that lower survival of brook trout near the age of first reproduction (large juveniles and small adults with high reproductive value), and to factors that decrease the growth of small juveniles (Marschall and Crowder 1996).

Human activity that warms stream water, increases siltation, and negatively alters stream chemistry, such as deforestation and development, can impact environmentally sensitive brook trout populations at all life stages. Within the Mid-Atlantic region (MD, PA, WV, VA, NJ) it has been found that when human land use exceeded 18% in a subwatershed, brook trout were likely extirpated, while in subwatersheds where human land use was less than 10%, intact populations were most likely to be found (Hudy et.al 2005). In watersheds where impervious surface area (roads, rooftops, parking lots) exceeded 4%, brook trout were eliminated, with substantial reductions in populations occurring with as little as .5% impervious surfaces (Southerland 2005).

Introduction of the European brown trout, having a higher tolerance of warmer water conditions and generally larger maximum size, has led to this exotic species outcompeting, displacing or replacing native brook trout in some stream habitats.

Differences in the distribution of brook and brown trout in Pennsylvania's Ridge and Valley Physiographic Province have been related to a stream's base-flow pH, gradient, and elevation (Kocovsky and Carline 2005). Exclusively allopatric (brook trout only), and brook trout predominated populations (more than 50% brook trout), tend to occur in more acidic, steeper, higher elevation streams; while brown trout predominated and allopatric brown trout populations increase with a lower gradient and elevation, and pH levels above 7.0 (Kocovsky and Carline 2005). As pH decreases from 7.1 to 6.1, it has been found that the proportion of brown trout to brook trout in mixed communities decreases sharply from equal proportions of each species, on average, to brook trout only communities (Kocovsky and Carline 2005).

This "headwaters-brook trout" and " lower reaches-brown trout " distributional pattern may be related to the brown trout's observed physical limitation (caused by a loss of body sodium affecting circulation) at acidic pH, resulting in a reduced ability to compete against brook trout for habitat and food at increasingly acidic stream pH levels (Kocovsky and Carline 2005). Another possible contributing factor is that the brown trout first stocked in Pennsylvania in the 1880's originated from European strains that were adapted to more alkaline conditions (Kocovsky and Carline 2005).

Whatever the reasons, the existing distributional pattern of brook trout in Pennsylvania makes forested headwater streams important refuges for brook trout populations. Recognizing the need to protect these populations, the Pennsylvania Fish and Boat Commission in June 2007 submitted an amendment to the Pennsylvania Wildlife Action Plan, adding the eastern brook trout as a species of greatest conservation need.

As part of the amendment, various conservation, management, and enhancement goals and objectives, derived from Pennsylvania's Brook Trout Conservation Strategy, are outlined. The goals and objectives focus on improving conditions for wild brook trout populations on a statewide basis. Goal 1: "Improve the scientific basis for making conservation decisions for wildlife, with special emphasis on species of greatest conservation concern", has a strategic objective to "inventory unassessed waters to confirm presence of brook trout" (Pennsylvania Wildlife Action Plan Amendment #1). This fish survey addresses that objective by documenting the status of brook trout populations in the Bushkill Creek Watershed.

Sampling Sites

The survey sampling sites can be described as being on low (1-2) order, low gradient, wadeable stream reaches generally having a series of riffle, run, and pool habitats. With primarily shale substrate, the stream reaches could be considered freestone and relatively infertile, particularly at upstream sites. The substrate size ranged from mostly boulder and cobble, to pebble, gravel, and sand, with silt at some locations. The type and amount of surrounding riparian vegetation varied with site location.

A total of seven sampling sites were surveyed on Bushkill Creek: site #1 on the east (Katellen) branch, site #2 on the west (Bender's Junction) branch, and sites #3-7 progressing downstream on the mainstem from Copella to Hahn Road. A total of six sampling sites were surveyed on Sober's Run: sites #1 and #2 on the east fork of the west branch, site #3 on the west fork of the west branch, site #4 on the west branch at the Jacobsburg Environmental Education Center boundary, and sites #5 and #6 on the east branch. Map 2 shows the locations of the sampling sites. A summary of the sampling site characteristics can be found in Appendix A-1, with selected site photographs in Appendix A-2.

All sampling sites except one were located on private land, requiring land owner permission prior to sampling.

Methods

Fish surveys were conducted from July through October during low-flow conditions. Fish assemblages at the sampling sites were surveyed using a Smith-Root, Inc. Model 12-B battery operated backpack electrofishing unit. A two-member team captured the stunned fish in dip nets while working upstream over varying stream lengths, mainly determined by the extent of the landowner's property. Since low-flow conditions during the sampling period often concentrated fish in pool zones isolated by sections of shallow riffles, the pool habitats were targeted to maximize effort. When water depth allowed, riffle zones were sampled to obtain representative fish species.

During collection in a pool or riffle, fish were removed and placed into buckets to assure for thorough sampling. All fish collected during the survey were identified to the species level and released. Brook trout individuals were counted and measured for total length, with photographs of selected brook trout taken for documentation. Stream temperature was also recorded with a hand-held thermometer during each sampling period and a general habitat description of each site was noted. Water pH was measured using a LaMotte colorimeter and stream alkalinity using a LaMotte alkalinity test kit.

Results and Discussion

The fish surveys resulted in a total of 18 fish species identified at the seven sampling sites on Bushkill Creek, and a total of 17 fish species identified at the six sampling sites on Sober's Run. There was a total of 19 fish species for all sampling sites on Bushkill Creek and Sober's Run. A table summarizing the fish species collected for each sampling site can be found in Appendix B, and a table listing fish species guild classifications can be found in Appendix C.

White sucker (*Catostomus commersoni)*, and creek chub (*Semotilus atromaculatus*) were found at all sites on Bushkill Creek and Sober's Run. Blacknose dace (*Rhinichthys attratulus*), cutlips minnow (*Exoglossum maxillingua*), and tessellated darter (*Etheostoma olmstedi*) were found at all sites on Bushkill Creek, and, with the exception of cutlips minnow, at a majority of sites on Sober's Run. Brown trout (*Salmo trutta*) became more prominent at downstream sampling sites.

These indicator species may be used to generally classify the fish assemblages at the sampling sites as coldwater/transitional (mean temperature = 17^0 C or 62.6^0F) fish

communities. Within this category, The Pennsylvania Aquatic Community Classification Project Phase I Final Report 2004 has described Community 1 (Dace and white sucker dominant cold/transitional community) as a: "community found throughout the state in primarily first- and second-order streams that maintained a cool summer temperature of approximately 16°C. The dominant species that defined this community were longnose and blacknose dace, along with white sucker and cutlips minnow, though other generalist headwater species such as creek chub were also commonly present."

The increased presence of brown trout at downstream sites, particularly on Sober's Run, may categorize some sampling sites as Community 2 (Non-native trout dominant cold/transitional community) described in The Pennsylvania Aquatic Community Classification Project Phase I Final Report 2004 as: "very similar to Community 1 in terms of physical stream characteristics. These two communities were the most similar in terms of general species assemblage, but the dominance of non-native brown and rainbow trout may indicate that past or present trout stocking programs have influenced the separation of these two groups."

Water temperatures measured in mid-August at Bushkill Creek sampling sites ranged from 17-22^{0}C. For Sober's Run, sampling site water temperatures measured for all but one site in September and October, ranged from 10-20^{0}C.

Brook trout populations totaling 35 individuals at four sampling sites on Bushkill Creek, and 7 individuals at one sampling site on Sober's Run (another site had just a single brook trout) indicate stream conditions at these stream sections, particularly summer water temperatures, are currently sufficient for their occurrence. Brook trout have been associated with Community 1 and to a lesser degree Community 2 in The Pennsylvania Aquatic Community Classification Project Phase I Final Report 2004. Photographs of several brook trout individuals collected can be found in Appendix D.

The presence of YOY or young-of-the-year (age 0) brook trout ($\leq$80mm total length or 2-3 in.) and the number of individuals collected with total lengths < 180mm or < 7 in. (7 in. is minimum stocking size) provides evidence that successful spawning must be taking place in sections of the Bushkill Creek and Sober's Run.

A table in Appendix E lists the number of brook trout collected at each site and their total lengths. Appendix F contains length-frequency histograms for all brook trout individuals collected and summed for Bushkill Creek Sites #1-4 (figure 1 a and b), and for each of these sites separately (figure 2 a-d). Length-frequency histograms for brook trout individuals collected at Sober's Run Site #1 are also found in Appendix F (figure 3a and b).

Since brook trout spawn only once a year in the fall, with all the eggs hatching around the same time the following spring, that set of young tend to grow at about the same rate for the first few years of life. The yearly separation between the hatching and growth of fish of different ages can be related to their lengths, and the grouping of different age classes.

The length histograms for Bushkill Creek Sites #1-4, separate the lengths of individuals by 5mm increments (figure 1a), and length groups associated with age classes (figure 1b). In naturally reproducing trout populations, a length histogram will be skewed to the left side, indicating YOY (age 0) and trout in their second (Age 1) and third (Age 2) year of life, with decreasing numbers of individuals as size increases (Schoss, Sharpe, Carline 2003). Characterizing a small, but self-sustaining brook trout population, Figure 1b displays this pattern: with YOY present, relatively strong age 1 and age 2 classes (classes with the highest reproductive value), and a decreasing abundance of individuals over 180mm (>7 in.). Figure 3b shows a similar pattern, indicating natural reproduction is also occurring in Sober's Run.

Of the total number of brook trout individuals collected, 20% at sites on the Bushkill Creek, and 7% at Sober's Run Site 1 were >180mm (>7 in.) in total length. One brook trout, or 2.9% of those collected at sites on Bushkill Creek, was 245mm (9.7 in.) in total length. In analyzing 25 years of Pennsylvania wild trout stream data, biologists from Pennsylvania Fish and Boat Commission found very few legal brook trout ($\geq$7 in.) and no brook trout nine inches or longer in half of the state's infertile, freestone, wild brook trout streams (Kaufman 2003).

Using past studies as a reference, brook trout $\geq$ 180mm (>7 in.) in infertile streams are likely in their fourth (age 3) year of life, and trout > 230mm (>9 in.) are possibly in the fifth (age 4) year of life (Cooper 1967); (Cooper and Scherer 1967); (Wydoski and Cooper 1966). The estimated longevity of some of the brook trout collected may be representative of populations in equilibrium with their natural environment with light levels of exploitation (Cooper 1967).

One large brook trout with a total length of 325 mm (13 in.) was collected in late August at site #4 on Sober's Run, in a deep pool beneath the damaged bridge on Keller Rd. It is possible that this fish was naturally occurring, having moved into the stream section from an upstream location. Large adult brook trout have been found to be significantly more mobile than small adults, using this mobility to access more productive, larger-sized stream reaches throughout a watershed in the summer months, then returning upstream in the fall to spawn (Petty and Lamothe 2005). But the size of this individual greatly exceeds expectations, and the fact that no other brook trout were found at this site, or other sites in direct sequence upstream, makes the origin of this trout questionable.

Of the sites sampled, Bushkill Creek Site #1 and Sober's Run Site #1 were found to have exclusively allopatric, brook trout only, populations. Bushkill Creek site #2 on the west (Bender's Junction) branch was found to have a brook trout-predominated population with 79% of the nineteen trout collected being brook trout with the remaining being brown trout. Brown trout were collected only from the downstream-most pool in the sampling length.

The stream at Bushkill Creek Site #1, part of the east (Katellen) branch, receives water from a large, red maple-highbush blueberry swamp upstream. The stream was at base-flow during the time of sampling in August and was tannin-colored, likely a result of organics received from the wetland. At a later date, during higher flow, the water was clear, with a measured pH of 6.5 and an alkalinity of 22 mg/l. It is conceivable that the water's pH would be lower when at base-flow and tannin-colored.

Sober's Run Site #1, at the headwaters of the east fork of the west branch of Sober's Run, flows through mature deciduous forest with some of the larger trees estimated at 150 years of age (William Sweeney, personal communication). The stream had a measured pH of 6.3 and an alkalinity of 20 mg/l. Bushkill Creek site #2 also flows through mature deciduous forest, with sections lined by eastern hemlock and giant rhododendron. The stream had a measured pH of 6.6 and an alkalinity of 20 mg/l.

One possible reason for these three sites having allopatric and brook trout-predominated populations may be the competitive restrictions placed on brown trout by more acidic water, resulting in the pattern observed in Pennsylvania streams of an increasing proportion of brook trout in mixed brook-brown trout populations as base-flow pH declines below 7.1 (Kocovsky and Carline 2005).

This factor may be protecting the existing brook trout from encroachment by brown trout, while the still adequate habitat conditions provided by the surrounding landscape act as a buffer against the human impacts affecting lower stream reaches.

If so, these headwater streams, requiring intact forests and wetland complexes to maintain them, serve as reproductive havens, critical to the persistence of brook trout populations in the Bushkill Creek Watershed.

Acknowledgements

I'd like to thank Mr. William Sweeney, Jacobsburg Environmental Education Center, for his assistance with the fish surveys, and his time in acquiring landowner permission.

Literature Cited

Bradt, P.T. 1974. The ecology of the benthic macroinvertebrate fauna of theBushkill Creek, Northampton County, PA. Ph.D. Dissertation, LehighUniversity, Bethlehem, PA, U.S.A. 182 pp.

Bradt, P. 1999. Stability and resilence in benthic macroinvertebrate assemblages, impact of physical disturbance over twenty-five years. Hydrobiologia 403:123-133.

Cooper, E. L. 1967. Growth and longevity of brook trout (*Salvelinus fontinalis*) in populations subjected to light exploitation. Transactions of the AmericanFisheries Society 96(4):383-386.

Cooper, E. L., and R. C. Scherer. 1967. Annual production of brook trout (*Salvelinus fontinalis*) in fertile and infertile streams of Pennsylvania. Proceedings of the Pennsylvania Academy of Science 41:35-40.

Creaser, C. W. 1930. Relative importance of hydrogen-ion concentration, temperature,dissolved oxygen, and carbon-dioxide tension, on habitat selection by brook trout. Ecology 11:246-262.

Dunson, D.A. and Martin, R.R. 1973. Survival of brook trout in a bog-derived acidity gradient. Ecology, Vol.54, No. 6, pp. 1370-1376

Eastern Brook Trout Joint Venture (EBTJV). 2006. Eastern brook trout: status and threats. Summary report of the Eastern Brook Trout Joint Venture, Trout Unlimited, Arlington,Virginia.

Hokanson, K. E. F., J. H. McCormick, B. R. Jones, and J. H. Tucker. 1973. Thermal requirements for maturation, spawning, and embryo survival of the brook trout, *Salvelinus fontinalis*. Journal of the Fisheries Research Board of Canada 30(7):975-984.

Hudy, M., T. M. Thieling, N. Gillespie and E. P. Smith. 2005. Distribution, status and perturbations to brook trout within the eastern United States. Final report to the steering committee of Eastern Brook Trout Joint Venture.

Kaufmann, M. 2003, January/February Wild trout in Pennsylvania. Pennsylvania Angler and Boater, Vol. 72 No. 1, pp. 24-25

Kocovsky, P.M. and Carline, R.F. 2005. Stream pH as an abiotic gradient influencing distributions of trout in Pennsylvania streams. Transactions of the American Fisheries Society 134:1299-1312.

Kocovsky, P.M. and Carline, R.F. 2006. Influence of landscape-scale factors in limiting brook trout populations in Pennsylvania streams. Transactions of the American Fisheries Society 135:76-88

MacCrimmon, H. R., and J. S. Campbell. 1969. World distribution of brook trout, *Salvelinus fontinalis*. Journal of the Fisheries Research Board of Canada 26:1699-1725.

Marschall, E.A. and Crowder, L.B. 1996. Assessing population responses to multiple anthropogenic effects: a case study with brook trout. Ecological Applications 6(1):152-167.

Pennsylvania Wildlife Action Plan Amendment #1. 2007. An amendment to the Pennsylvania wildlife action plan. Addition of the eastern brook trout as a species of greatest conservation need. Pennsylvania Fish and Boat Commission.

Petty, J.T. and Lamothe, P.J. 2005. Spatial and seasonal dynamics of brook trout populations inhabiting a central Appalachian watershed. Transactions of the American Fisheries Society 134:572-587.

Raleigh, R. F. 1982. Habitat suitability index models: Brook trout. U.S. Dept. Int., Fish and Wildlifife Service. FWS/Obs-82/10.24. 42 pp.

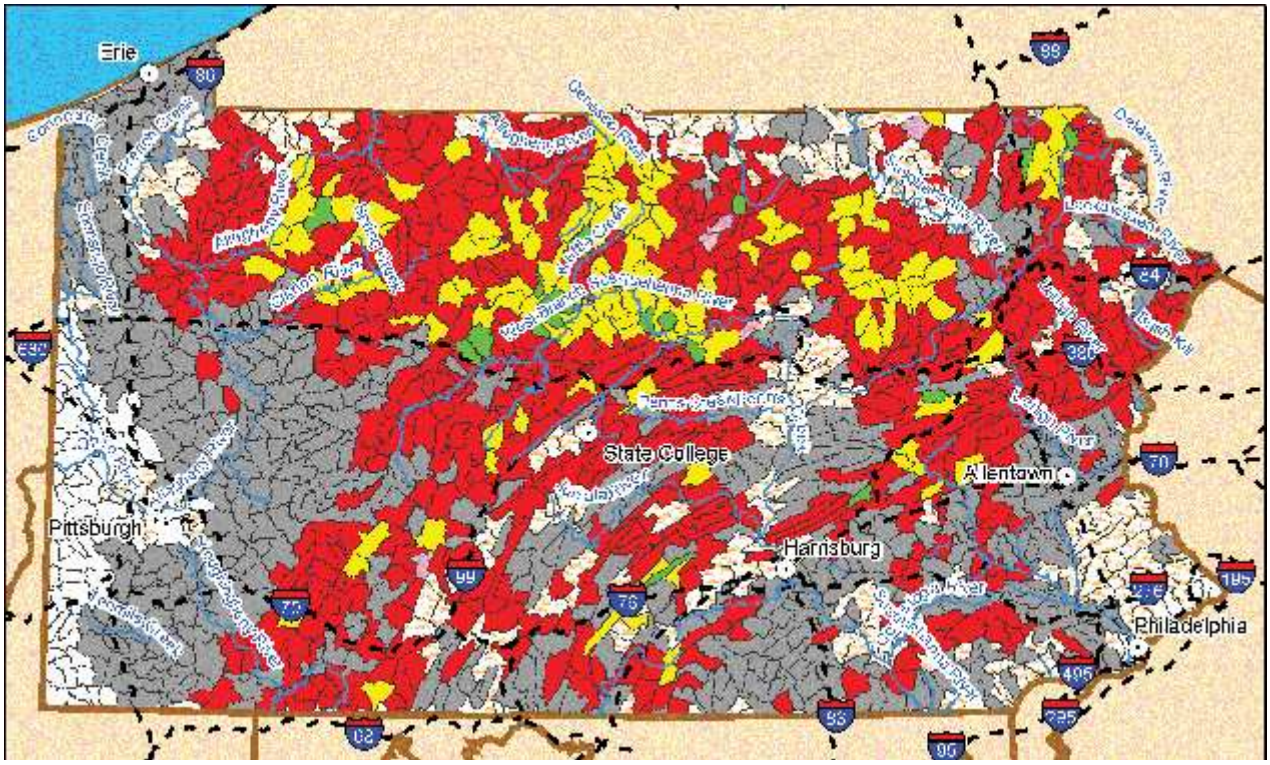
Schoss, A. E. Sharpe, W. E. and Carline, R. 2003. Fish surveys and management recommendations for Fort Indiantown Gap National Guard Training Center, Pennsylvania PSIE 2003-7

Southerland, M., L. Erb, G. Rogers, R. Morgan, K. Eshleman, M. Kline, K. Kline, S. Stranko, P.Kazyak, J. Kilian, J. Ladell, and J. Thompson. 2005. Maryland Biological Stream Survey 2000-2004, Volume 14: Stressors Affecting Maryland Streams (CBWP-MANTA-EA-05-11). Report prepared for Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division, Annapolis, MD.

Stream Examination Report PFBC Bushkill Creek section 02, September 15, 1976

Wydoski, R. S. and E. L. Cooper. 1966. Maturation and fecundity of brook trout from infertile streams. Journal of the Fisheries Research Board of Canada 23:623-649.

MAP 1: Pennsylvania Brook Trout Population Status by Subwatershed



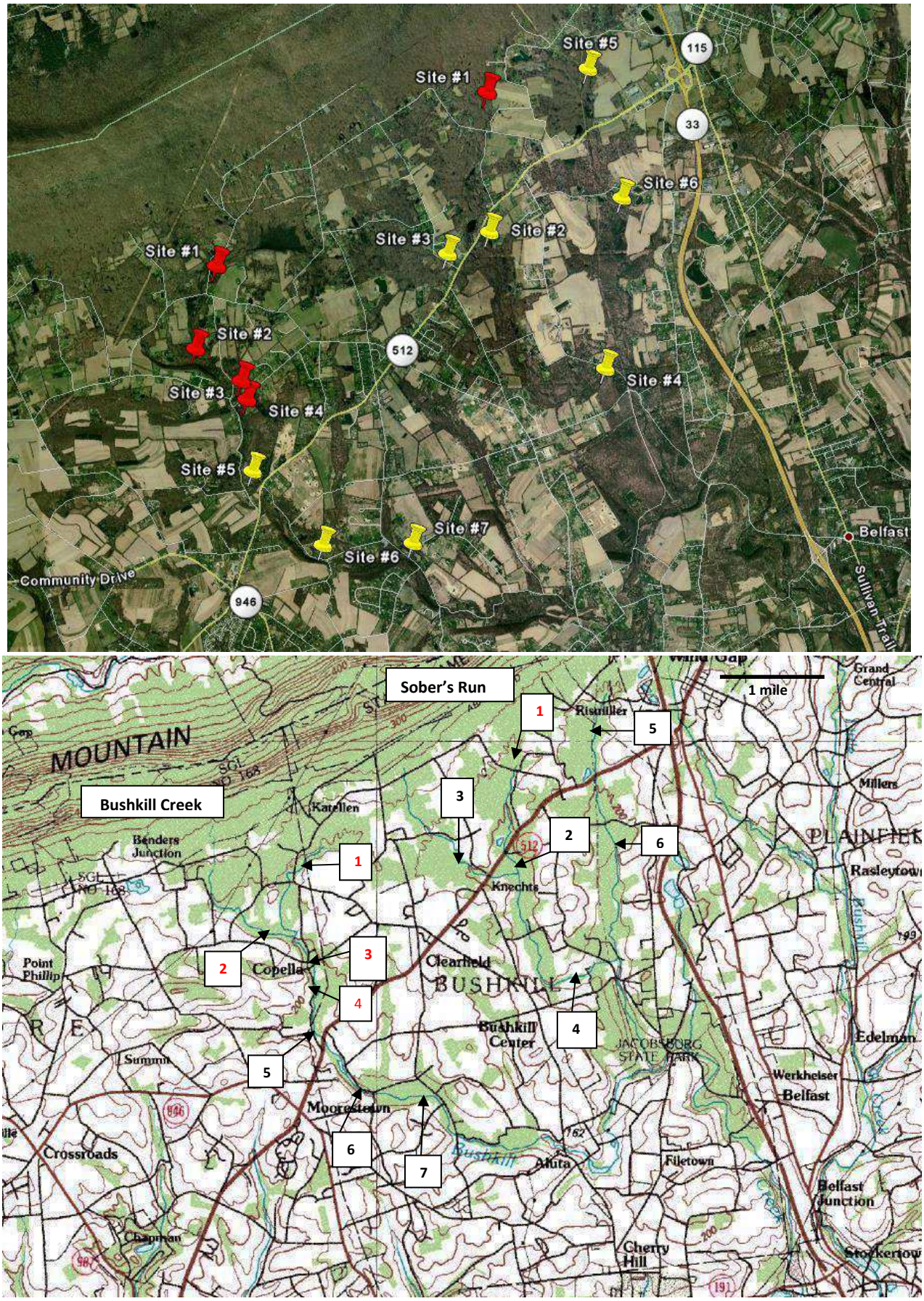
Legend

- Intact (16)
- Reduced (118)
- Greatly Reduced (507)
- Qualitative Presence (5)
- Extirpated (449)
- Unknown, No Data (218)
- Never Occurred (72)
- Rivers
- Lake
- Interstate
- Cities

0 25 50
Miles

Subwatershed Classifications within Lehigh Valley

Map data derived from state and federal data and compiled in EBTJV assessment results titled, *Distribution, status, and perturbations to brook trout within the eastern United States, 2006.* **Authored by Mark Hudy, US Forest Service; Teresa Thieling, James Madison University; Nathaniel Gillespie, Trout Unlimited; Eric Smith, Virginia Tech. Map created on 2/24/06 by Nathaniel Gillespie, Trout Unlimited.**



MAP 2: Bushkill Creek and Sober's Run Fish Survey Sampling Site Locations.

Red Pins (top satellite image) and Box Numbers (bottom topographical map) designate sites with Brook Trout Populations.

(Sober's Run Site #4 only 1 brook trout individual) (Image sources: ***Google satellite image (USGS and PA DCNR)***; ***USGS topographical map Wind Gap Quadrant***)

Sampling Site	latitude/longitude for Map 2 pin (approx. site center)	Elevation (feet above sea level)	Nearest Road/Bridge crossings	Sampling site length (meters (m) miles (mi.)	Riparian tree buffer	Substrate emdeddedness	Water Temperature Date/Time
Site #1 Bushkill Creek	40 48 48.45 N 75 22 13.37 W	703 ft.	Bushkill Drive bridge upstream	150m (.09 mi.)	decid. forested except near road/fields	low	8/13/07 20.5°C @ 1215 hrs.
Site #2 Bushkill Creek	40 48 15.71 N 75 22 27.43 W	680 ft.	500m downstream of West End Drive bridge	450m (.28 mi.)	mature decid. forest w/some hemlock	low	8/15/07 17°C @ 1130 hrs.
Site #3 Bushkill Creek	40 48 01.61 N 75 22 03.97 W	651 ft.	Bushkill Drive Bridge downstream to Bushkill Center Road bridge	150m (.09 mi.)	narrow to none	low	8/16/07 21°C @ 1530 hrs.
Site #4 Bushkill Creek	40 47 54.04 N 75 22 01.65 W	647 ft.	100m downstream of Bushkill Center Road Bridge	170m (.11 mi.)	narrow /some decid.forested	low	8/17/07 21°C @ 1430 hrs.
Site #5 Bushkill Creek	40 47 24.92 N 75 22 01.12 W	613 ft.	small bridge 50m upstream of Rt. 512	200 m (.12 mi.)	narrow / some decid.forested	some siltation	8/18/07 19°C @ 1315 hrs.
Site #6 Bushkill Creek	40 46 53.36 N 75 21 26.01 W	606 ft.	Creamery Road Bridge upstream	280 m (.17 mi.)	narrow/some conif. forested	some siltation by bridge	8/17/07 22°C @ 1330 hrs.
Site #7 Bushkill Creek	40 46 51.94 N 75 20 38.11 W	566 ft.	25m upstream of Hahn Road Bridge	250m (.16 mi.)	narrow to decid. forested	some siltation by bridge	8/16/07 21°C @ 1345 hrs.
Site #1 Sober's Run	40 49 51.76 N 75 19 44.00 W	707 ft.	150 upstream from East Mtn. Road off Allentown Road	375 m (.23 mi.)	mature decid. forest	low	10/20/07 16°C @1200 hrs.
Site #2 Sober's Run	40 48 55.66 N 75 19 47.06 W	642 ft.	Downstream of Rt. 512 bridge to powerline	310 m (.2 mi.)	decid. forested/ narrow near road	some siltation over cobble	9/24/07 19°C @ 1830 hrs.
Site #3 Sober's Run	40 48 47.82 N 75 20 10.22 W	667 ft.	45m upstream of Rt. 512 off Broad Road	320 m (.2 mi.)	some decid. forested narrow near road	some siltation over cobble	9/24/07 18°C @ 1630 hrs.
Site #4 Sober's Run	40 47 55.77 N 75 18 49.59 W	562 ft.	upstream of Keller Road bridge	425 m (.26 mi.)	decid. forested	low	8/29/07 20°C @ 1600 hrs.
Site #5 Sober's Run	40 49 58.96 N 75 18 49.69 W	701 ft.	370 m upstream of Rt. 512	370 m (.23 mi.)	decid.forested/ open by powerline	some siltation over cobble	7/6/07 NA
Site #6 Sober's Run	40 49 06.25 N 75 18 35.64 W	612 ft.	160 m downstream of Kromer Road	235 m (.15 mi.)	decid. forested	low	10/31/07 10°C @ 1600 hrs.

Appendix A-1: Summary of Sampling Site Characteristics

Appendix A-2

Site #1 Bushkill Creek

Site #2 Bushkill Creek

Fish Species Collected at Bushkill Creek and Sober's Run Sampling Sites (July-October 2007)

		Bushkill Creek Sampling Sites								Sober's Run Sampling Sites					
Common Name	**Scientific Name**	**Site #1**	**Site #2**	**Site #3**	**Site #4**	**Site #5**	**Site #6**	**Site #7**		**Site #1**	**Site #2**	**Site #3**	**Site #4**	**Site #5**	**Site #6**
Brook Trout	*Salvelinus fontinalis*	X	X	X	X					X			X		
Brown Trout	*Salmo trutta*		X	X	X	X	X	X				X	X	X	X
Rainbow Trout	*Oncorhynchus mykiss*							X			X				
White Sucker	*Catostomus commersoni*	X	X	X	X	X	X	X		X	X	X	X	X	X
American Eel	*Anguilla rostratus*			X		X	X	X			X		X	X	
Blacknose Dace	*Rhinichthys attratulus*	X	X	X	X	X	X	X		X			X	X	X
Longnose Dace	*Rhinichthys cataractae*			X		X							X		
Creek Chub	*Semotilus atromaculatus*	X	X	X	X	X	X	X		X	X	X	X	X	X
Fallfish	*Semotilus corporalis*										X				
Cutlips Minnow	*Exoglossum maxillingua*	X	X	X	X	X	X	X					X		X
Common Shiner	*Luxilus cornatus*	X		X	X	X		X			X	X	X		X
Tessellated Darter	*Etheostoma olmstedi*	X	X	X	X	X	X	X		X	X	X	X		X
Bluegill Sunfish	*Lepomis macochirus*				X	X	X				X	X		X	X
Pumpkinseed Sunfish	*Lepomis gibbosus*	X		X	X		X	X		X	X	X	X	X	
Rock Bass	*Ambloplites rupestris*	X		X	X	X	X	X							
Largemouth Bass	*Micropterus salmoides*	X		X	X		X			X	X				X
Margined Madtom	*Notorus insignis*			X											
Brown bullhead	*Ameiurus nebulosus*			X							X				
Redfin Pickeral	*Esox americanus americanus*	X		X	X	X	X	X			X	X	X	X	X
Total Species =19	***Number of Species per Site***	**11**	**7**	**16**	**13**	**12**	**12**	**12**		**7**	**12**	**8**	**12**	**8**	**10**

Appendix B

Fish Species Guild Classifications

Common Name	Scientific Name	EP Tolerance Guild	Feeding Guild	Temperature Guild
Brook Trout	*Salvelinus fontinalis*	I	TC	C
Brown Trout	*Salmo trutta*	I	TC	Ct
Rainbow Trout	*Oncorhynchus mykiss*	I	TC	C
White Sucker	*Catostomus commersoni*	T	GF	E
American Eel	*Anguilla rostratus*	T	TC	E
Blacknose Dace	*Rhinichthys attratulus*	T	GF	E
Longnose Dace	*Rhinichthys cataractae*	M	BI	Ct
Creek Chub	*Semotilus atromaculatus*	T	GF	E
Fallfish	*Semotilus corporalis*	M	GF	E
Cutlips Minnow	*Exoglossum maxillingua*	I	BI	E
Common Shiner	*Luxilus cornatus*	M	GF	E
Tessellated Darter	*Etheostoma olmstedi*	M	BI	E
Bluegill Sunfish	*Lepomis macochirus*	T	GF	W
Pumpkinseed Sunfish	*Lepomis gibbosus*	M	GF	W
Rock Bass	*Ambloplites rupestris*	M	TC	E
Largemouth Bass	*Micropterus salmoides*	M	TC	W
Margined Madtom	*Notorus insignis*	M	BI	W
Brown Bullhead	*Ameiurus nebulosus*	T	GF	W
Redfin Pickeral	*Esox americanus americanus*	M	TC	E

Guild Attributes: Leonhardt (Adapted in-part from: Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities, ed Simon Table 12.1)

Environmental Perturbation Tolerance Guilds

T = Tolerant
M = Intermediate
I = Intolerant (sensitive to a wide range of environmental stresses)

Temperature Guilds

C= Coldwater
Ct = Coldwater transitional
E = Eurythermal (inhabits Cold &W arm waters)
W = Warmwater

Feeding Guilds

GF = Generalist Feeder
BI = Benthic Insectivore
TC = Top Carnivore

Appendix C

Appendix D

Brook Trout *Salvelinus fontinalis*

Number of Brook Trout Individuals per Total Length

Total Length (Inches)	Total Length (Millimeters)	Bushkill Creek Site #1	Bushkill Creek Site #2	Bushkill Creek Site #3	Bushkill Creek Site #4	Sober's Run Site #1	Sober's Run Site #4
2.4	60	1	1		1		
2.6	65					2	
3.1	80			2			
4.75	120					1	
5.1	130			3			
5.3	135		1				
5.5	140	3	1	1		1	
5.7	145		1			1	
6.0	150	2	2		1		
6.1	155		2				
6.3	160		2	1		1	
6.7	170			2			
6.9	175		1				
7.5	190		1				
7.7	195		1				
7.9	200		1				
8.1	205				1		
8.3	210			1			
8.7	220					1	
8.9	225			1			
9.7	245		1				
13.0	330						1
Total Number of Individuals Collected @ Site		6	15	11	3	7	1

Appendix E

Appendix F

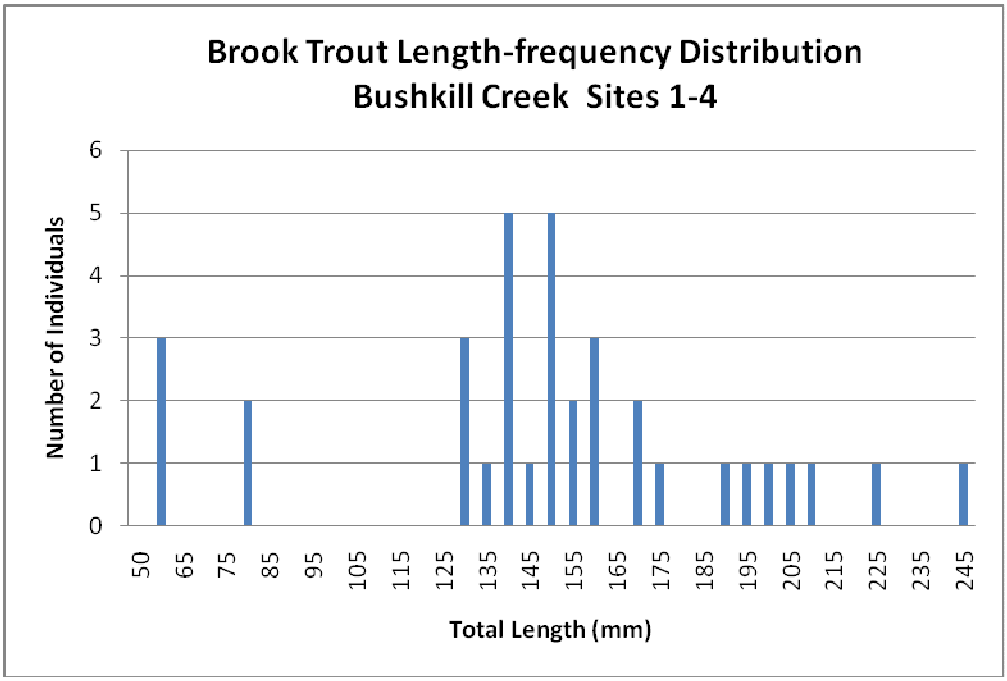


Figure 1a

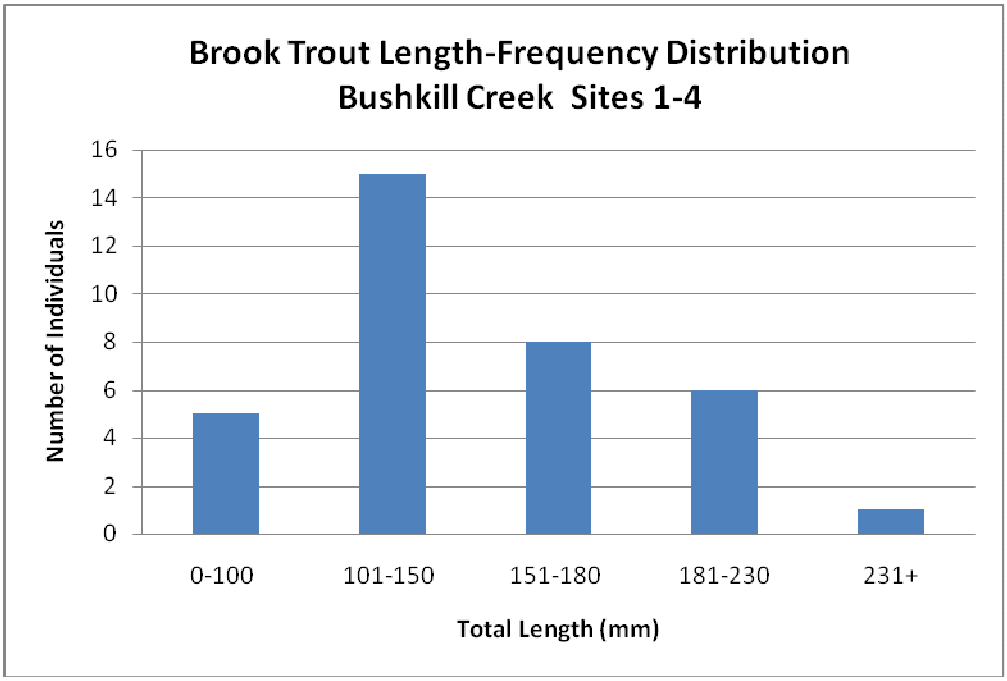


Figure 1b

Appendix F

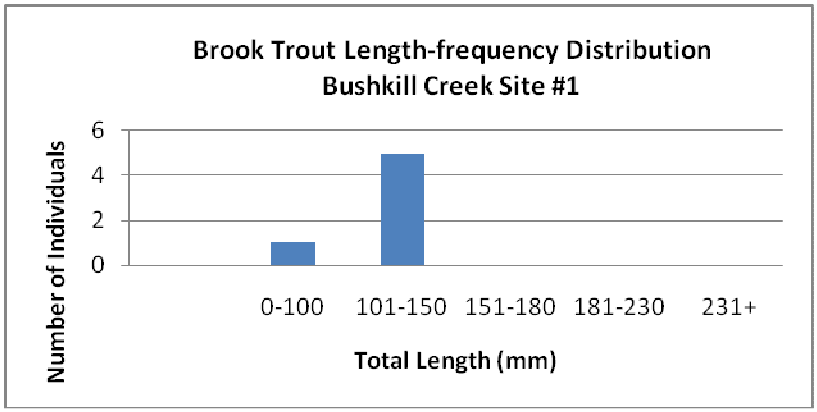


Figure 2a

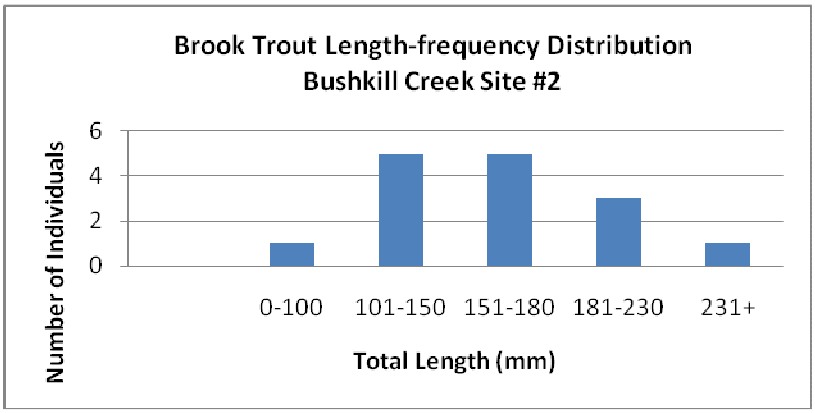


Figure 2b

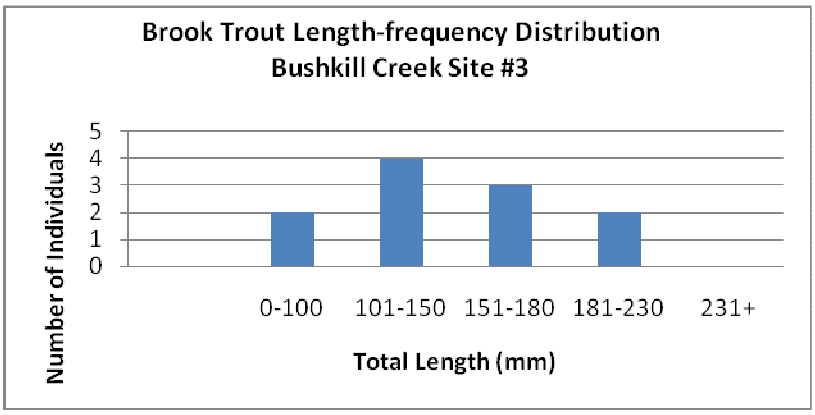


Figure 2c

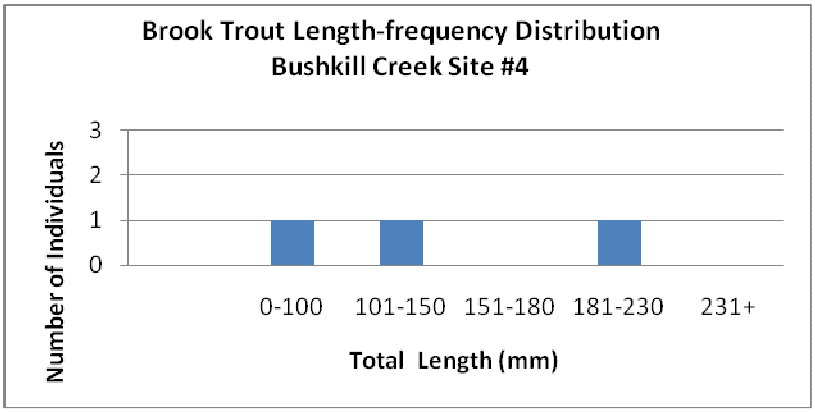


Figure 2d

Appendix F

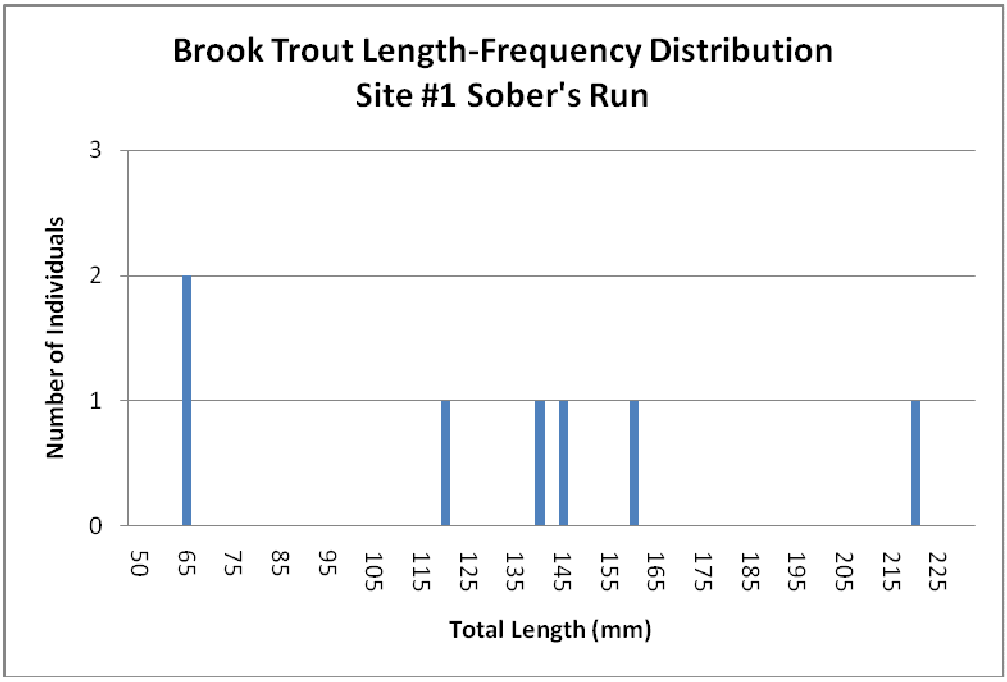


Figure 3a

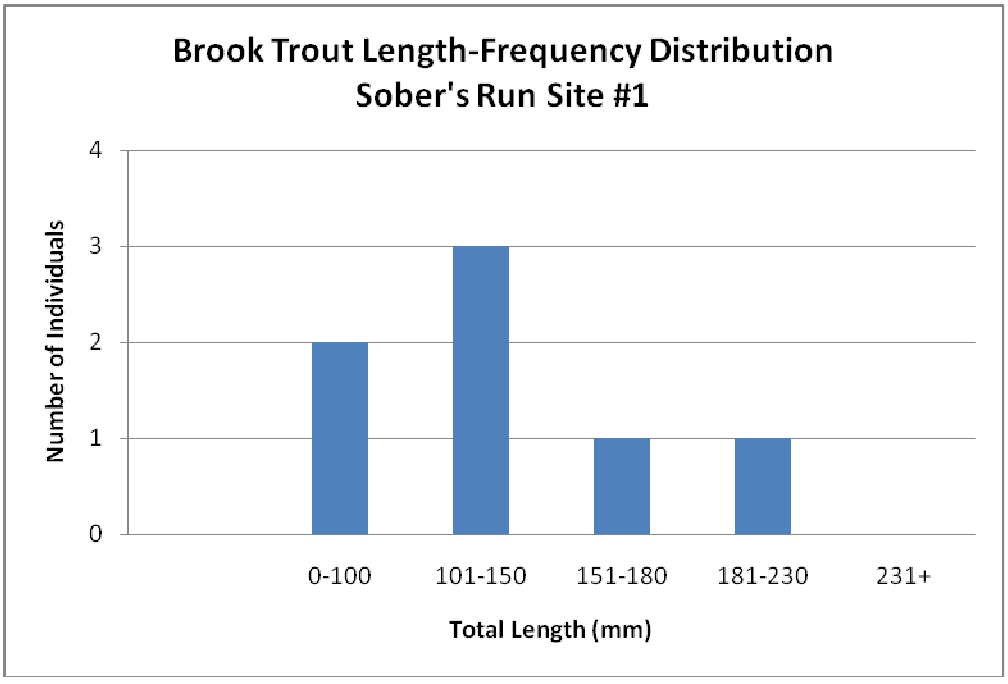
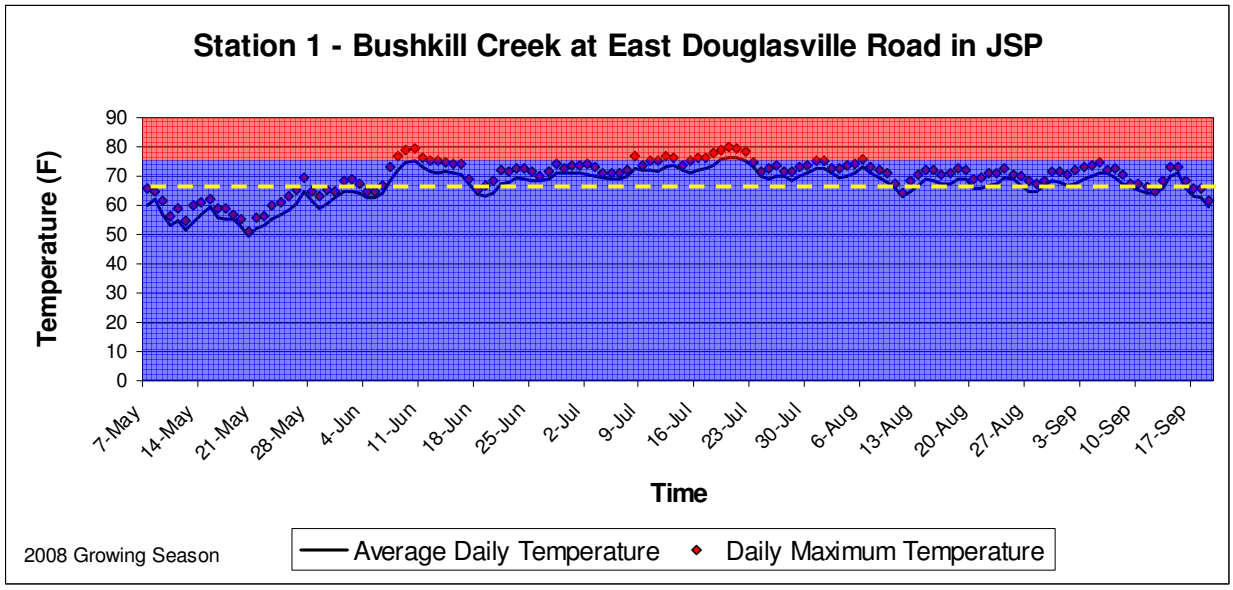
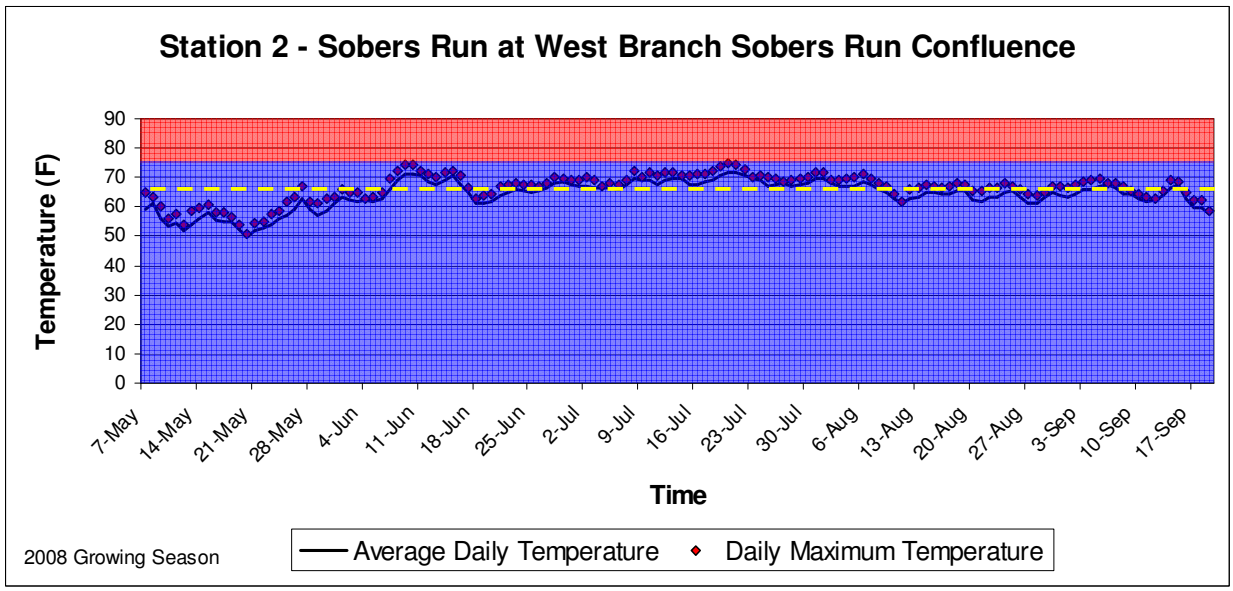


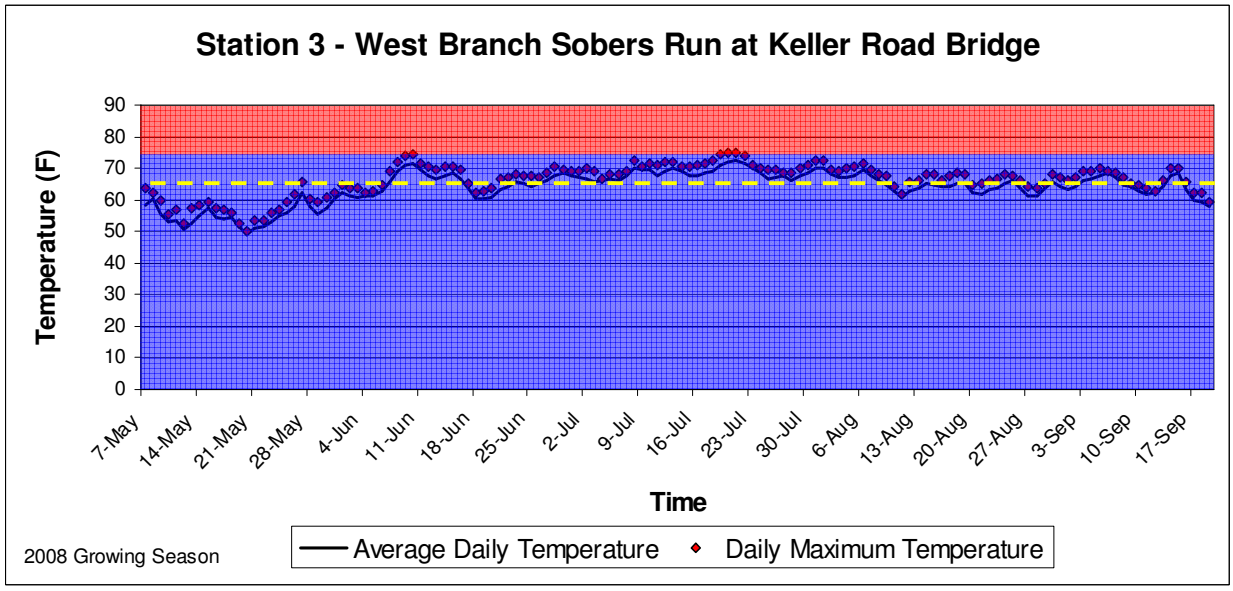
Figure 3b

Appendix E

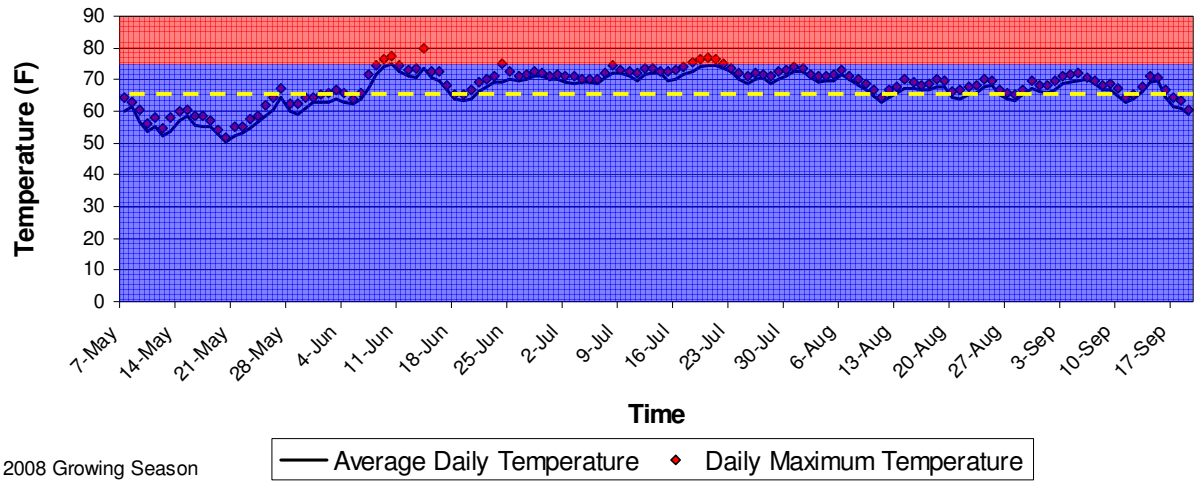
Temperature Data
Upper Bushkill Creek 2008


Station 1 - Bushkill Creek at East Douglasville Road in JSP
Temperature (F)
90
80
70
60
50
40
30
20
10
0
7-May
14-May
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
Time
2008 Growing Season
Average Daily Temperature
Daily Maximum Temperature


Station 2 - Sobers Run at West Branch Sobers Run Confluence
Temperature (F)
90
80
70
60
50
40
30
20
10
0
7-May
14-May
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
Time
2008 Growing Season
Average Daily Temperature
Daily Maximum Temperature


Station 3 - West Branch Sobers Run at Keller Road Bridge
Temperature (F)
90
80
70
60
50
40
30
20
10
0
7-May
14-May
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
Time
2008 Growing Season
Average Daily Temperature
Daily Maximum Temperature

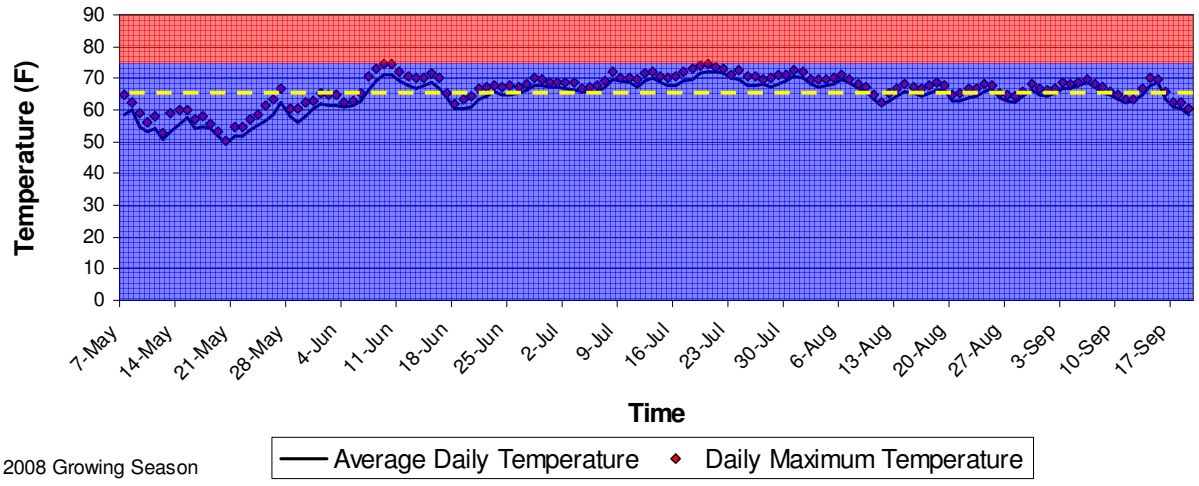
Station 4 - Tributary to West Branch Sobers Run at Rt 512



2008 Growing Season

Average Daily Temperature ◆ Daily Maximum Temperature

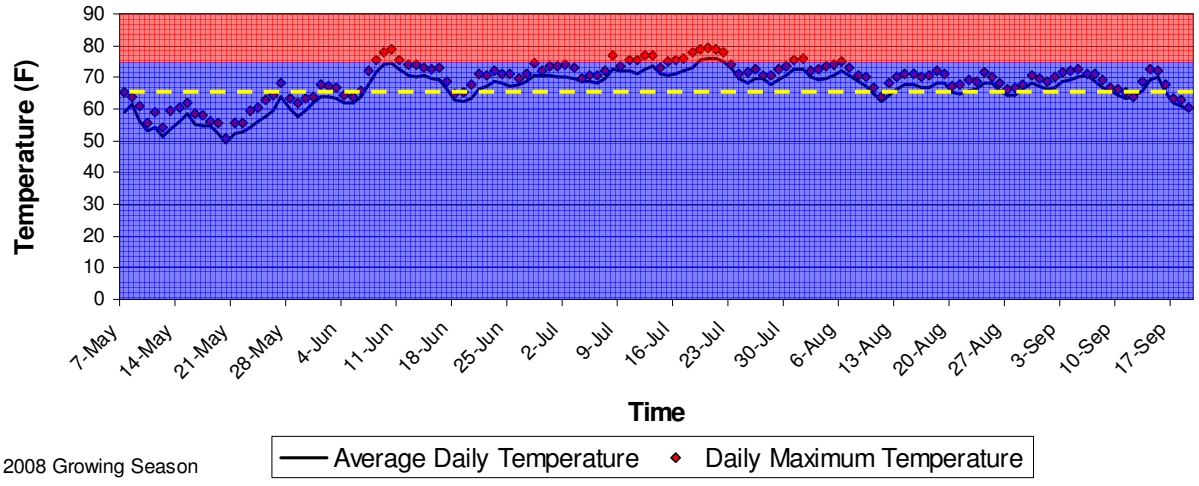
Station 5 - West Branch Sobers Run at Rt 512



2008 Growing Season

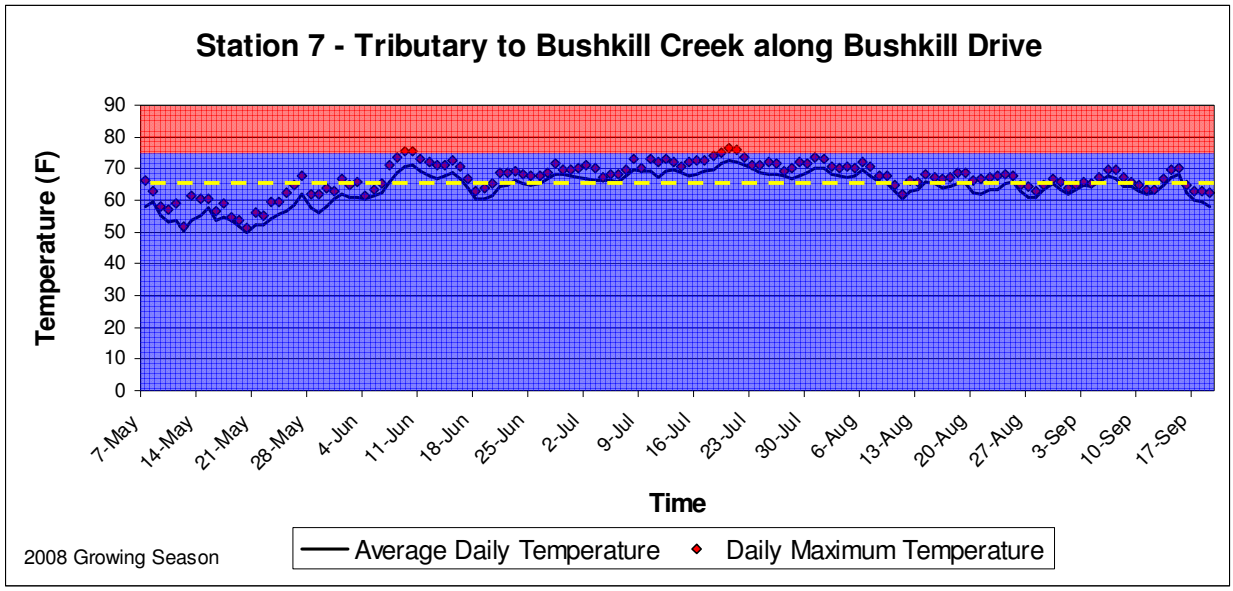
Average Daily Temperature ◆ Daily Maximum Temperature

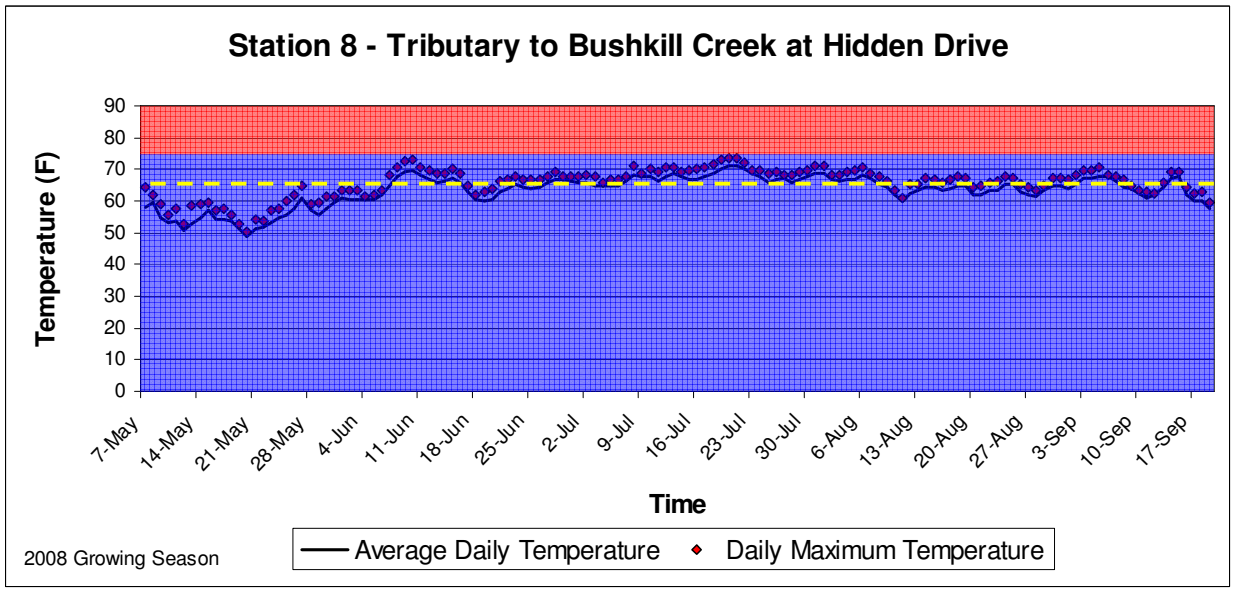
Station 6 - Bushkill Creek at West Douglasville & Clearfield Roads

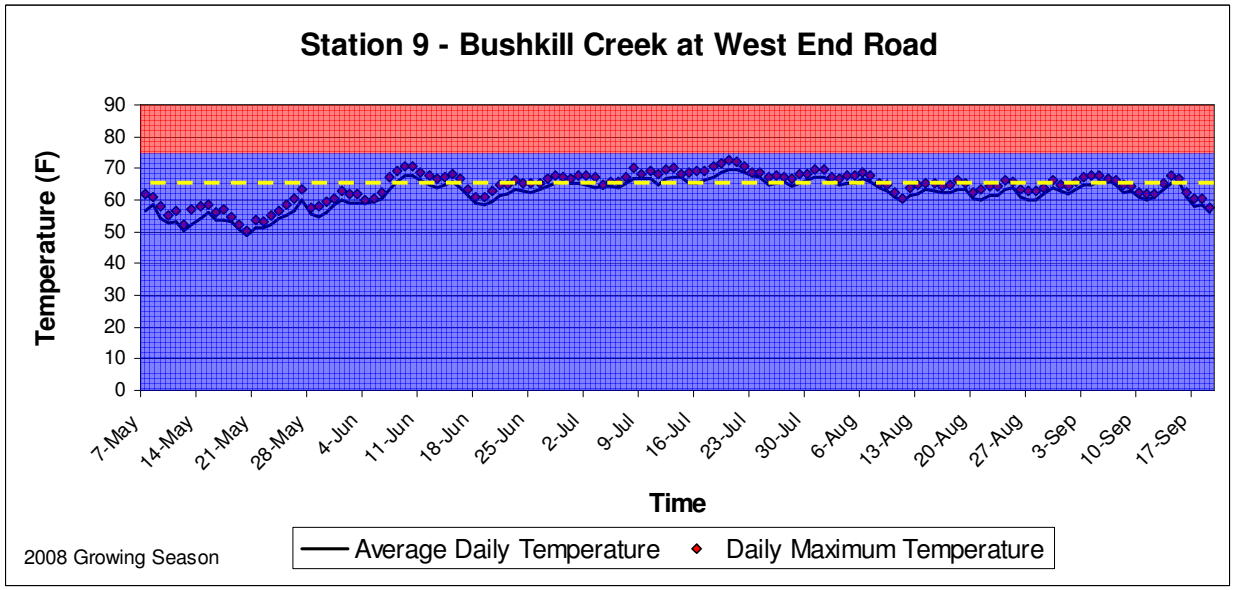


2008 Growing Season

Average Daily Temperature ◆ Daily Maximum Temperature


Station 7 - Tributary to Bushkill Creek along Bushkill Drive
Temperature (F)
90
80
70
60
50
40
30
20
10
0
7-May
14-May
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
Time
2008 Growing Season
Average Daily Temperature
Daily Maximum Temperature


Station 8 - Tributary to Bushkill Creek at Hidden Drive
Temperature (F)
90
80
70
60
50
40
30
20
10
0
7-May
14-May
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
Time
2008 Growing Season
Average Daily Temperature
Daily Maximum Temperature


Station 9 - Bushkill Creek at West End Road
Temperature (F)
90
80
70
60
50
40
30
20
10
0
7-May
14-May
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
Time
2008 Growing Season
Average Daily Temperature
Daily Maximum Temperature

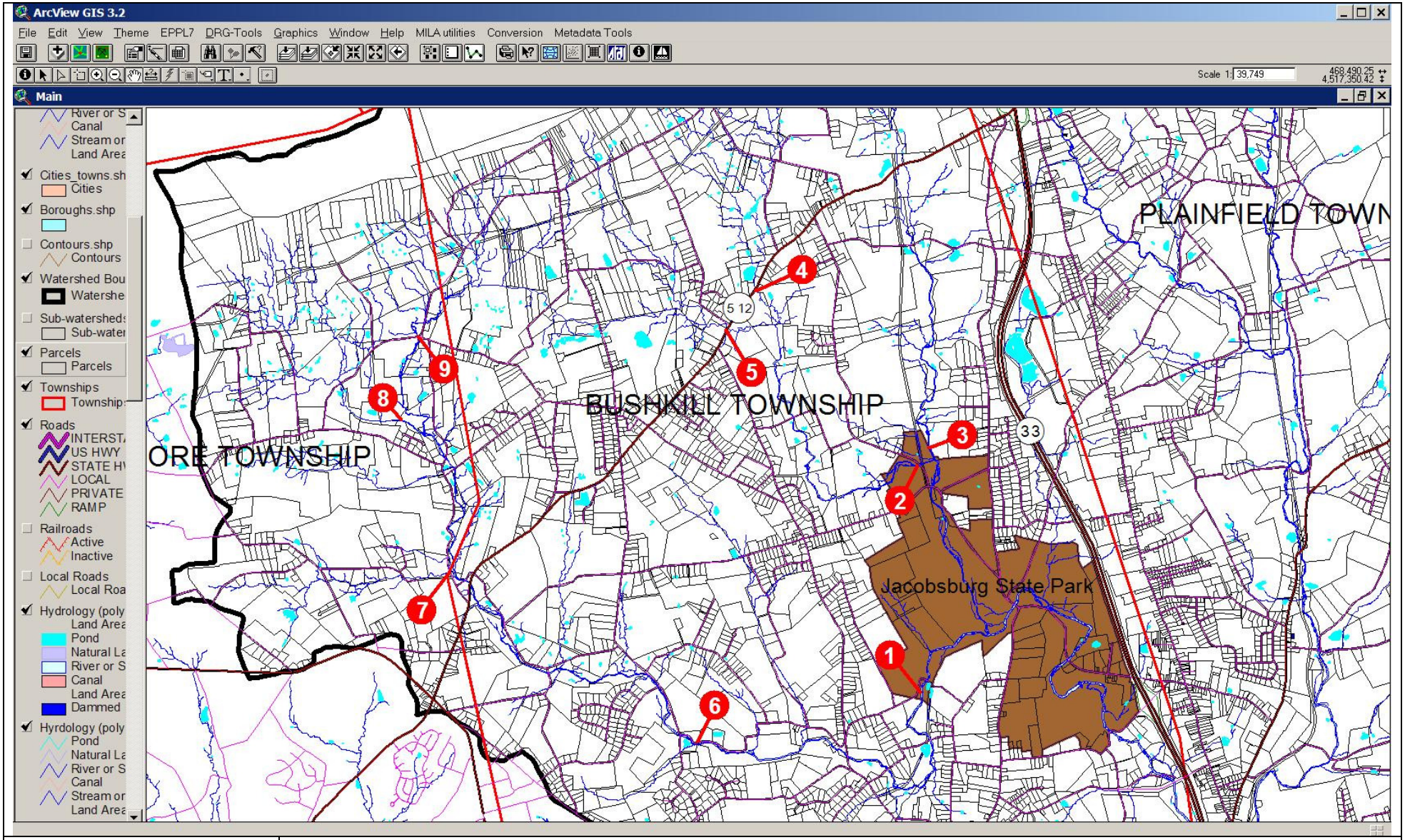
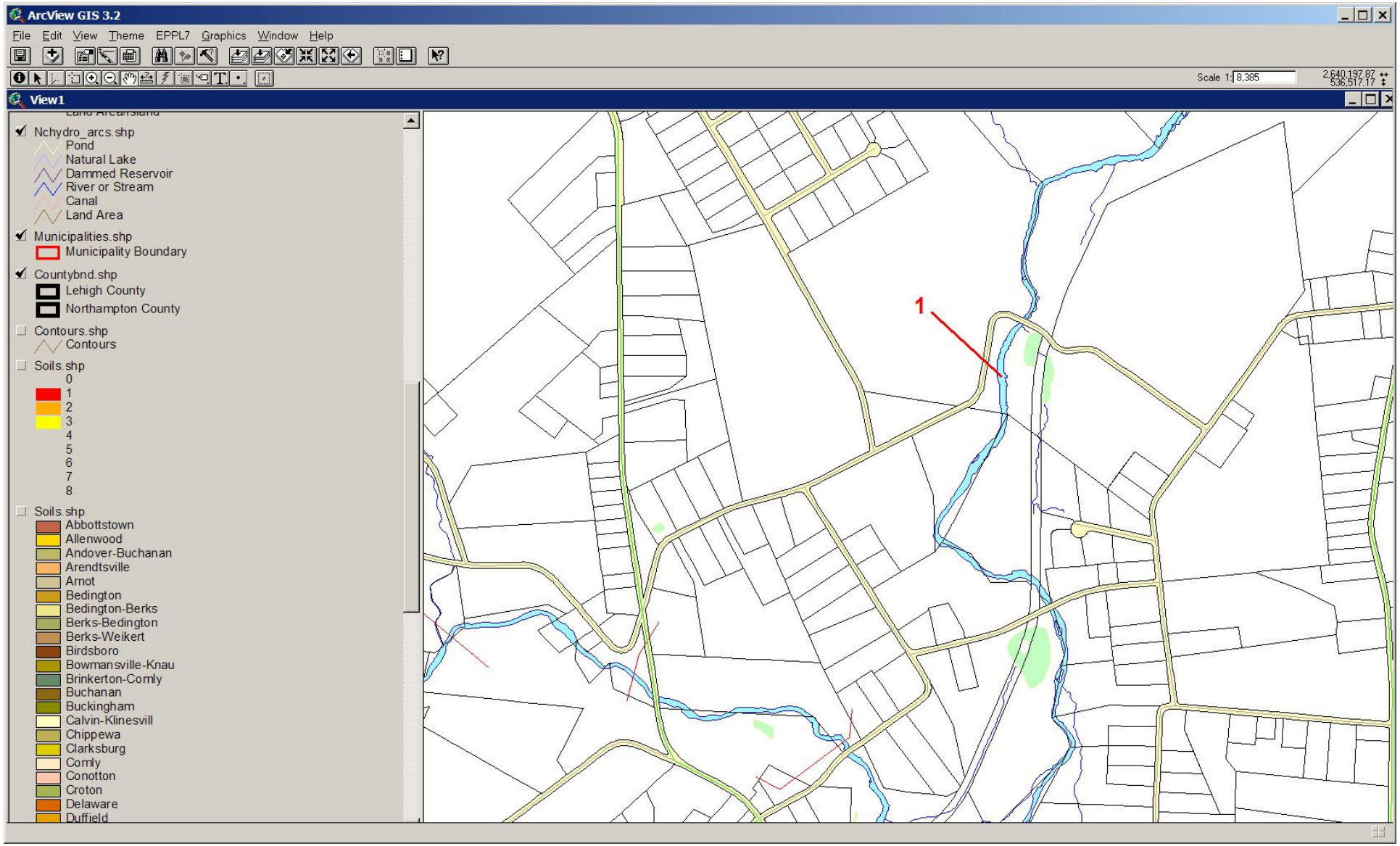


FIGURE	**Temperature Monitoring Station Locations – Upper Bushkill Watershed** (Source Map: Lehigh Valley Planning Commission, 2005)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Dammed Reservoir
River or Stream
Canal
Land Area
Municipalities.shp
Municipality Boundary
Countybnd.shp
Lehigh County
Northampton County
Contours.shp
Contours
Soils.shp
0
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2
3
4
5
6
7
8
Soils.shp
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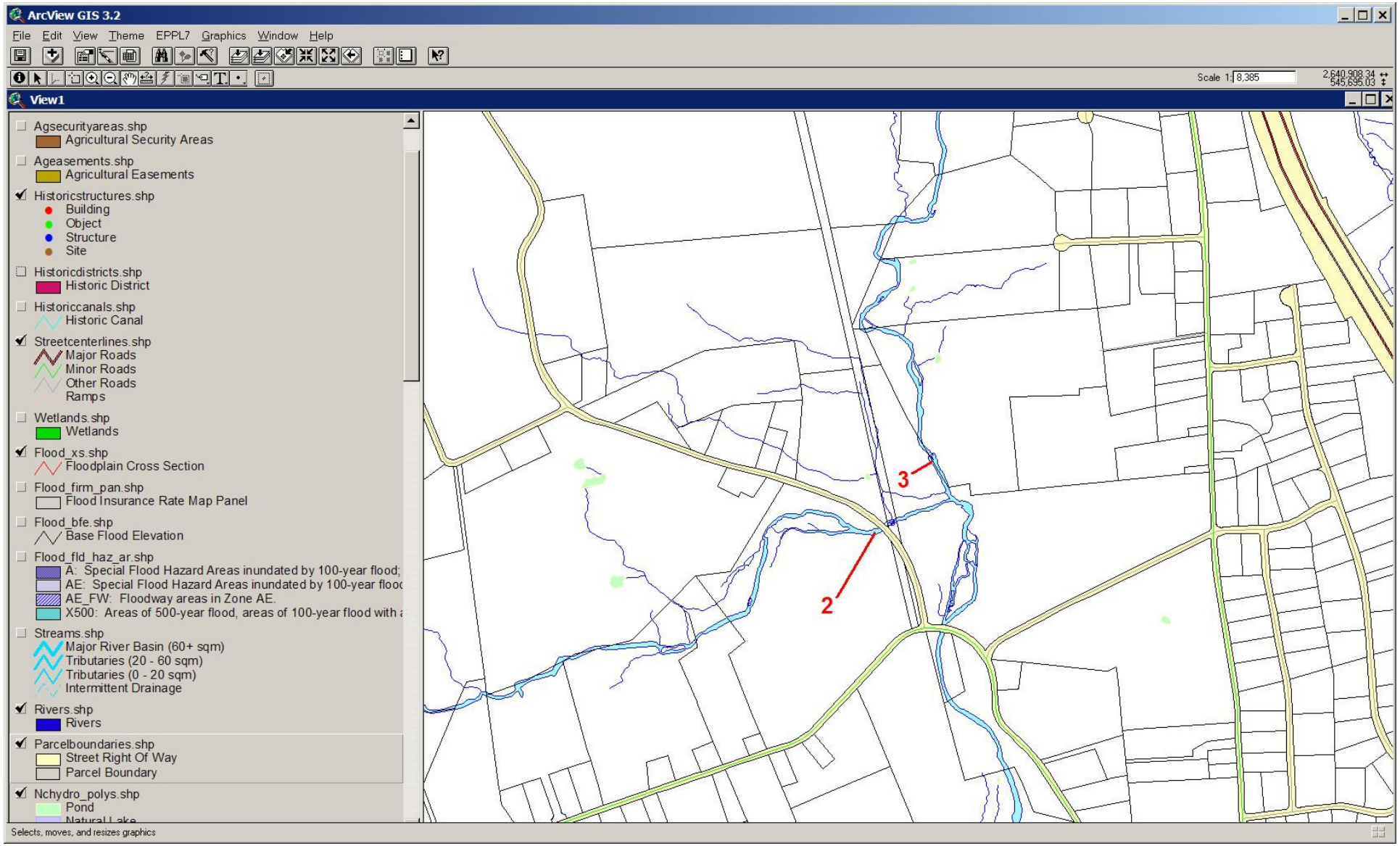
Allenwood
Andover-Buchanan
Arendtsville
Arnot
Bedington
Bedington-Berks
Berks-Bedington
Berks-Weikert
Birdsboro
Bowmansville-Knau
Brinkerton-Comly
Buchanan
Buckingham
Calvin-Klinesvill
Chippewa
Clarksburg
Comly
Conotton
Croton
Delaware
Duffield
1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Agricultural Security Areas
Ageasements.shp
Agricultural Easements
Historicstructures.shp
Building
Object
Structure
Site
Historicdistricts.shp
Historic District
Historiccanals.shp
Historic Canal
Streetcenterlines.shp
Major Roads
Minor Roads
Other Roads
Ramps
Wetlands.shp
Wetlands
Flood_xs.shp
Floodplain Cross Section
Flood_firm_pan.shp
Flood Insurance Rate Map Panel
Flood_bfe.shp
Base Flood Elevation
Flood_fld_haz_ar.shp
A: Special Flood Hazard Areas inundated by 100-year flood;
AE: Special Flood Hazard Areas inundated by 100-year flooc
AE_FW: Floodway areas in Zone AE.
X500: Areas of 500-year flood, areas of 100-year flood with a
Streams.shp
Major River Basin (60+ sqm)
Tributaries (20 - 60 sqm)
Tributaries (0 - 20 sqm)
Intermittent Drainage
Rivers.shp
Rivers
Parcelboundaries.shp
Street Right Of Way
Parcel Boundary
Nchydro_polys.shp
Pond
Natural Lake
3
2
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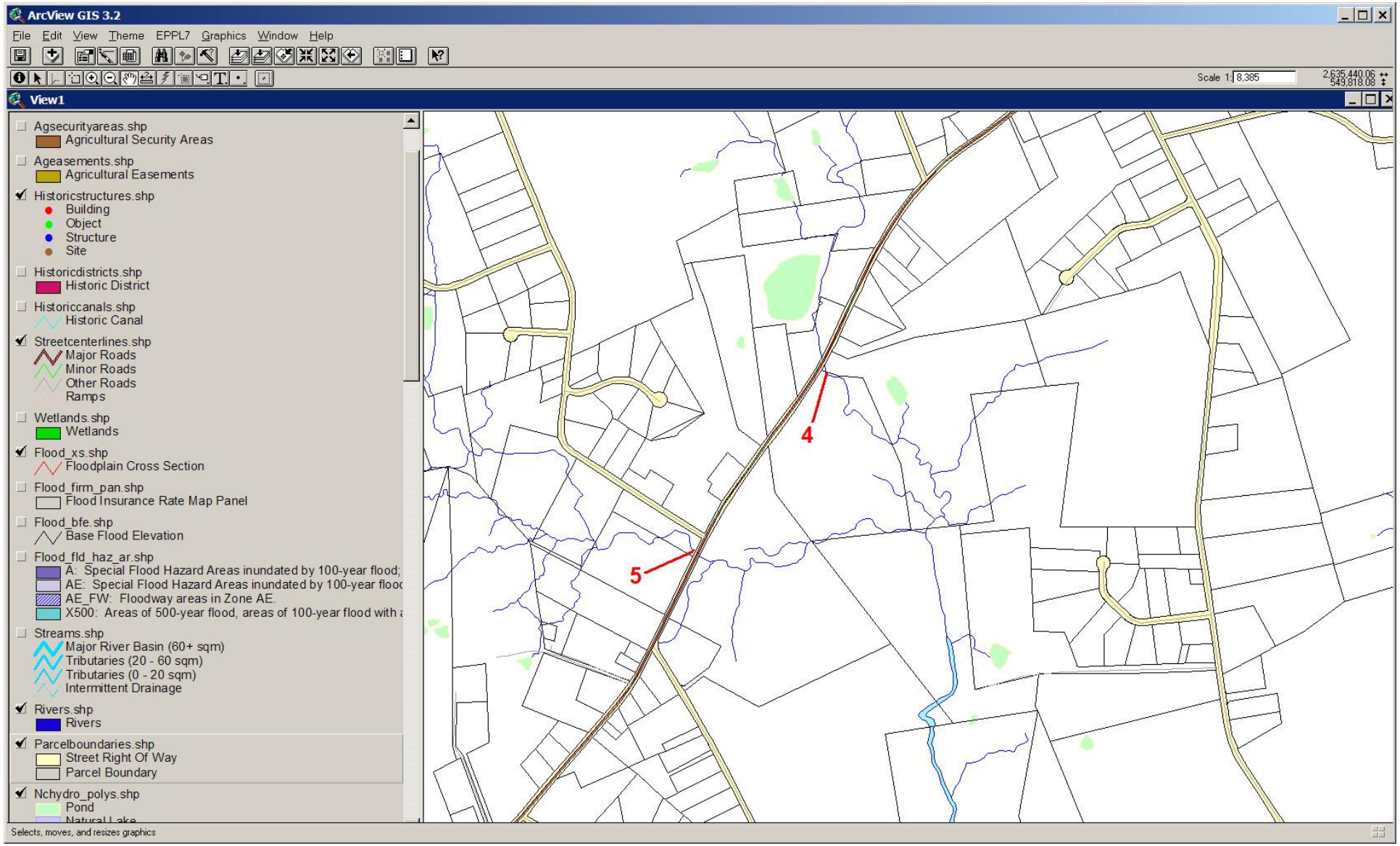
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Historic District
Historiccanals.shp
Historic Canal
Streetcenterlines.shp
Major Roads
Minor Roads
Other Roads
Ramps
Wetlands.shp
Wetlands
Flood_xs.shp
Floodplain Cross Section
Flood_firm_pan.shp
Flood Insurance Rate Map Panel
Flood_bfe.shp
Base Flood Elevation
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Streams.shp
Major River Basin (60+ sqm)
Tributaries (20 - 60 sqm)
Tributaries (0 - 20 sqm)
Intermittent Drainage
Rivers.shp
Rivers
Parcelboundaries.shp
Street Right Of Way
Parcel Boundary
Nchydro_polys.shp
Pond
Natural Lake
4
5
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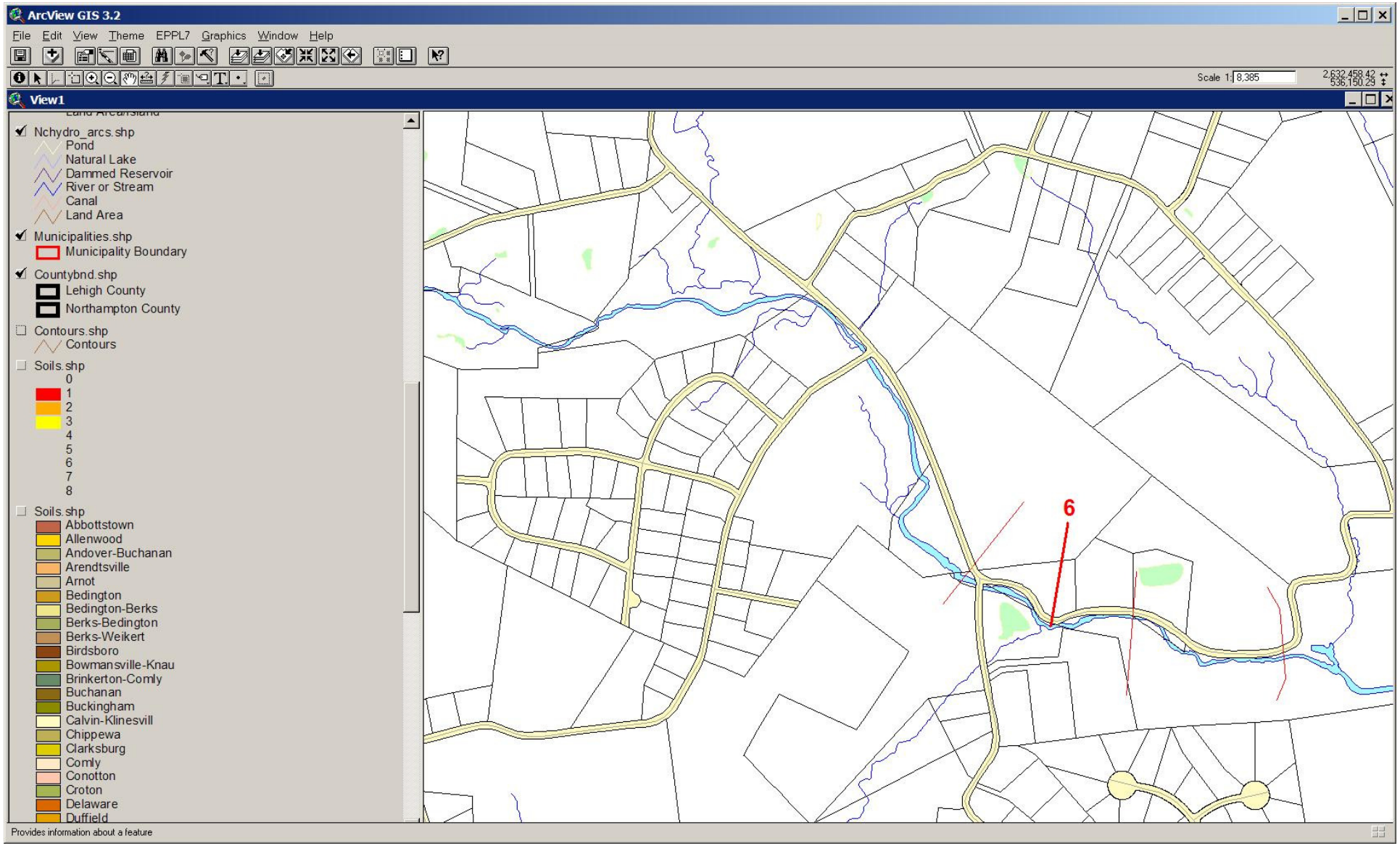
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Natural Lake
Dammed Reservoir
River or Stream
Canal
Land Area
Municipalities.shp
Municipality Boundary
Countybnd.shp
Lehigh County
Northampton County
Contours.shp
Contours
Soils.shp
0
1
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8
Soils.shp
Abbottstown
Allenwood
Andover-Buchanan
Arendtsville
Arnot
Bedington
Bedington-Berks
Berks-Bedington
Berks-Weikert
Birdsboro
Bowmansville-Knau
Brinkerton-Comly
Buchanan
Buckingham
Calvin-Klinesvill
Chippewa
Clarksburg
Comly
Conotton
Croton
Delaware
Duffield
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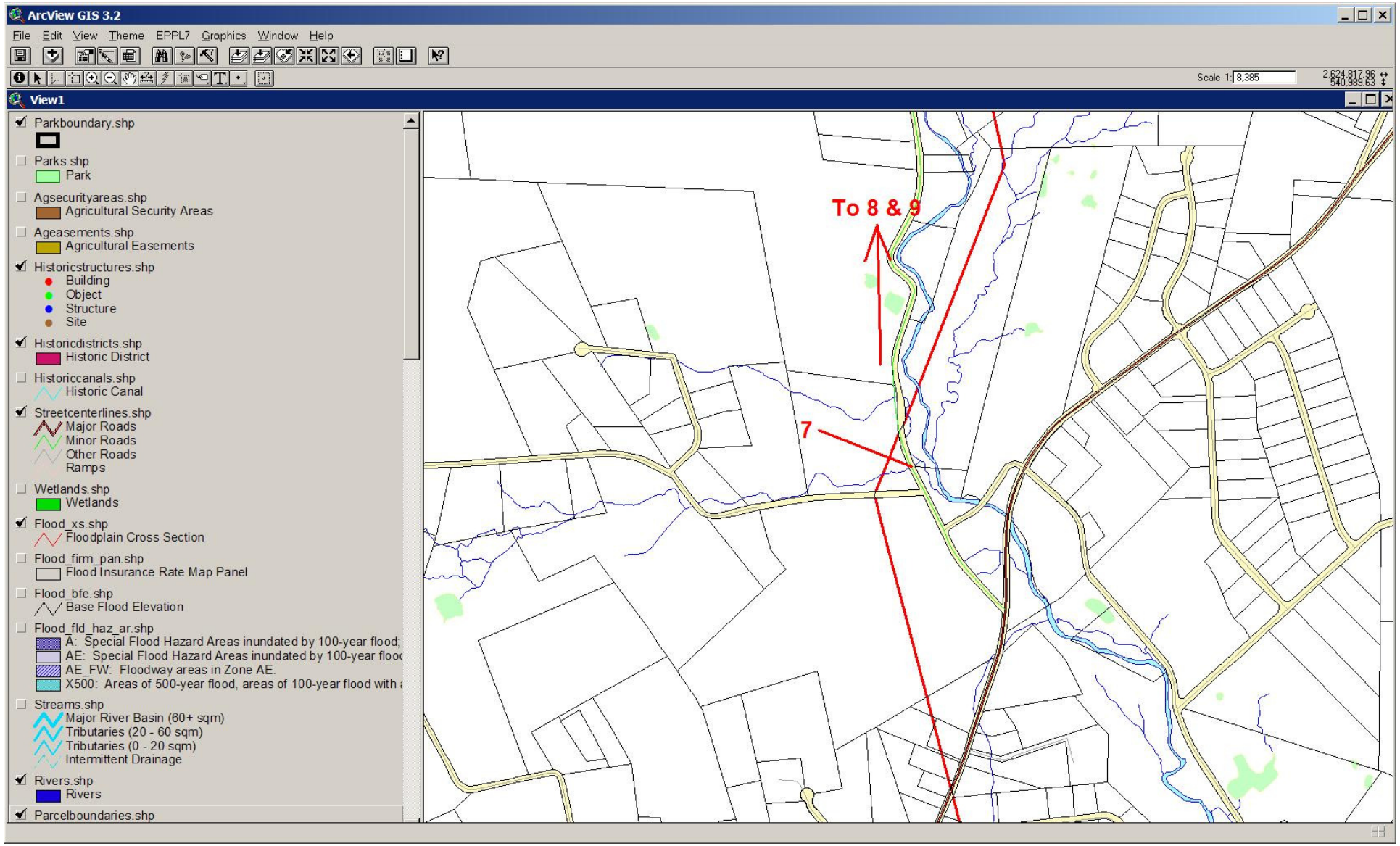
Provides information about a feature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Agricultural Easements
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Object
Structure
Site
Historicdistricts.shp
Historic District
Historiccanals.shp
Historic Canal
Streetcenterlines.shp
Major Roads
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Other Roads
Ramps
Wetlands.shp
Wetlands
Flood_xs.shp
Floodplain Cross Section
Flood_firm_pan.shp
Flood Insurance Rate Map Panel
Flood_bfe.shp
Base Flood Elevation
Flood_fld_haz_ar.shp
A: Special Flood Hazard Areas inundated by 100-year flood;
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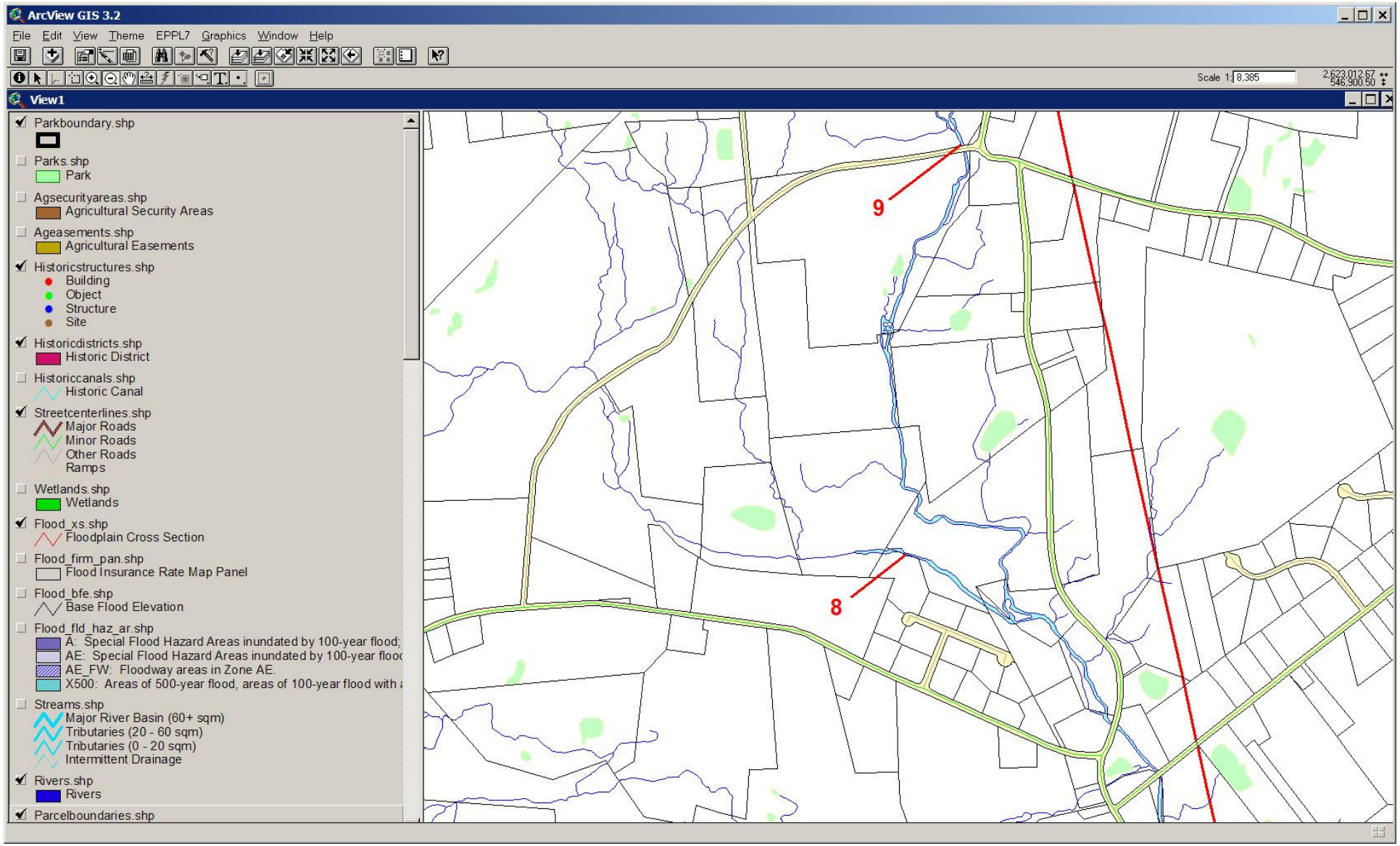
Streams.shp
Major River Basin (60+ sqm)
Tributaries (20 - 60 sqm)
Tributaries (0 - 20 sqm)
Intermittent Drainage
Rivers.shp
Rivers
Parcelboundaries.shp
To 8 & 9
7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Historic District
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Wetlands.shp
Wetlands
Flood_xs.shp
Floodplain Cross Section
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Major River Basin (60+ sqm)
Tributaries (20 - 60 sqm)
Tributaries (0 - 20 sqm)
Intermittent Drainage
Rivers.shp
Rivers
Parcelboundaries.shp
9
8

Appendix F

Patricia Thornton Bradt
The Ecology of the Benthic Macroinvertebrate Fauna of the Bushkill Creek, Northampton County, Pennsylvania
(Excerpt from Dissertation, 1974)

THE ECOLOGY OF THE BENTHIC MACROINVERTEBRATE FAUNA OF THE BUSHKILL CREEK, NORTHAMPTON COUNTY, PENNSYLVANIA

by

Patricia Thornton Bradt

A Dissertation

Presented to the Graduate Committee

of Lehigh University

in Candidacy for the Degree of

Doctor of Philosophy

in

Biology

Lehigh University

1974

reported as ppm.

12. Total Iron. Total iron was measured by the 1,10 phenanthroline method (Hach, 1969). Colorimetric readings were made with the Bausch and Lomb Spectronic 20. Results are reported in ppm using the Hach (1971) tables for conversion of percent transmittance to ppm.

13. Calcium Hardness. Calcium hardness determinations were done using titration with disodium dihydrogen-1,2-cyclohexanediamine-tetra-acetate (CDTA) (Hach, 1969). Results are reported in ppm calcium hardness.

B. BIOLOGY

1. Benthic Macroinvertebrates. The benthic macroinvertebrate population was sampled 31 times at stations 1, 6 and 8, 30 times at station 7. The population was sampled with a Surber Square Foot Sampler (Surber, 1936). The sampling was done in riffle areas at a depth of 6 to 10 inches. Care was taken to see that the sampling areas were in as similar a substrate as possible. The investigator collected all the invertebrate samples to insure that the collection method was uniform (Surber, 1936). Two square feet of stream bottom were sampled on each sampling day at each station. The rocks in the square foot sampled were scrubbed with a brush and the invertebrates and debris flowed into the open net. The debris and benthic fauna were immediately placed in a bottle in the field with 70% ethyl alcohol for preservation. The macroinvertebrate samples were later sorted by the

saturated sugar flotation technique (Michigan Institute for Fisheries, 1959) and transferred to fresh 70% ethyl alcohol. The macroinvertebrates were later counted and identified using the standard keys (Chu, 1949; Pennak, 1953; Usinger, 1956). Most individuals were classified to genus. The results of the two square feet at each station were averaged for use in the statistical analysis. Parameters measured were wet weight per square foot, number of individuals per square foot, number of taxa per square foot and diversity index per square foot. Wet weight was determined by letting the drained sample set on absorbent paper for one minute and then weighing on the Mettler 0-1200 balance (Needham and Needham, 1962).

Methods

2. Fish Population. The fish population was sampled twice - July 1972 and July 1973 - by direct current electrofishing (Alabaster, 1962) at the four invertebrate stations (1, 6, 7, 8). In July 1972 an extra station was electrofished because it was reported to be an excellent fishing pool and was in the proposed Jacobsburg dam area. The location of this station (3A) is noted on the map (figure 2). The electrofishing was done with a 5 watt, 115 volt, 4 cycle Georator Corporation portable generator. John Weaver, Northampton County Waterways Patrolman for the Pennsylvania Fish Commission, Dr. Earl Peace, Dr. Isadore Mineo, Dr. David Bell, several Lafayette undergraduate students (studying the stream under a National Science Foundation Undergraduate Research Grant) and several interested Bushkill Watershed Association members aided in the shocking operation. The stunned fish were removed from the stream with nets and placed in a

plastic trash can with 10.0 ppm quinaldrine, a fish anesthetic. The fish were then weighed with a portable scale, measured and identified. The fish were then placed in a can of creek water in order to recover from the anesthetic. After the fish had recovered they were returned to the stream.

Electrofishing was initiated at the downstream end of the station and 200 feet of stream were shocked. A block of sodium chloride was placed in the water at station 1 a half hour before the shocking began in order to increase the conductivity of the water and improve the electric current capacity of the water.

Parameters measured are total numbers, number of species and total weight. Scales were taken from representative fish for age determination (Lagler, 1956).

3. Coliform Bacteria. The coliform bacteria were sampled at all stations by the membrane filter method (American Public Health Assoc., 1965). The water was collected in 50 cc sterile bottles. An aliquot of the water was taken with a sterile pipette and filtered through a sterile membrane filter (0.45 µm). The filter was removed and placed in a sterile petri dish with an absorbent pad saturated with m-EndoBroth MF (Difco 0749). The endobroth was made fresh every sampling day according to label directions. The plates were incubated in an inverted position at 35°C for 12 to 18 hours. The coliform bacteria, which show a green metallic sheen on endobroth, were counted the following day. The coliform bacteria are reported as number of bacteria per 100 ml water.

(150.0 ppm) was recorded at station 8 on June 20, 1973. The lowest value (28.0 ppm) was recorded at station 1 on both August 7, 1973 and September 16, 1973. The highest mean value (118 ppm) was recorded at station 8 and the lowest mean value (35.0 ppm) was recorded at station 1.

B. BIOLOGY Results

1. Benthic Macroinvertebrate Fauna

a. Wet Weight. The wet weight in grams per square foot (the average of two square feet) for each invertebrate station is shown in table A15. Highest wet weight (4.98 gm) was recorded at station 7 on July 25, 1973. The lowest wet weight (0.03 gm) was found at station 1 on February 27, 1973. The highest mean wet weight (1.87 gm) was recorded at station 7, the lowest mean wet weight (0.57 gm) was recorded at station 8. The highest wet weights were recorded in the summer months.

b. Total Numbers of Invertebrates. The total numbers of macroinvertebrates per square foot (an average of two square feet) is shown in table A16. The highest number of macroinvertebrates (1005) was recorded at station 7 on July 25, 1972. The lowest number (9) of macroinvertebrates was recorded at station 6 on December 19, 1972 and at station 8 on November 28, 1972. The highest mean of numbers of invertebrates per square foot (435) was recorded at station 7, the lowest mean (70.7) at station 1. The highest total numbers were recorded in the summer months.

Results

c. Total Numbers of Macroinvertebrate Taxa. The total numbers of macroinvertebrate taxa per square foot (based on an average of two square feet) is shown in table A17. The highest number of taxa per square foot (23.5) was recorded at station 7 on August 30, 1972. The lowest number of taxa per square foot (4.5) was recorded at station 8 on November 28, 1972. The highest mean number of taxa per square foot (18.4) was found at station 7, the lowest mean number of taxa (12.9) recorded at station 8. The number of taxa per square foot was generally higher in the summer months.

d. Diversity Index. The diversity indices per square foot (based on an average of number of macroinvertebrates from two square feet) are shown in table A18. The highest diversity index (4.14) was recorded at station 1 on June 4, 1973. The lowest diversity index (1.53) was recorded at station 6 on May 4, 1972. The highest mean diversity index (3.42) was recorded at station 1, the lowest mean diversity index (2.87) at station 8.

e. Numbers and Taxa of Macroinvertebrates.

i. Station 1

Table A19 shows the total numbers and taxa found at station 1. A total number of 4189 organisms were recorded. The most numberous macroinvertebrate (770) was Stenonema (18% of total) and the second most numerous (460) were the members of the family Elmidae (11% of total). Ephemerella was dominant in numbers in May, Glossosoma in June, Hydropsyche in July, Stenonema in August, September and October, Elmidae in November, December and January, Tendipedidae in February and

March, and Ephemerella in April. The highest number (225) of macro-invertebrates per square foot was found on August 22, 1973, the lowest number (6) was found on February 27, 1973.

ii. Station 6

Table A20 shows the total numbers and taxa found at station 6. A total number of 9601 macroinvertebrates were recorded. The most numerous macroinvertebrate (2853 - 30%) was Hydropsyche, the second most numerous (2089 - 22%) was Cheumatopsyche. Tendipedidae dominated in May and June, Hydropsyche in July, August and September, Cheumatopsyche in October and November, Hydropsyche in December, Cheumatopsyche in January, and Tendipedidae in February, March and April. Highest number (732) of macroinvertebrates per square foot was found on September 12, 1973, the lowest number (9) was found on April 3, 1973.

iii. Station 7

Table A21 shows the total numbers and taxa per square foot found at station 7. A total number of 25,168 organisms were recorded. Most numerous macroinvertebrate was Hydropsyche (8753 - 35%), second most numerous macroinvertebrate were members of the family Tendipedidae (4797 - 19%). Ephemerella dominated in May, Tendipedidae in June, Hydropsyche in July, August, September and October, Tendipedidae in November, Hydropsyche in December and January, Tendipedidae in February, and Ephemerella in March and April. Highest number (1167) of macroinvertebrates per square foot were found on July 25, 1973, the lowest number (13) on May 4, 1972.

Results

of both 1972 and 1973. Station 1 was not included in this analysis due to the presence of large organisms (Procambarus and Tipula).

2. Fish. Table 2 shows the families of fish caught at stations 1, 3A, 6, 7 and 8 in the summers of 1972 and 1973. Greatest total weight (20,015 grams) for 200 feet of stream was obtained at station 6 on June 24, 1973. At this time 197 fish were caught, representing 15 species. 99 of these fish were Catostomus commersoni. The smallest total weight (2353 grams) was recorded at station 8 on June 24, 1973; 5 different species were caught at this time. Figure 43 shows the average weight of two samplings, the total numbers and the total number of taxa for each station. Total weight, number of taxa and total numbers per 200 feet of stream were lower in 1972 than in 1973 at stations 1, 6 and 7. At station 8 the number of fish was lower in 1972, but the number of taxa and weight were higher in 1972 than in 1973.

The most numerous fish at station 1 was Catostomus commersoni. A total of 23 white suckers were found with a combined weight of 94 oz. Nine brown trout were found at station 1, with a total weight of 53 oz. Two of the brown trout (Salmo trutta) had been reproduced in the stream, according to John Weaver of the Pennsylvania Fish Commission. Six eels were found, total weight 87 oz.

The most numerous fish at station 3A was Catostomus commersoni, with a total of five suckers weighing 14 oz. Three eels were found (A. rostrata) weighing a total of 49 oz. One brown trout was found weighing 35 oz.

The most numerous fish at station 6 was Catostomus

Table #2

Results of Electrofishing on the Bushkill Creek

Family	Station #1 '72	Station #1 '73	#3A '72	Station #6 '72	Station #6 '73	Station #7 '72	Station #7 '73	Station #8 '72	Station #8 '73
Salmonidae	1	8	1		1	1	8	2	2
Catostomidae	11	16	5	16	99	2	11	1	3
Esocidae		1	2						
Cyprinidae	15	43	8	31	72	8	80	13	10
Ictaluridae	1	2	3		1		1		
Anguillidae	3	3	3	1	3	6	7	2	7
Centrachidae	3	3	14	1	15	8	4		
Percidae	2			1			2		
Cottidae		1			6		10		
Chelyridae								1	
Total Fish	36	78	36	19	197	25	123	19	32
Total Taxa	10	12	9	4	17	7	13	7	5
Weight (ounces)	86	157	109	153	706	118	143	130	83
grams	2438	4451	3090	4337	20015	3345	4054	3686	2353

Sampling Dates:

1972 - July 14, 1972

1973 - June 24, 1973

Appendix Table A 15

Invertebrate Wet Weight (grams) Per Square Foot [e]

	1	6	7	8
1972				
5/4	0.48	0.11	0.59	0.60
5/25	0.90	0.70	4.10	1.40
6/7	0.20	0.75	3.98	0.60
6/22	no sampling due to high water			
7/5	2.27+	0.23	0.75	0.08
7/19	1.72+	0.50	1.30	0.23
8/1	1.67+	0.50	2.55	0.85
8/15	0.23	1.30	1.93	0.50
8/30	1.75+	0.35	1.60	0.80
9/15	0.15	0.48	2.17	0.83
9/27	0.08	0.90	1.45	1.45
10/11	0.96	1.00	0.95	0.43
10/25	0.45	2.20	1.33	1.35
11/7	0.23	1.18	1.35	0.98
11/28	0.10	-	0.73	0.08
12/19	0.10	0.06	1.00	0.04
1973				
1/16	0.20	0.80	1.25	0.20
2/27	0.03*	0.11	1.60	0.20
3/15	0.45	0.26	1.68	0.09
4/3	0.38	0.04	high water	0.14
4/17	0.96	0.10	2.35	0.23
5/1	1.65++	0.75	2.75	0.35
5/15	2.65++	0.30	2.93	0.35
6/4	2.58+	0.25	3.38	0.25
6/20	4.28+	1.05	1.95	0.55
7/11	0.23	0.70	1.60	0.18
7/25	1.98+	0.95	4.98**	1.13
8/7	0.40	0.93	1.95	1.35
8/22	0.23	1.55	0.45	0.58
9/12	0.20	1.48	1.15	0.93
9/26	0.35	1.38	0.70	0.35

e based on an average of two square feet
* lowest value
** highest value
\- not done
\+ includes Procambarus
++ includes Tipula

Appendix Table A16

Invertebrate Total Numbers Per Square Foot ⊖

	1	6	7	8
1972				
5/4	78	30	87	57
5/25	58	115	348	258
6/7	41	91	348	64
6/22	no sampling due to high water			
7/5	25	66	242	31
7/19	42	96	382	290
8/1	59	143	515	354
8/15	123	329	431	213
8/30	121	102	483	335
9/15	66	209	638	331
9/27	42	252	636	311
10/11	36	231	582	417
10/25	162	423	713	437
11/7	53	270	678	317
11/28	24	-	158	9*
12/19	31	9*	240	11
1973				
1/16	24	40	265	16
2/27	25	33	265	58
3/15	103	35	336	22
4/3	68	12	-	12
4/17	46	24	312	40
5/1	54	135	435	184
5/15	77	142	383	184
6/4	79	63	293	60
6/20	120	277	978	504
7/11	44	141	329	65
7/25	84	229	1005**	205
8/7	92	217	381	233
8/22	177	350	313	158
9/12	88	484	611	352
9/26	80	268	242	300

⊖ based on an average of two square feet
* lowest value
** highest value
\- not done

Appendix Table A17

Total Number of Invertebrate Taxa Per Square Foot ⊕

	1	6	7	8
1972				
5/4	16.0	4.5	9.0	12.0
5/25	13.0	15.5	17.5	18.5
6/7	13.0	14.5	19.0	13.0
6/22	-	-	-	-
7/5	8.5	14.5	16.5	9.5
7/19	14.0	15.5	15.5	15.5
8/1	16.0	16.5	18.5	19.0
8/15	19.0	22.5	20.0	16.0
8/30	18.0	11.5	23.5**	18.5
9/15	14.5	16.0	24.5	20.0
9/27	12.5	14.5	18.5	15.5
10/11	10.5	16.5	16.0	12.0
10/25	15.0	19.0	17.5	13.5
11/7	13.5	12.0	18.5	15.5
11/28	10.0	-	15.0	4.5*
12/19	11.0	5.5	16.5	7.0
1973				
1/16	10.5	10.5	15.5	10.5
2/27	6.5	7.5	16.5	8.0
3/15	13.5	6.5	17.0	8.0
4/3	16.5	7.0	-	7.5
4/17	11.0	8.0	15.5	8.0
5/1	15.5	15.0	18.0	12.0
5/15	20.5	10.5	19.0	13.5
6/4	23.0	15.5	20.0	10.0
6/20	19.0	16.0	22.5	14.0
7/11	12.0	15.0	18.5	11.0
7/25	18.5	20.5	22.0	14.0
8/7	16.5	19.0	23.0	15.5
8/22	16.0	22.0	21.5	14.5
9/12	15.5	19.5	22.0	14.5
9/26	17.0	15.0	16.0	14.5

⊕ based on an average of two square feet
* lowest value
** highest value
\- not done

Appendix Table A18

Diversity Index - Invertebrates Per Square Foot [e]

	1	6	7	8
1972				
5/4	3.41	1.53*	2.68	3.41
5/25	2.97	2.79	3.00	2.86
6/7	3.65	3.41	2.96	3.39
6/22	-	-	-	-
7/5	3.18	3.77	3.27	3.20
7/19	3.95	3.01	2.78	1.83
8/1	4.03	3.20	2.84	3.55
8/15	3.60	3.19	3.19	3.43
8/30	3.42	2.93	3.53	3.24
9/15	3.23	3.18	3.29	3.80
9/27	3.36	2.30	2.57	2.99
10/11	3.58	2.78	2.64	2.74
10/25	3.34	2.70	2.98	3.14
11/7	3.50	2.46	2.80	3.16
11/28	3.28	2.17	3.46	2.73
12/19	3.01	2.92	3.19	3.18
1973				
1/16	3.59	2.91	3.12	3.52
2/27	2.72	2.71	3.05	2.26
3/15	2.74	2.20	2.96	3.19
4/3	3.70	3.15	-	3.32
4/17	3.65	3.42	2.73	2.76
5/1	3.68	3.23	3.03	1.63
5/15	3.90	1.84	3.07	2.06
6/4	4.14**	3.38	3.03	2.55
6/20	3.31	3.28	2.58	1.68
7/11	3.51	2.81	2.62	2.93
7/25	3.86	3.26	1.97	2.42
8/7	3.40	3.28	2.92	2.89
8/22	2.50	3.46	3.58	3.15
9/12	3.06	2.97	2.98	2.45
9/26	2.84	2.49	3.31	2.73

e based on an average of two square feet
* lowest value
** highest value
\- not done

Appendix Table A19

Total Numbers and Taxa of Macroinvertebrates - Station #1

	May (8)*	Jun (6)	Jul (8)	Aug (8)	Sep (10)	Oct (4)	Nov (4)	Dec (2)	Jan (2)	Feb (2)	Mar (2)	Apr (4)	Total	%
Invert.														
Trichoptera														
Hydropsyche	64	46	71	57	37	35	9	7	3	1	1	17	348	8
Cheumatopsyche	33	11	23	47	70	51	22	4	4	0	8	8	281	7
Hydroptila	3	6	10	5	7	1	2	1	0	0	0	0	35	1
Chimarra	8	14	9	14	5	47	7	1	2	1	1	4	113	3
Neophylax	32	12	59	48	20	3	0	0	0	0	0	0	174	4
Glossosoma	6	99	41	48	76	53	14	2	1	2	3	17	362	9
Diptera														
Tendipedidae	52	40	21	22	25	4	2	0	7	19	94	45	331	8
Atherix	4	1	5	5	13	9	1	0	2	1	0	8	49	1
Antocha	18	5	4	17	8	1	2	0	0	0	1	6	62	1
Simulium	4	4	2	2	2	0	0	0	2	15	50	11	92	2
Ephemeroptera														
Baetis	6	35	6	12	15	0	0	0	0	0	1	5	80	1
Pseudocl.	16	2	5	4	1	0	0	0	0	0	0	0	28	1
Isonychia	3	2	6	44	46	10	3	1	0	0	2	2	119	3
Ephemerella	162	97	6	3	1	9	4	0	1	2	10	51	346	8
Stenonema	3	4	23	365	272	68	21	2	2	1	5	4	770	18
Coleoptera														
Elmidae	28	39	37	90	97	66	40	8	12	6	19	18	460	11
Psepharus	18	33	26	28	28	10	9	3	3	1	2	4	165	4
Other Col.	4	0	0	2	2	0	0	0	0	0	0	1	9	-
Plecoptera	17	3	4	6	2	14	10	2	0	1	1	3	63	2
Odonata	3	4	0	5	9	0	0	0	0	0	0	1	22	1
Decapoda	1	2	3	1	2	0	0	0	0	0	0	0	9	-
Annelida	13	2	8	4	8	6	3	0	4	0	1	2	51	1
Other	27	16	18	70	47	8	3	-	4	-	6	21	220	5
Total	525	477	387	899	793	395	152	31	47	50	205	228	4189	

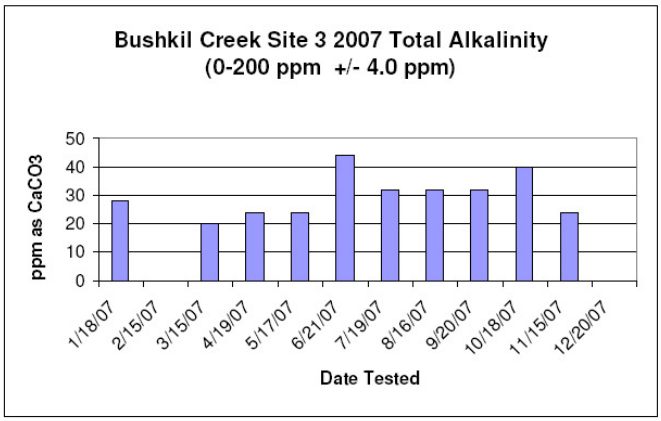
* Number in parenthesis indicates number of square feet sampled that month

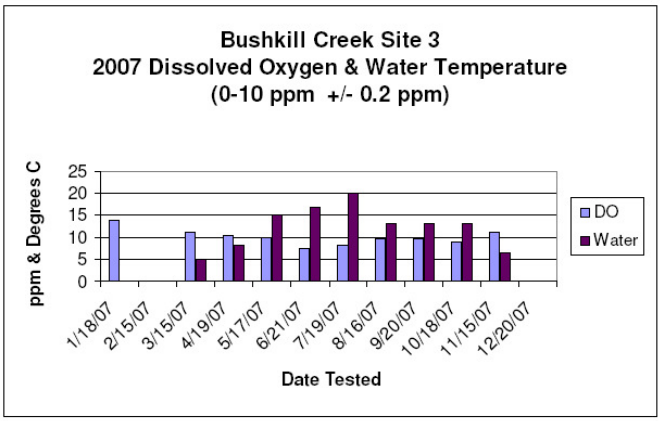
Appendix G

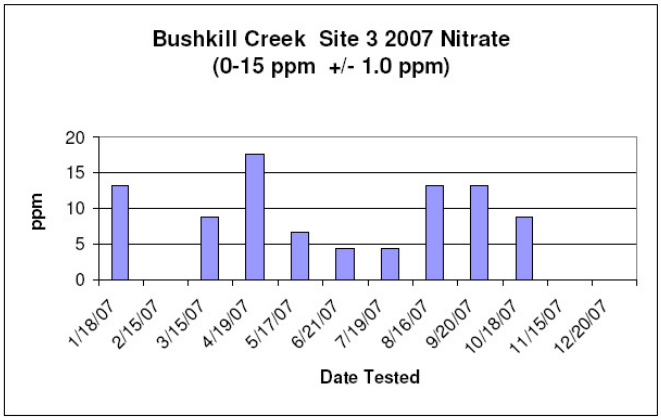
Retired and Senior Volunteer Program
Water Quality Data for the
Upper Bushkill Creek Watershed

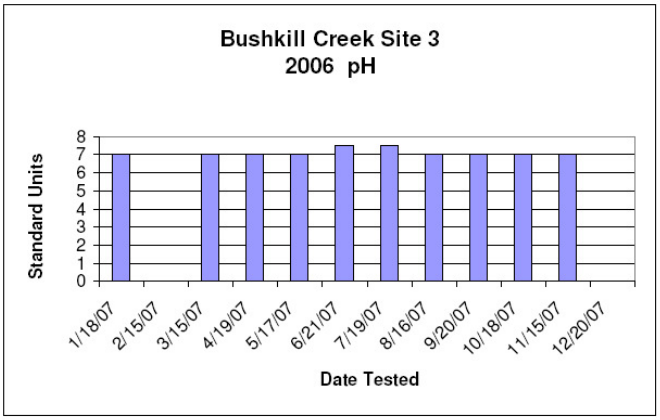
Bridge at East Douglassville Rd, JSP Site 3

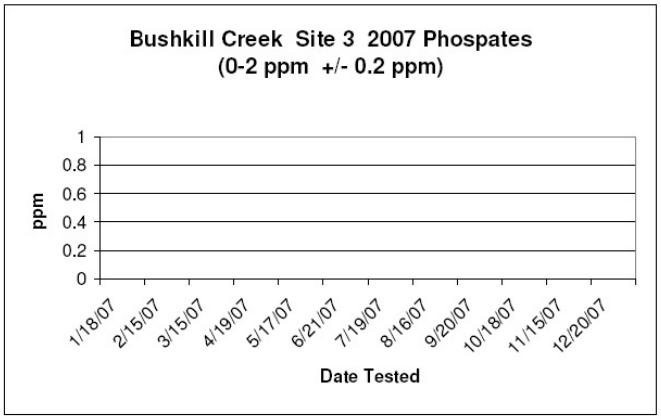
Date	pH	Nitrate (ppm)	Phosp (ppm)	DO (ppm)	Alk (ppm)	Turb (JTU)	Air Temp (deg C)	Water Temp (deg C)	Phosp PPMx100
Range	0-14	0-44	0-50	0.2-20	5-400				
1/18/07	7	13.2	0	13.8	28	0	-3	0	0
2/15/07	0	0	0	0	0	0	0	0	0
3/15/07	7	8.8	0	11	20	0	8	5	0
4/19/07	7	17.6	0	10.4	24	0	10	8	0
5/17/07	7	6.6	0	10	24	0	15	15	0
6/21/07	7.5	4.4	0	7.4	44	0	17	17	0
7/19/07	7.5	4.4	0	8	32	0	21	20	0
8/16/07	7	13.2	0	9.6	32	0	14	13	0
9/20/07	7	13.2	0	9.6	32	0	14	13	0
10/18/07	7	8.8	0	9	40	0	15	13	0
11/15/07	7	0	0	11	24	0	3.5	6.5	0
12/20/07	0	0	0	0	0	0	0	0	0

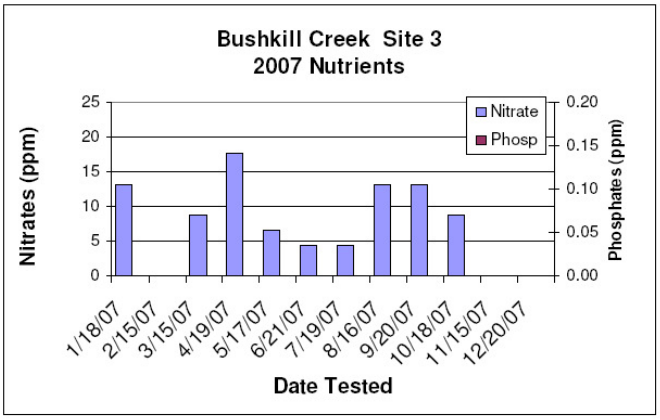






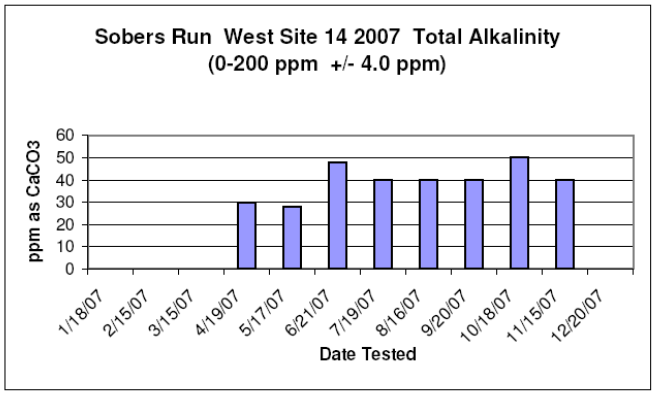


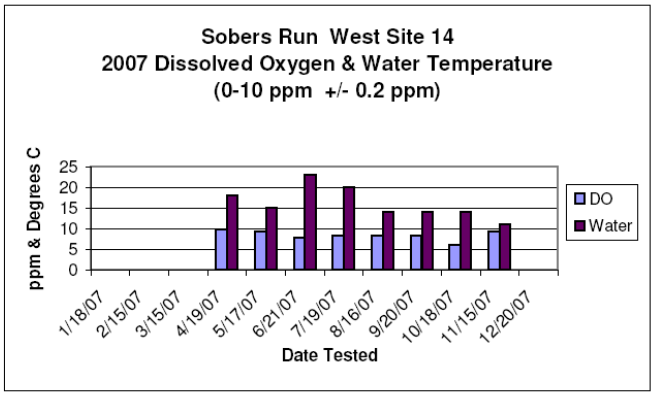


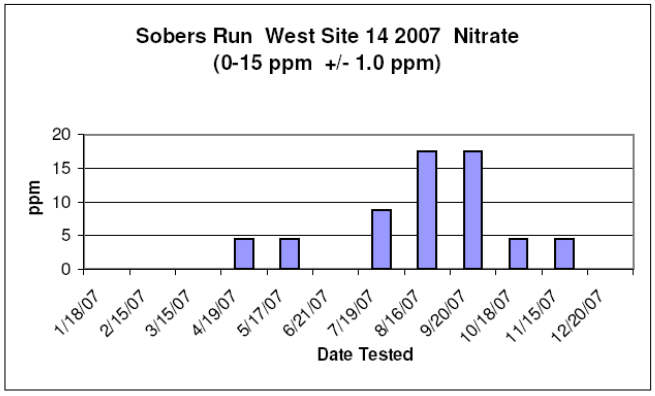


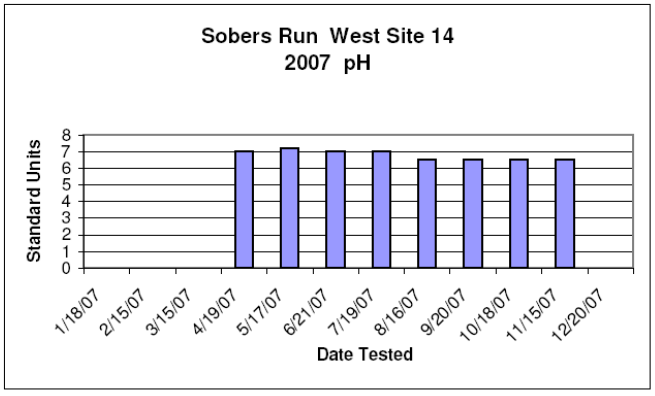
Sobers Run - West Site 14

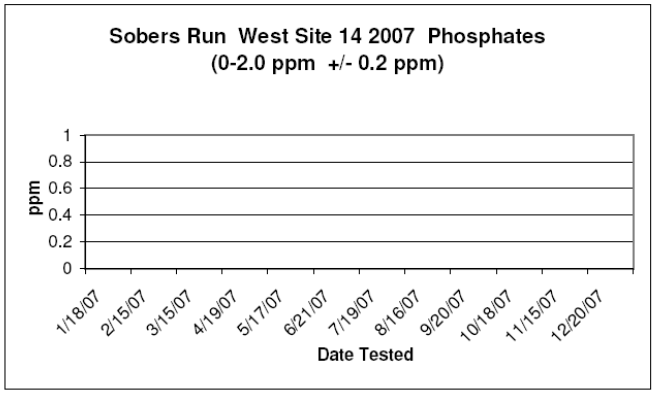
Date	pH	Nitrate (ppm)	Phosp (ppm)	DO (ppm)	Alk (ppm)	Turb (JTU)	Air Temp (deg C)	Water Temp (deg C)	Phosp PPMx100
Range	0-14	0-44	0-50	0.2-20	5-400				
1/18/07	0	0	0	0	0	0	0	0	0
2/15/07	0	0	0	0	0	0	0	0	0
3/15/07	0	0	0	0	0	0	0	0	0
4/19/07	7	4.4	0	9.8	30	0	21	18	0
5/17/07	7.2	4.4	0	9.2	28	0	22	15	0
6/21/07	7	0	0	7.8	48	0	27	23	0
7/19/07	7	8.8	0	8.3	40	0	22	20	0
8/16/07	6.5	17.6	0	8.4	40	0	23	14	0
9/20/07	6.5	17.6	0	8.4	40	0	23	14	0
10/18/07	6.5	4.4	0	6	50	0	16	14	0
11/15/07	6.5	4.4	0	9.4	40	0	17	11	0
12/20/07	0	0	0	0	0	0	0	0	0

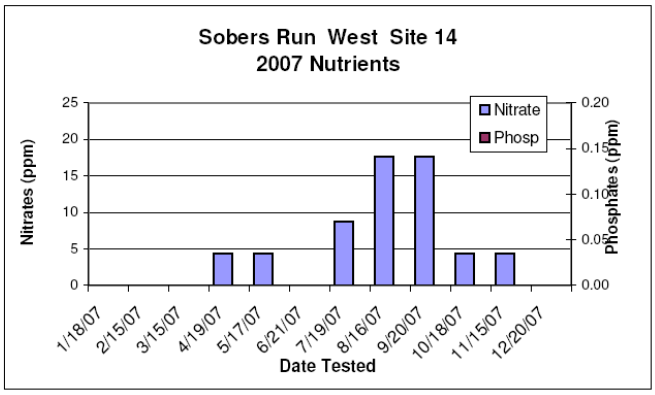












Sobers Run Site 15

Date	pH	Nitrate (ppm)	Phosp (ppm)	DO (ppm)	Alk (ppm)	Turb (JTU)	Air Temp (deg C)	Water Temp (deg C)	Phosp PPMx100
Range	0-14	0-44	0-50	0.2-20	5-400				
1/18/07	0	0	0	0	0	0	0	0	0
2/15/07	0	0	0	0	0	0	0	0	0
3/15/07	0	0	0	0	0	0	21	0	0
4/19/07	6.5	0	0	10	45	0	21	18	0
5/17/07	7.4	4.4	0	9.4	40	0	22	15	0
6/21/07	7	4.4	0	7.8	30	0	26	22	0
7/19/07	7	4.4	0	9	40	0	22	19	0
8/16/07	7	8.8	0	8	48	0	23	15	0
9/20/07	7	8.8	0	8	48	0	23	15	0
10/18/07	7	4.4	0	8.6	25	0	16	15	0
11/15/07	6	4.4	0	7.8	42	0	17	12	0
12/20/07	0	0	0	0	0	0	0	0	0