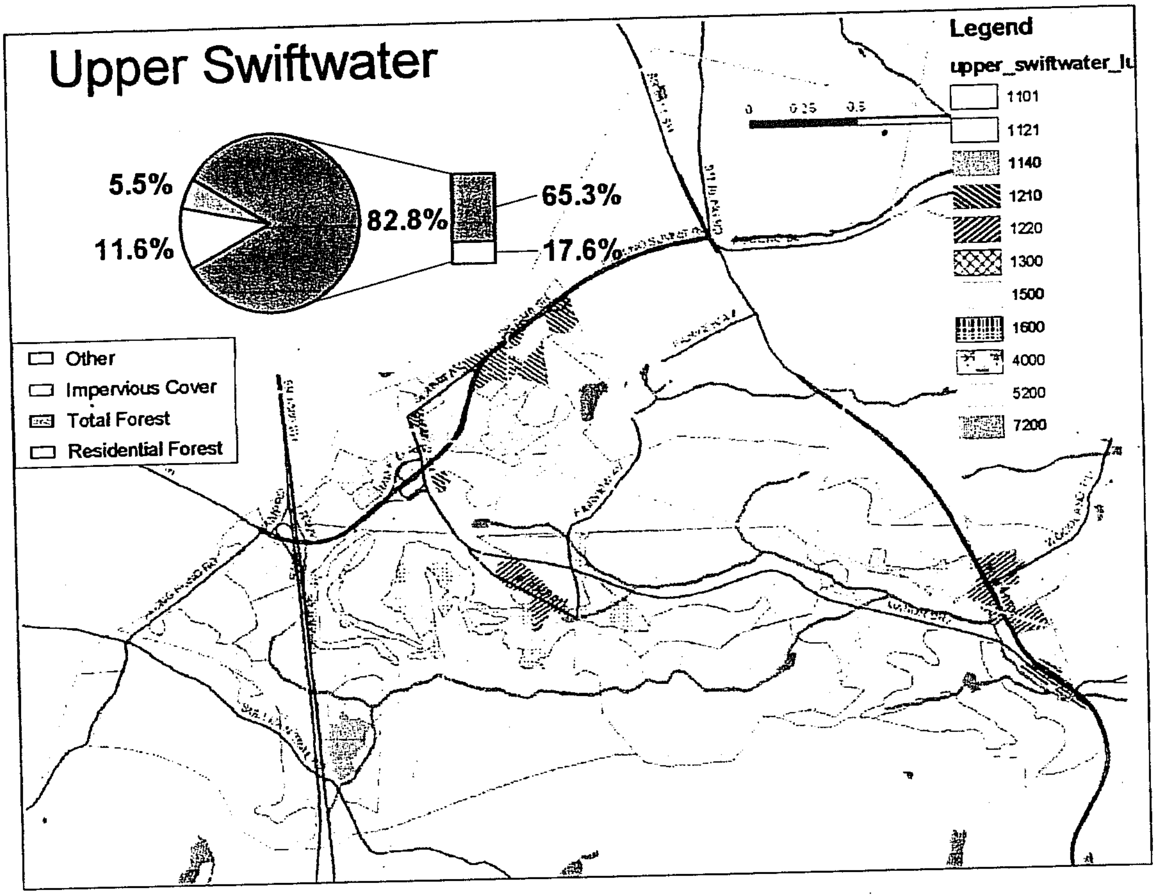
Upper Swiftwater
5.5%
11.6%
82.8%
65.3%
17.6%
Other
Impervious Cover
Total Forest
Residential Forest
Legend
upper_swiftwater_lu
1101
1121
1140
1210
1220
1300
1500
1600
4000
5200
7200

BENTHIC MACROINVERTEBRATES

OF

SWIFTWATER CREEK

ABOVE AND BELOW THE POCONO MANOR SEWAGE TREATMENT PLANT

DISCHARGE

NOVEMBER 12, 2001

Submitted by

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For

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BENTHIC MACROINVERTEBRATES OF SWIFTWATER CREEK ABOVE AND BELOW POCONO MANOR SEWAGE TREATMENT PLANT OUTFALL, NOVEWMBER 12, 2001

BACKGROUND

On November 12, 2001, at the request of Paradise Township Supervisors, Aquatic Resource Consulting (ARC) biologists Don Baylor and Jim Hartzler sampled benthic macroinvertebrates at two stations on Swiftwater Creek, Monroe County, PA. The purpose of the sampling was to evaluate the impact of the discharge from Pocono Manor's sewage treatment plant on Swiftwater Creek.

Aquatic macroinvertebrates are preferred indicators of stream water quality because of their limited mobility, one to three year life cycles, and specific sensitivities to pollutants. Clean streams usually support numerous species of invertebrates, theoretically evenly represented in number. Impairment may be indicated by low taxa richness, shifts in community balance toward dominance of pollution-tolerant forms, or overall scarçity of invertebrates (Plafkin, et al. 1989). In order to assure an accurate assessment, recent work in bio-monitoring stresses the use of several parameters, or metrics, to measure different components of the community structure.

METHODS

Sampling methods followed those recommended by the US Environmental Protection Agency Protocol III (Plafkin, et al., 1989) with the latest modifications adopted by Pennsylvania Department of Environmental Protection (PA DEP, 1997). At each station, two samples were taken with a D-frame kick net. The net was placed against the substrate and the substrate was disturbed for a distance of approximately one meter above the net. Organisms and debris were composited for each station.

In the laboratory, organisms were removed from debris then placed in an enameled pan marked with grids. Organisms were removed from the pan starting with a randomly selected grid until over 100 organisms were obtained. Organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value if known (Bode, et al. 1996 and Environmental Analysts 1990). Taxa richness, modified EPT index, modified Hilsenhoff biotic index (Hilsenhoff, 1987), percent dominant taxon, and percent modified mayflies were calculated for each station to apply the DEP Central Office's most recent draft guidance for use with special protection and anti-degradation studies. A description and brief rationale for each of the five metrics follow:

1. Taxa Richness – is an index of diversity. The number of taxa (kinds) of invertebrates indicates the health of the benthic community through measurement of the number of species present. Generally, number of species increases with increased water quality. However, habitat variability (stream order and size, substrate composition, current velocity) can affect this number.

2. Modified EPT Index – is a measure of community balance. The insect orders Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies) collectively referred to as EPT, are generally considered pollution sensitive (Plafkin et al. 1989). Healthy biotic conditions are reflected when these taxa are well represented in the benthic community. Thus, the total number of taxa within the EPT insect groups minus those considered pollution tolerant is used to evaluate community balance.

3. Modified Hilsenhoff Biotic Index – is a direct measure of pollution tolerance. Since many of the aquatic invertebrate taxa have been associated with specific values for tolerance to organic pollutants, a biotic index is also used to measure the degree of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated (Table 1).

Table 1. Evaluation of water quality using biotic index values (Hilsenhoff, 1987)

BIOTIC INDEX	WATER QUALITY	DEGREE OF ORGANIC POLLUTION
0.00-3.50	Excellent	None Apparent
3.51-4.50	Very Good	Possible Slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly Significant
6.51-7.50	Fairly Poor	Significant
7.51-8.50	Poor	Very Significant
8.51-10.00	Very Poor	Severe

4. Percent Dominant Taxon – measures evenness of community structure. It is the percent of the total abundance made up by the single most abundant taxon. Dominance of a few taxa may suggest environmental stress; however, the tolerance value of the dominant taxon must be considered.

5. Percent Modified Mayflies – is another measure of balance. Mayflies are considered one of the least tolerant orders to organic pollution and acidification. Undisturbed streams generally have an abundance of mayflies. Pennsylvania uses the percentage contribution of mayflies to the total number of organisms as an indication of water quality. This metric is modified to exclude those mayflies considered pollution tolerant.

Each of the five metrics uses a different scoring scale, so they were converted to the same scale using the normalizing scores listed below.

Table 2. Biological condition scoring criteria for converting metric values to normalized scores for comparison to reference stations.

Metric	METRIC VALUE COMPARISON TO REFERENCE			
Taxa Richness (candidate/reference)	>80%	79-70%	69-60%	<60%
Modified EPT Index (candidate/reference)	>80%	79-60%	59-50%	<50%
Mod. Hilsenhoff Biotic Index (candidate-reference)	<0.71	0.72-1.11	1.12-1.13	>1.13
% Dominant Taxon (candidate-reference)	<10	11-16	17-20	>22
% Mod. Mayflies (reference-candidate)	<12	13-20	21-40	>40
Normalizing Score	6	4	2	0

Habitat was assessed at each station using the format prescribed for riffle/run predominance in EPA's Rapid Bioassessment Protocols (Plafkin, et al. 1989) and subsequently modified by PADEP. Each station was visually evaluated for 12 parameters, which were rated on a scale of 1-20. Scores for all parameters were added to yield a total habitat score.

SAMPLING STATIONS

Samples were collected at two stations (Figure 1). Station 1 was a riffle area approximately 50 meters above the point where the flow from Pocono Manor's discharge enters Swiftwater Creek, and Station 2 was a similar riffle area approximately 50 meters below the confluence of the discharge and Swiftwater Creek.

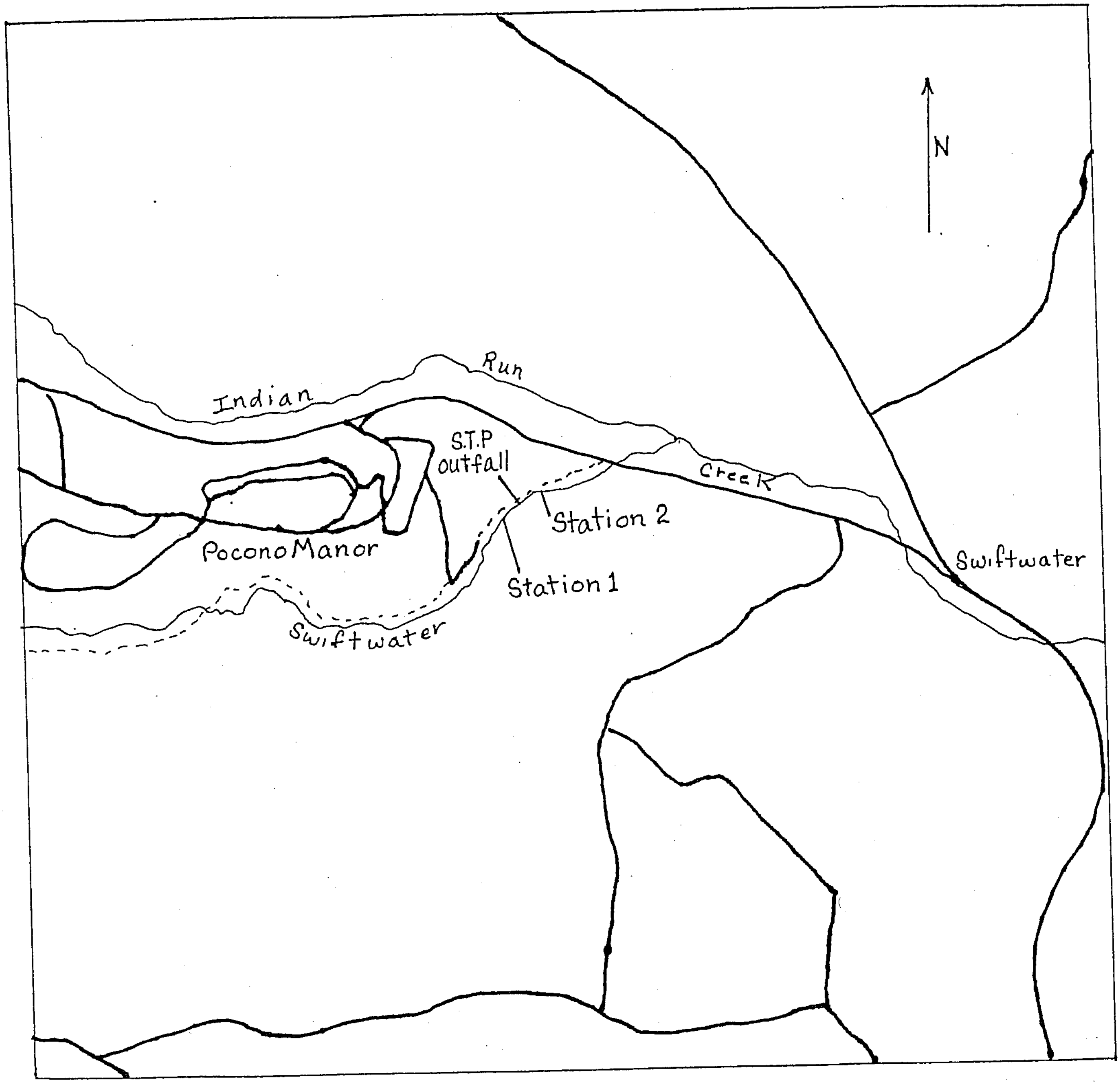

Figure 1. Stations on Swiftwater Creek above and below the Pocono Manor STP discharge sampled for benthic macroinvertebrates on November 12, 2001 (from USGS Mount Pocono, PA quad.).

RESULTS AND DISCUSSION

HABITAT

Habitat ratings fell within the optimum range for both stations (Table 3). Habitat appeared to be nearly the same at both stations with the only limitation being a lack of deeper water due to the small size of the stream and low flows at the time of sampling. Except for an unpaved woodland road that parallels the stream, this portion of Swiftwater Creek appears to be in a relatively pristine, natural state regarding physical habitat.

Table 3. Habitat assessment of sampling stations on Swiftwater Creek, November 12, 2001. Score ranges: optimal 240-192, suboptimal 180-132, marginal 120-72, poor <60.

HABITAT PARAMETER	SCORE	
	STATION 1 ABOVE	STATION 2 BELOW
1. Instream Cover	17	16
2. Epifaunal Substrate	18	18
3. Imbeddedness	18	19
4. Velocity/Depth Regimes	16	15
5. Channel Alteration	20	20
6. Sediment Deposition	19	19
7. Frequency of Riffles	18	18
8. Channel Flow Status	17	17
9. Condition of Banks	19	20
10. Bank Vegetative Protection	20	20
11. Grazing & Other Disruptive Pressure	17	17
12. Riparian Zone Width	18	17
TOTAL SCORE	**217**	**216**

MACROINVERTEBRATE COMMUNITIES

At the time of the November 2001 sampling, macroinvertebrates of Swiftwater Creek indicated little or no impairment from the Pocono Manor's STP discharge. According to PA DEP's latest community metric scoring criteria, Station 2 below the outfall scored 100% of the reference station above the outfall (Table 4). Taxa richness, EPT index values, percentages of mayflies (modified), and percentages of the dominant taxon were very similar for both stations. Stoneflies of the genus *Leuctra* were the dominant taxon at Station 1, and caddisfly larvae of *Dolophilodes distinctus* were dominant at Station 2 (Appendix A). Both of these taxa have a pollution tolerance rating of 0. Invertebrates intolerant of organic pollution were a large majority of the organisms at both stations. The greatest difference in metrics between the stations was in the biotic index values (Table 4). The somewhat poorer value at Station 2 (2.00) than that at Station 1 (1.31) remains well within the clean stream range (Table 1). The difference in these values of 0.69 was just within the range giving Station 2 the same normalizing score as Station 1 (see table 2). This difference may suggest a slight organic enrichment from the STP outfall between stations.

Table 4. Macroinvertebrate community metrics and scores for samples from Swiftwater Creek above and below Pocono Manor's sewage treatment plant discharge on November 12, 2001

SPRING METRICS	STATION 1		STATION 2	
	VALUE	SCORE	VALUE	SCORE
Number of Organisms in Subsample	128	-	113	-
Number of Grids Picked	9	-	17	-
Taxa Richness	21	6	20	6
Modified EPT Index	16	6	14	6
Modified Hilsenhoff Biotic Index	1.31	6	2.00	6
Percent Dominant Taxon	27%	6	23%	6
Percent Modified Mayflies	21%	6	24%	6
Biological Condition Score		**30**		
Percent of Reference		**100%**		

Appendix A. Taxa, numbers, biotic index pollution tolerance value (BI), and functional feeding group (FG) for benthic macroinvertebrates from Swiftwater Creek, above and below Pocono Manor's sewage treatment plant discharge, November 12, 2001 (Cg=collector/gatherer, Sc=scraper, Fc=filtering collector, P=predator, Sh=shredder).

TAXA	STATIONS		BI	FG
	STATION 1 ABOVE	STATION 2 BELOW		
Ephemeroptera (mayflies)				
Ephemerella invaria/rotunda	7	14	1	Cg
Epeorus pluralis/punctata	5	4	0	Sc
Paraleptophlebia sp.	13	8	2	Cg
Stenonema modestum	-	1	3	Sc
Baetis sp.	2	10	6	Cg
Acerpenna pygmaea	1	-	4	Cg
Heptagenia sp.	1	-	3	Sc
Trichoptera (caddisflies)				
Dolophilodes distinctus	19	25	0	Fc
Hydropsyche (Ceratopsyche) ventura	6	1	4	Fc
H. (Cratopsyche) sparna	-	1	1	Fc
Cheumatopsyche sp.	1	1	5	Fc
Rhyacophila fuscula	3	5	0	P
R. carolina	2	-	1	P
R. manistee	1	4	1	P
R. torva	-	2	1	P
Lepidostoma sp.	6	1	1	Sh
Plecoptera (stoneflies)				
Tallaperla sp.	4	1	0	Sh
Pteronarcys scotti	2	-	0	Sh
Leuctra sp.	35	10	0	Sh
Yugus bulbosus	1	1	-	-
Chloroperlidae	5	4	0	P
Diptera (true flies)				
Chironomidae	12	18	6	-
Antocha sp.	1	-	3	Cg
Hexatoma sp.	1	-	2	P
Simulium sp.	-	1	5	Fc
Coleoptera (beetles)				
Oreodytes sp.	-	1	-	P

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AQUATIC
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ELECTROFISHING SURVEY OF SWIFTWATER CREEK

Prepared for

Paradise Township Supervisors

Jim Hartzler
November 2000

INTRODUCTION

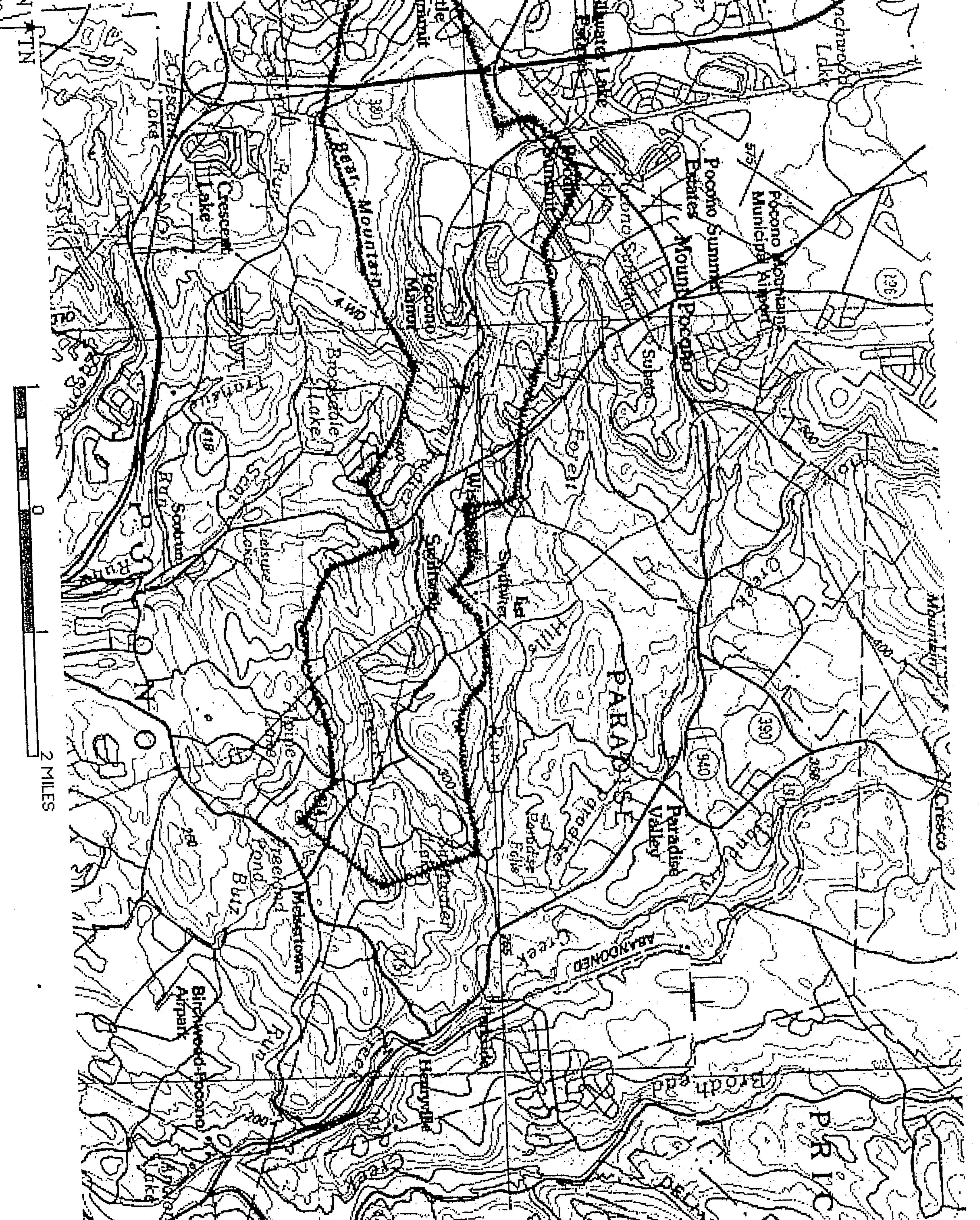
On 13 October 2000, Aquatic Resource Consulting (ARC) conducted an inventory of the fish community of Swiftwater Creek at the request of the Paradise Township Supervisors. In recent years, significant residential and commercial development has occurred in the watershed, and this trend is projected to continue. Increased surface runoff, groundwater depletion, and impacts from regulated discharges associated with these activities have the potential to degrade the existing water quality, habitat, and aquatic biota of the stream. This survey is designed to establish a database of information describing the present fishery. Future inventories will permit monitoring of changes that may occur related to impacts from land use. In conjunction with this survey, ARC also sampled the aquatic macroinvertebrate community at several sites on Swiftwater Creek on. Those results are available in a separate report (Baylor 2000).

STREAM DESCRIPTION

Swiftwater Creek is a second order tributary to Paradise Creek that originates on the Pocono Plateau adjacent the Rt. 380/Rt. 940 interchange approximately 3 miles west of Mt. Pocono, PA (Figure 1). A tributary, Indian Run, joins the main branch just upstream from Swiftwater, PA, along Route 611. From this point, the stream flows eastward through a relatively narrow, steep valley before its juncture with Forest Hills Run and Paradise Creek near Henryville, PA. The watershed is heavily forested, and the primary land use is residential housing with commercial development concentrated along the Rt. 611 corridor.

Water analyses conducted by the Monroe County Planning Commission indicate the water is slightly alkaline with relatively low nutrient (nitrate and phosphate) levels and low mineral content. Several sewage treatment plants discharge waste into Swiftwater Creek, including facilities at Pocono Manor, the Pocono Mountain School District, and Aventis-Pasteur (a vaccine production facility). Swiftwater Creek is classified by PA DEP as a High Quality Coldwater Fishery.

Figure 1. Swiftwater Creek watershed (outlined).



METHODS

Portions of Swiftwater Creek were sampled using a Coffelt BP1C backpack variable-voltage electrofishing unit with handheld electrodes and nets. Three consecutive runs were made in an upstream direction at each station to permit estimates of trout abundance (numbers) and biomass (weight per unit area). All fish species were identified and released. Trout were also weighed and measured.

Sampling locations were as follows (Figure 2, and Figures 3a, 3b, and 3c.):

(A) Upper – begin approximately 300 feet above Swiftwater Preserve property line (cable); end approximately 300 feet below Rt. 314 bridge (sampling distance = 295 feet).
(B) Middle – adjacent open field along Rt. 314 beside Aventis stormwater detention pond; begin and end at riffle areas (sampling distance = 360 feet).
(C) Lower – begin at riffle area approximately 150 feet above Rt. 314 bridge off Lower Swiftwater Rd.; end above pool area (sampling distance = 190 feet).

RESULTS AND DISCUSSION

Fish Species

Three species of salmonids – fish in the trout and salmon family – whose distribution is limited to relatively unpolluted, coldwater ecosystems, dominated in collections from Swiftwater Creek (Tables 1 and 2). Brown trout (***Salmo trutta***) was by far the predominant species. Next in abundance were wild rainbow trout (***Oncorhynchus mykiss***), a species recently reclassified as a salmon based upon its genetic makeup and original distribution (coastal streams of the western U.S.). Only a few wild brook trout (***Salvelinus fontinalis***), the only salmonid native to the Pocono area and the eastern U.S., were found. Three other species often associated with wild trout in Northeastern streams – slimy sculpin (***Cottus cognatus***), white sucker (***Catostomus commersoni***), and longnose dace (***Rhinichthys cataractae***) – were also collected. In addition, four stocked trout (three brown trout, one rainbow trout) were taken at the lower station and one stocked rainbow trout was recovered at the upper station. The criteria for identification of stocked (hatchery) trout were size, pigmentation, and fin condition (compared to wild trout, hatchery trout are generally larger, less colorful, and the fins are rounded from erosion caused by confinement in rearing ponds and raceways).

Figure 2. Sampling locations on Swiftwater Creek, 13 October 2000.

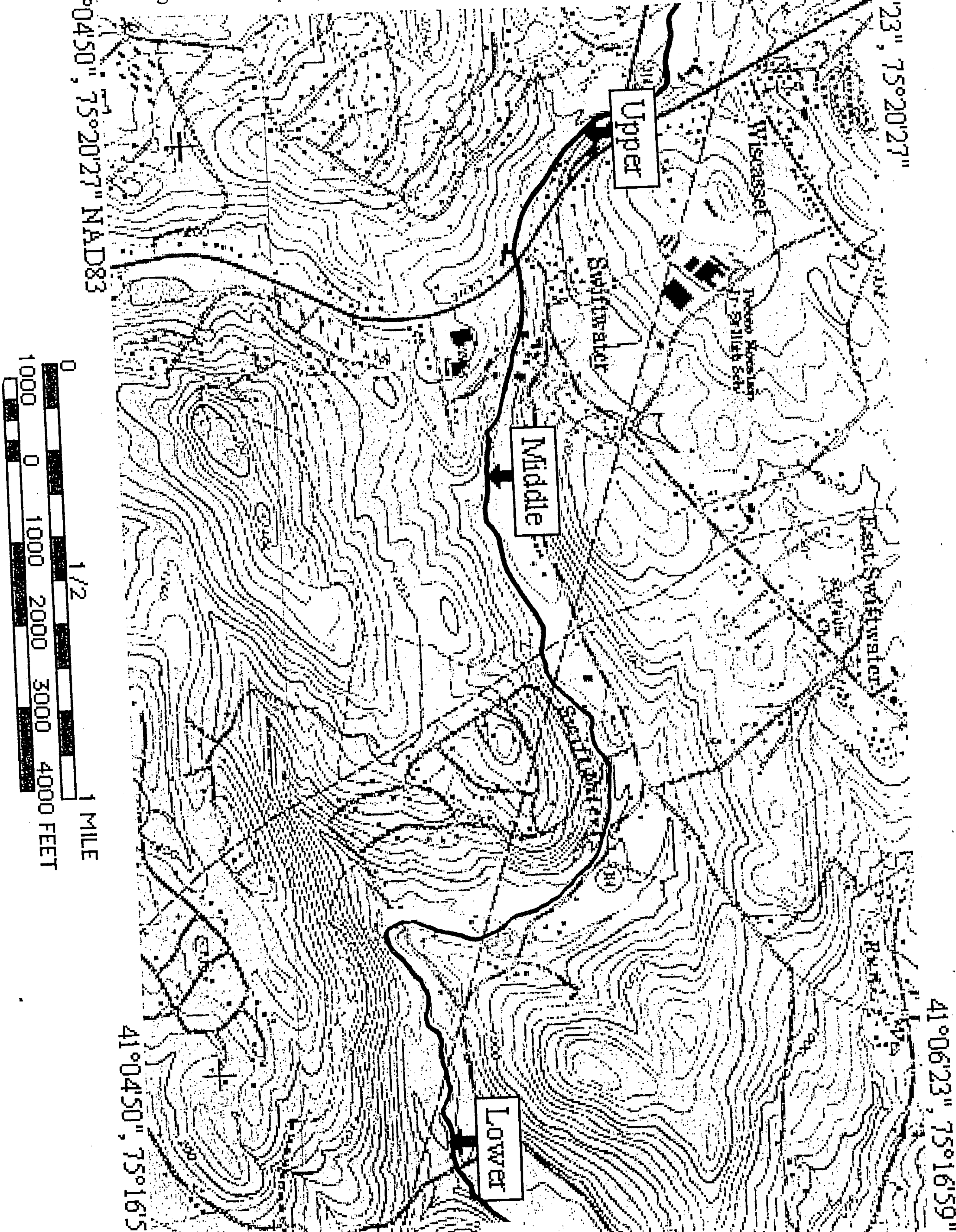


Figure 3a. Upper sampling location on Swiftwater Creek.

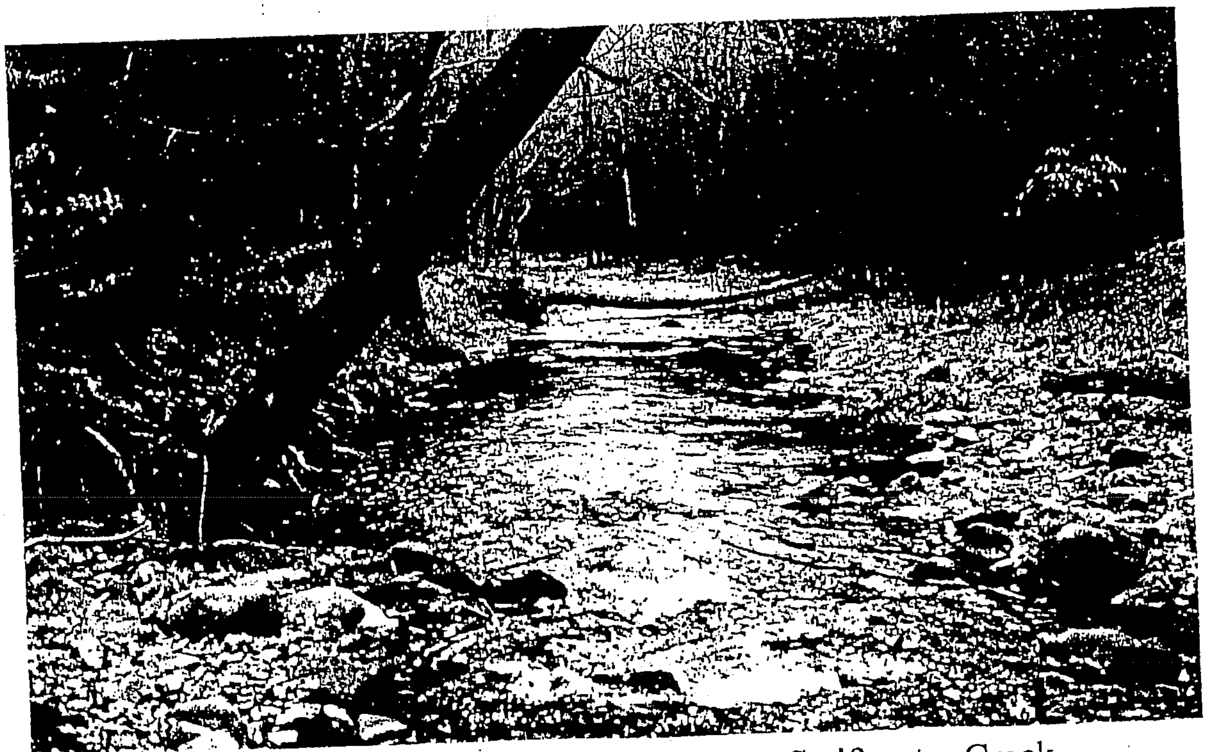


Figure 3b. Middle sampling location on Swiftwater Creek.

Figure 3c. Lower sampling location on Swiftwater Creek.

The four most abundant fish taxa in Swiftwater Creek - brook, brown and rainbow trout, and sculpins - are classified as coldwater species that subsist primarily on aquatic insects and fish, and are intolerant to environmental pollutants and habitat degradation (Table 2). Brook trout, the primary inhabitant of many headwater Pocono streams, are particularly sensitive to extremely low concentrations of heavy metals, chlorine (used to disinfect treated waste), and other dissolved contaminants. All salmonids require high dissolved oxygen levels and are stressed when concentrations of organic (=oxygen demanding) wastes are excessive. Most trout cannot survive temperatures above 20 degrees C (68 degrees F) for prolonged periods. In addition, dependence on aquatic macroinvertebrates, including many pollution intolerant mayfly, caddisfly, and stonefly species, as the primary food source makes resident fish species in Swiftwater Creek particularly vulnerable to even small changes in water quality and habitat disturbance. Sculpins, for example, reproduce by depositing adhesive eggs on the underside of cobble and boulders; siltation caused by sediment from surface runoff can lead to reproductive failure. Sedimentation can also suffocate trout eggs and fry that incubate for several months in gravel beds (redds) constructed by fish during reproduction. Catastrophic flows from excessive runoff during storm events can destroy redds by scouring.

Table 1. Summary of electrofishing data at three stations on Swiftwater Creek on 13 October 2000. A slash (-) indicates species was absent.

STATION	Upper	Middle	Lower
Length (feet)	295	360	190
Avg. width (feet)	18	19	13
Area – acres	0.121	0.158	0.056
Hectares	0.049	0.064	0.023

FISH SPECIES	Number Collected		
Brown trout (*Salmo trutta*)			
Wild	90	206	243
Stocked	0	0	3
Rainbow trout (*Oncorhynchus mykiss*)			
Wild	24	2	1
Stocked	1	-	1
Brook trout (*Salvelinus fontinalis*)	3	6	-
Slimy sculpin (*Cottus cognatus*)	abundant	abundant	abundant
White sucker (*Catostomus commersoni*)	-	-	rare
Longnose dace (*Rhinichthys cataractae*)	-	-	rare

Table 2. Classification of fish species collected at three stations on Swiftwater Creek on 13 October 2000.

SPECIES	Distribution	Temperature Class	Tolerance	Trophic Class
Brown trout	exotic	coldwater	intolerant	top carnivore
Rainbow trout	exotic	coldwater	intolerant	top carnivore
Brook trout	native	coldwater	intolerant	top carnivore
Slimy sculpin	native	coldwater	intolerant	benthic invertivore
White sucker	native	coolwater	tolerant	generalist feeder
Longnose dace	native	coolwater	moderate	benthic invertivore

Key:

Distribution: Exotic = introduced; native = indigenous to region.

Temperature class: Coldwater = <22 degrees F; coolwater = 22-24 degrees F; warmwater = >24 degrees F.

Tolerance: To environmental perturbation

Trophic class: Primary foraging strategy. For example, carnivores feed on other fish and insects. Invertivores feed primarily on aquatic insects. Generalist feeders are omnivores, i.e., feed on available forage (plants and animals).

The presence of a few dace and suckers in Swiftwater Creek, two groups which can tolerate warmer stream temperatures and are less sensitive to stream pollution, is not indicative of poor water quality. Such species often migrate from less pristine downstream areas. The distribution of longnose dace seems to be limited to small to medium-sized streams with torrential flows (steeper gradient). White suckers are considered a tolerant species that forages indiscriminately on bottom sediment (generalist feeder), but their distribution ranges from cold, mountainous brooks to warmer, lowland rivers.

Brown Trout

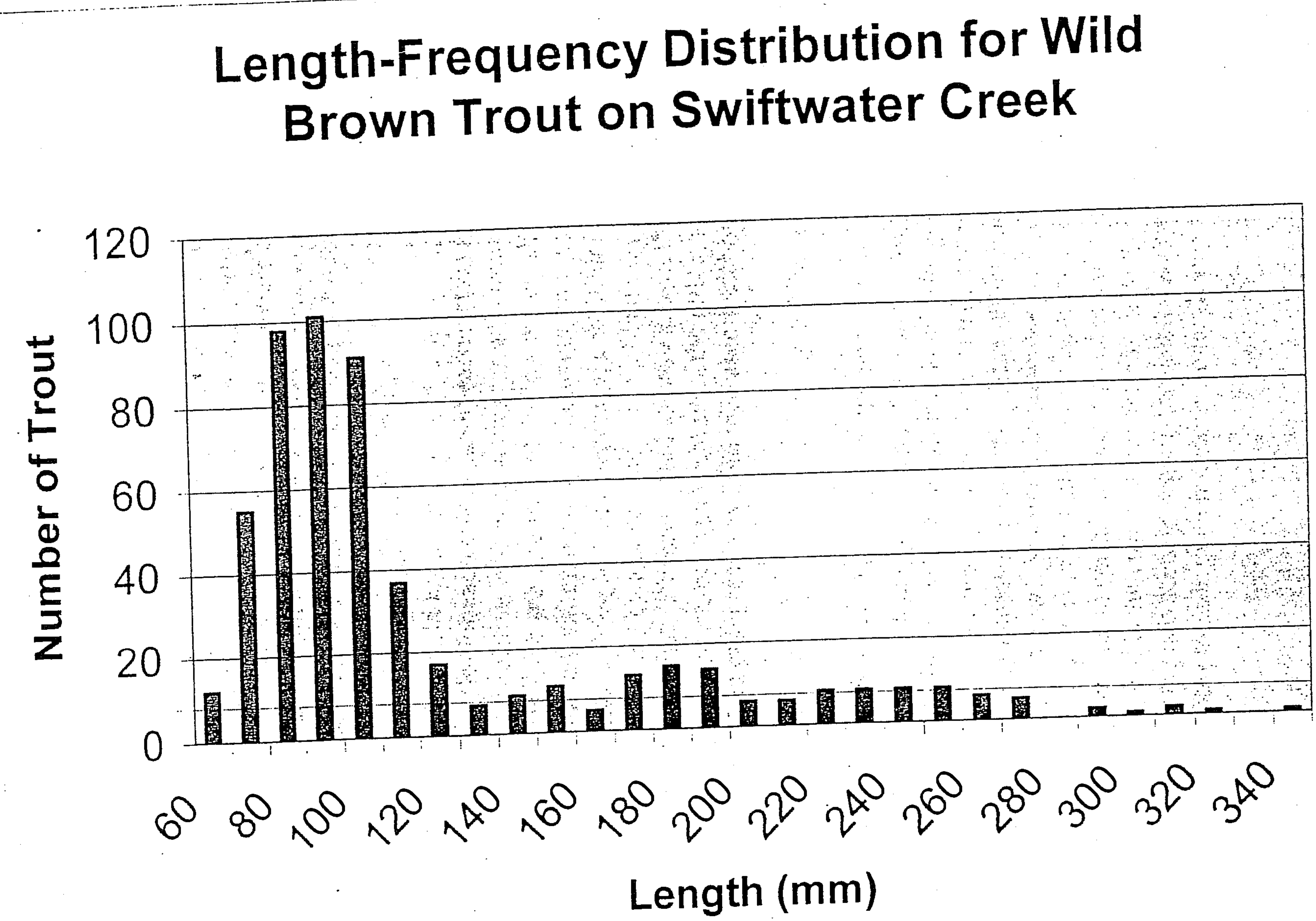
Numbers and weight of wild brown trout at all three stations on Swiftwater Creek exceeded the PA Fish & Boat Commission's standard for Class A Wild Trout Waters (40 kg/hectare) – see Table 3. Estimated biomass at the lower site (246.8 kg/hectare) was more than 6 times the standard, and the value at the most upstream station above Swiftwater, PA, was more than double. These are extremely high values for a relatively infertile headwater stream. Both Devil's Hole Creek and the upper Paradise Creek in the nearby sub-watershed have trout biomass exceeding 120 kg/hectare (Hartzler 1999; Hartzler 2000). In the Pocono region, carrying capacities over 200 kg/hectare have been recorded on certain meadow portions of McMichael Creek (Hartzler 1990).

The large number of fingerling (<5 inches) trout collected at all sampling locations on Swiftwater Creek indicated excellent reproductive success and survival of age 0+ brown trout (Table 3). In fact, estimated numbers of this group – young-of-year brown trout (spawned in fall 1999) – averaged more than one fish per foot of stream at the lower station. Reproduction was lowest at the most upstream site. Several factors affect spawning success, including the number of mature fish, suitable substrate material (gravel and cobble), sediment load, stream gradient, and volume of flow.

Growth rates for wild brown trout are comparable to values found on other Pocono streams. Growth was estimated from a length-frequency (L-F) distribution, which graphs individual trout collected according to size (Figure 4). Peaks in the curve represent the average size of a particular age group, or cohort, of trout. For example, 0+ trout (young-of-year) averaged 90-100 mm in Swiftwater Creek at the time of sampling. Yearlings (1+) trout were 170-180 mm long at this time, with some variation above and below this value since all individuals do not grow at the same rate. Hence, the 60-120 mm and 121-200 mm groups in Table 3 correspond to the 0+ and 1+ age classes, respectively. Beyond 1+ years, the L-F distribution has limited value because of

Table 3. Data summary for wild brown trout collected by electrofishing survey of Swiftwater Creek on 13 October 2000.

		STATION	
	Upper	Middle	Lower
BROWN TROUT			
		Number Collected	
Size – mm (inches)			
0-120 (0-4.7)	46	156	206
121-200 (4.8-7.9)	21	36	22
>200 (>7.9)	23	14	15
		Population Estimate	
Size – mm (inches)			
0-120 (0-4.7)	62	173	224
121-200 (4.8-7.9)	22	40	23
>200 (>7.9)	24	14	15
		Estimated biomass	
Kg/hectare	105.1	77.8	246.8
(Pounds/acre)	93.8	69.5	220.4
		Avg. Condition Factor (K)	
Size – mm (inches)			
0-120 (0-4.7)	0.99	0.94	0.97
121-200 (4.8-7.9)	0.92	0.93	0.84
>200 (>7.9)	1.03	0.95	0.91


Length-Frequency Distribution for Wild
Brown Trout on Swiftwater Creek
Number of Trout
0
20
40
60
80
100
120
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
Length (mm)

overlap in size among the ages classes. Larger fish must be aged from the microscopic examination of boney body parts (scales and otoliths).

A good balance exists among the different age (size) groups of trout in the wild brown trout population that helps to sustain the fishery. Young-of-year normally outnumber by several times the number of yearling fish, which in turn are more numerous than mature trout (2+ years and older), as natural mortality removes fish from the population. However, there are obviously sufficient numbers of older, spawning adults to assure good reproduction on Swiftwater Creek. Several wild brown trout over 305 mm (12 inches) were collected. The largest, at the upper station, measured 337 mm (13.3 inches).

In general, most of the wild brown trout collected were in good condition. Average condition factors (K) for each size group at each station are shown in Table 3. K measures a fish's weight relative to length; values for wild trout usually fall within the range 0.90-1.10. Except for yearling trout at the lower site, all groups of brown trout on Swiftwater Creek fell within this range. Competition for food and space among trout can affect weight gain or loss, so that a decline in condition could be attributed to intraspecific competition caused by an overabundance of fish rather than degradation of water quality or physical habitat. However, studies have shown that the condition of wild trout declines in late summer, perhaps because of the reduced biomass of aquatic insects larvae and depletion of fat reserves from increased metabolism due to higher water temperatures.

Rainbow Trout

Rainbow trout may have established a reproducing population on Swiftwater Creek, particularly at the upper location. Twenty-four trout, mostly young-of-year, were collected at this site, and the average condition factor was good (Table 4). Two rainbow trout over 203 mm (8 inches), presumably yearling trout based upon a L-F distribution, were found. A biomass estimate for wild rainbow trout of 20 kg/hectare was calculated for this stream area. Several wild rainbows were also taken at the other two stations. The wild rainbow trout collected in Swiftwater Creek are undoubtedly the product of successful spawning in spring 2000 and 1999 by either mature stocked or wild trout. Unlike brook and brown trout, which reproduce in the fall, rainbows spawn in late winter or early spring and seem to require torrential flows to be successful. The distribution of wild rainbow trout is quite limited in Pennsylvania and other northeastern states.

Table. 4 Data summary for wild rainbow and brook trout collected by electrofishing survey of Swiftwater Creek on 13 October 2000. (A slash [-] indicates an insufficient number of fish were collected to perform the calculation.)

	STATION		
	Upper	Middle	Lower
RAINBOW TROUT			
	Number Collected		
Size – mm (inches)			
0-120 (0-4.7)	21	0	1
>120 (>4.7)	3	2	0
	Population Estimate		
Size – mm (inches)			
0-120 (0-4.7)	32	-	-
>120 (>4.7)	3	-	-
	Estimated biomass		
Kg/hectare	20.0	-	-
(Pounds/acre)	17.9		
	Avg. Condition Factor (K)		
Size – mm (inches)			
0-120 (0-4.7)	1.00	-	0.96
>120 (>4.7)	0.90	0.88	-
BROOK TROUT			
	Number Collected		
Size – mm (inches)			
0-120 (0-4.7)	1	0	0
> 121 (>4.7)	2	6	0
	Avg. Condition Factor (K)		
Size – mm (inches)			
0-120 (0-4.7)	1.10	-	-
>120 (>4.7)	0.88	0.95	-

Brook Trout

Brook trout, the only salmonid native to Pocono streams, were far less numerous on Swiftwater Creek than wild brown or rainbow trout. In fact, too few were taken to permit an estimate of biomass, although most individuals were in good condition (Table 4). Prior to the introduction of these two exotics – brown trout from Europe in the late 1800's and rainbow trout from the western U.S. shortly thereafter – brook trout were quite numerous in all coldwater streams in the Northeast, including the Poconos. Both brown and rainbow trout can tolerate warmer, more degraded conditions than brook trout. Not surprisingly, brown trout have supplanted brook trout on most warmer lowland waterways, and numbers of native brook trout in upstream reaches have diminished. The only areas where brook trout continue to thrive and resist this encroachment are more acid, headwater brooks which are sustained by upwelling groundwater (springs). However, in some Appalachian streams, rainbow trout have penetrated waterways where browns have failed, presenting a significant threat to the survival of native brook trout populations. This process may be occurring on Swiftwater Creek.

SUMMARY

Swiftwater Creek has a fish community of relatively low diversity dominated by species intolerant to high water temperatures and environmental degradation. Wild brown trout (***Salmo trutta***) predominated in collections at the three locations electrofished. Biomass estimates for this species at all stations ranged from 2 to 6 times greater than the PA Fish & Boat Commision's standard (40 kg/hectare) for Class A Wild Trout Waters. Based upon the abundance of fingerling (<5 inches) trout, reproductive success at all stations was excellent. The wild brown trout populations at the three sampling areas were well balanced (all age groups well represented), and average condition factors for the various size groups of fish were good.

Wild rainbow trout (***Oncorhynchus mykiss***), whose distribution is quite limited in Pennsylvania and other Northeastern states, were also collected at all stations but were most numerous at the upper site. Only a few wild brook trout (***Salvelinus fontinalis***), the only salmonid native to the region, were found at the upper and middle sample areas; none were present at the lower site. Slimy sculpins (***Cottus cognatus***), another coldwater species restricted to undegraded headwater Pocono streams, were numerous at all stations. A few individuals of two taxa classified as coolwater species with a higher tolerance to environmental disturbance and pollutants - longnose dace (***Rhinichthys cataractae***) and white sucker (***Catostomus commersoni***) - were also collected at the lower site.

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BENTHIC MACROINVERTEBRATES

OF

SWIFTWATER CREEK, SEPTEMBER 20, 2000

FOR

PARADISE TOWNSHIP

Submitted by

Donald L. Baylor

For

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BENTHIC MACROINVERTEBRATES OF SWIFTWATER CREEK, SEPTEMBER 20, 2000 FOR PARADISE TOWNSHIP

BACKGROUND

On September 20, 2000 at the request of Paradise Township Supervisors, Aquatic Resource Consulting (ARC) sampled benthic macroinvertebrates at two stations on Swiftwater Creek, Monroe County, PA. The purpose of the sampling was to evaluate point and non-point source impacts to Swiftwater Creek from land development and discharges near Swiftwater.

Aquatic macroinvertebrates are preferred indicators of stream water quality because of their limited mobility, one to three year life cycles, and specific sensitivities to pollutants. Clean streams usually support numerous species of invertebrates, theoretically evenly represented in number. Impairment may be indicated by low taxa richness, shifts in community balance toward dominance of pollution-tolerant forms, or overall scarcity of invertebrates (Plafkin, et al. 1998). In order to assure an accurate assessment, recent work in bio-monitoring stresses the use of several parameters, or metrics, to measure different components of the community structure.

METHODS

Sampling methods followed those recommended by Hilsenhoff (1982) and the US Environmental Protection Agency Protocol III (Environmental Analysts, 1990). At each station, two samples were taken from a riffle and run with a D-frame net. The net was placed against the substrate and the substrate above the screen was disturbed with a four-pronged cultivating tool and by hand. Organisms and debris were composited for each station in a plastic bag and preserved in Kahle's solution for transport to the laboratory.

In the laboratory, samples were placed in an enamel pan marked with numbered grids. Large debris was removed and organisms were picked from the debris starting with a randomly selected grid until over 100 organisms were obtained. Organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value if known (Bode, et al. 1996 and Environmental Analysts 1990). Taxa richness, modified EPT index, modified Hilsenhoff biotic index, percent dominant taxon, and percent modified mayflies were calculated for each station to apply DEP' Central Office's most recent draft guidance for use with special protection and anti-degradation studies (communication from Tomas E. Stauffer, Northeast Regional Office Water Pollution Biologist). A description and brief rationale for each of the five metrics follows:

1. Taxa Richness – is an index of diversity. The number of taxa (kinds) of invertebrates indicates the health of the benthic community through measurement of the number of species present. Generally, number of species increases with increased water quality. However, habitat variability (stream order and size, substrate composition, current velocity) can affect this number.

2. Modified EPT Index – is a measure of community balance. The insect orders Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies) collectively referred to as EPT, are generally considered pollution sensitive (Plafkin et al. 1989). Healthy biotic conditions are reflected when these taxa are well represented in the benthic community. Thus, the total number of taxa within the EPT insect groups minus those considered pollution tolerant is used to evaluate community balance.

3. Modified Hilsenhoff Biotic Index – is a direct measure of pollution tolerance. Since many of the aquatic invertebrate taxa have been associated with specific values for tolerance to organic pollutants, a biotic index is also used to measure the degree of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated (Table 1).

Table 1. Evaluation of water quality using biotic index values (Hilsenhoff, 1987)

Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	None apparent
3.51-4.50	Very good	Possible slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly significant
6.51-7.50	Fairly poor	Significant
7.51-8.50	Poor	Very significant
8.51-10.00	Very	

4. Percent Dominant Taxon – measures evenness of community structure. It is the percent of the total abundance made up by the single most abundant taxon. Dominance of a few taxa may suggest environmental stress; however, the tolerance value of the dominant taxon must be considered.

5. Percent Modified Mayflies – is another measure of balance. Mayflies are considered one of the least tolerant orders to organic pollution and acidification. Undisturbed streams generally have an abundance of mayflies. Pennsylvania uses the

percent contribution of mayflies to the total number of organisms as an indication of water quality. This metric is modified to exclude those mayflies considered pollution tolerant.

Each of the five metrics uses a different scoring scale, so they were converted to the same scale using the normalizing scores listed below (PA Department of Environmental Protection, 1999).

Biological Condition Scoring Criteria

Metric	6	4	2	0
Taxa Richness (candidate/reference)	>80%	79-70%	69-60%	<60%
Modified EPT Index (candidate/reference)	>80%	79-60%	59-50%	<50%
Mod. Hilsenhoff Biotic Index (candidate-reference)	<0.71	0.72-1.11	1.12-1.13	>1.13
% Dominant Taxon (candidate-reference)	<10	11-16	17-20	>22
% Mod. Mayflies (reference-candidate)	<12	13-20	21-40	>40

In addition to these five metrics, Shannon –Weiner species diversity, equitability, and percent filtering collectors were calculated for each site. These metrics were not used in arriving at the composite scores for calculating percentage similarity of stations. They were used to give additional insight into benthic community structure at the two stations. A brief explanation of these metrics follows:

1. Shannon-Weiner Species Diversity – measures the number of species and their numerical balance. Undegraded streams usually support numerous species of macroinvertebrates, theoretically evenly represented. Diversity values in unpolluted streams generally range from 3 to 4; in degraded streams, values often fall below 1 (Wilhm, 1970).

2. Equitability – is a measure of the evenness with which individuals are distributed among the taxa. The value compares the distribution in the sample to that expected in undisturbed streams. Equitability usually ranges between 0.6 and 0.8 in undisturbed streams. Slight levels of degradation reduce equitability below 0.5 – usually between 0.3 and 0.0.

3. Percent filtering collectors – is a measure of impact from suspended solids usually resulting from sediment in run-off. Filtering collectors are the first benthic organisms to be reduced in abundance by silt in the water column, as suspended solids clog their filter-feeding mechanisms.

Habitat was assessed at each station using the format prescribed in EPA's Rapid Bioassessment Protocols (Plafkin, et al. 1989) and subsequently modified and used by PA Department of Environmental Protection (DEP). Each station was evaluated on a scale of 1 to 20 according to 12 parameters, and scores for all parameters were added to yield a total habitat score.

SAMPLING STATIONS

Samples were collected at two stations on Swiftwater Preserve property (Figures 1). A description of each station follows:

1. Station 1 was located approximately 1500 feet upstream of the Route 611 crossing of Swiftwater Creek, a short distance above the property line between Swiftwater Inn and Swiftwater Preserve: latitude – N 41 degrees 5.76', longitude – W 75 degrees 19.90' at an elevation of 1190 feet.

2. Station 2 was located approximately 2300 feet downstream from the Route 611 crossing of Swiftwater Creek approximately 50 yards below the property line between Aventis-Pasteur and Swiftwater Preserve: latitude N 41 degrees 5.59', longitude W75 degrees 19.10' at an elevation of 1103 feet.

RESULTS AND DISCUSSION

On September 20, 2000, benthic macroinvertebrate samples from two stations on Swiftwater Creek indicated little or no difference in water quality above and below the village of Swiftwater and the discharges from Aventis-Pasteur and the Pocono Mountain School. Station 2 scored 100% of Station 1 according to PA DEP methodology (Table 2). Only the Hilsenhoff Biotic Index score was slightly poorer at the downstream station. It was not significantly different, however, and attained the optimum score of 6 in the biological scoring criteria (Table 2). Taxa richness, modified EPT index, and percent modified mayflies, were actually superior at Station 2, and the percent dominant taxon was only 1% higher (Table 2).

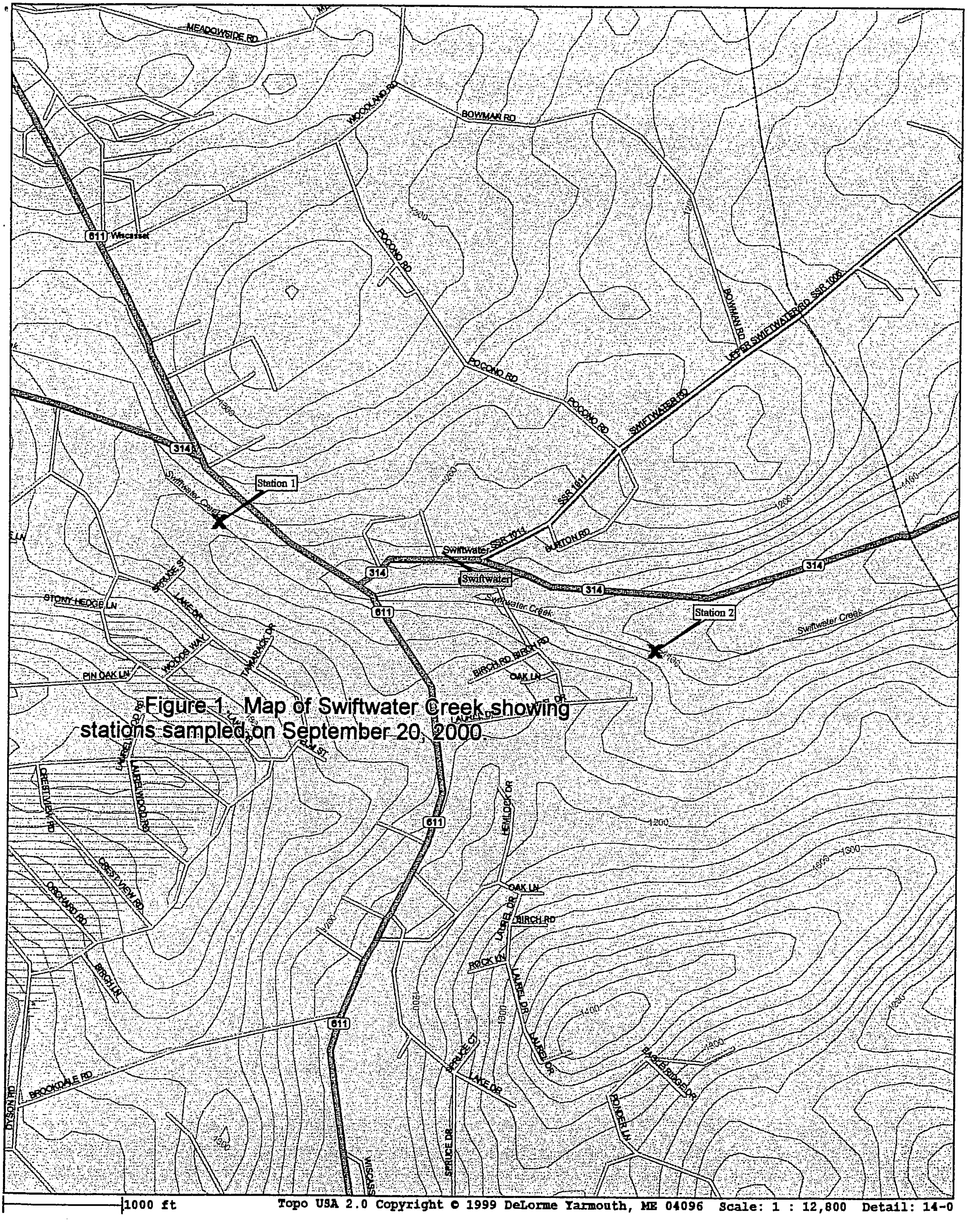

Figure 1. Map of Swiftwater Creek showing stations sampled on September 20, 2000.

1000 ft Topo USA 2.0 Copyright © 1999 DeLorme Yarmouth, ME 04096 Scale: 1 : 12,800 Detail: 14-0

The metrics used in addition to the PA DEP protocols also indicated a high degree of similarity between the stations (Table 2). Shannon-Weiner diversity, equitability, and percent filtering collectors were very similar, indicating benthic communities with similar balance and little or no difference in impact from suspended solids (silt carried in the water column).

Table 2. Macroinvertebrate community metric scores for samples collected from Swiftwater Creek on September 20, 2000.

METRIC	STATION 1 – ABOVE		STATION 2 – BELOW	
	Metric Value	Score	Metric Value	Score
Number of Organisms in Subsample	116	-	124	-
Shannon-Weiner Diversity Index	3.18	-	3.59	-
Equitability	0.74	-	0.79	-
Percent Filtering Collectors	53%	-	49%	-
Taxa Richness	16	6	20	6
Modified EPT Index	11	6	14	6
Hilsenhoff Biotic Index	2.18	6	2.86	6
Percent Dominant Taxon	22%	6	23%	6
Percent Modified Mayflies	4%	6	10%	6
Biological Condition Score		30		30
Percent of Reference		100%		100%

Habitat scores for both stations were within the optimal category though Station 2 had a slightly lower score than Station 1 (Table 3). The stations were observed to be very similar in relation to most habitat parameters. Station 2 had somewhat more sediment deposition, a wider channel with less of the channel whetted by flow, and more lawn surface in the immediate riparian area. Riparian zone width was rated slightly poorer at Station 1 because of the proximity of a road to the eastern stream bank. Habitat differences were not sufficient to cause measurable differences in benthic invertebrate samples.

Table 3. Swiftwater Creek, September 20, 2000 habitat assessment. Score ranges: optimal 240-192, suboptimal 180-132, marginal 120-72, poor <60.

HABITAT PARAMETER	SCORE	
	STATION 1 - ABOVE	STATION 2 - BELOW
1. Instream Cover	15	13
2. Epifaunal Substrate	20	20
3. imbeddedness	20	20
4. Velocity/Depth Regimes	9	9
5. Channel Alteration	20	20
6. Sediment Deposition	20	15
7. Frequency of Riffles	20	20
8. Channel Flow Status	17	14
9. Condition of Banks	11	13
10. Bank Vegetative Protection	17	16
11. Grazing & Other Disruptive Pressure	20	16
12. Riparian Zone Width	13	17
TOTAL SCORE	202	193

RECOMMENDATIONS

Benthic macroinvertebrates should be monitored periodically on Swiftwater Creek to assure that water quality is being maintained through future development of the watershed.

Appendix A. Taxa, numbers, Biotic Index value (BI), and functional feeding group designation for benthic macroinvertebrates from Swiftwater Creek, September 20, 2000 (CG=collector/gatherer, SC=scraper, FC=filtering collector, P=predator, SH=shredder).

TAXA	STATION 1 ABOVE	STATION 2 BELOW	BI	FFG
Ephemeroptera (mayflies)				
Ephemerella excrucians	1	-	1	CG
E. sp.	1	12	1	CG
Epeorus sp.	-	1	0	SC
Stenonema sp.	-	5	3	SC
Paraleptophlebia sp.	1	5	2	CG
Baetis tricaudatus	17	11	6	CG
B. flavistrigia	2	-	4	CG
B. pluto	1	-	6	CG
Trichoptera (cadisflies)				
Brachycentrus solomoni	25	-	1	FC
Dolophilodes distinctus	21	24	0	FC
Ceratopsyche sparna	8	4	1	FC
C. slossonae	4	5	4	FC
Cheumatopsyche sp.	3	28	5	FC
Lepidostoma sp.	1	-	1	SH
Rhyacophila fuscula	-	2	0	P
R. torva	-	2	1	P
R. manistee	-	2	1	P
R. sp.	-	1	1	P
Plecoptera (stoneflies)				
Pteronarcys scotti	-	2	0	SH
Phasgonophora capitata	-	2	2	P
Sweltsa sp.	18	13	0	SH
Leuctra sp.	2	-	0	SH
Diptera (true flies)				
Chironomidae	10	9	6	-
Hexatoma sp.	-	2	2	P
Mollusca (snails)				
Physidae	1	1	8	CG
Turbellaria				
Macrostomum sp.	-	4	6	CG

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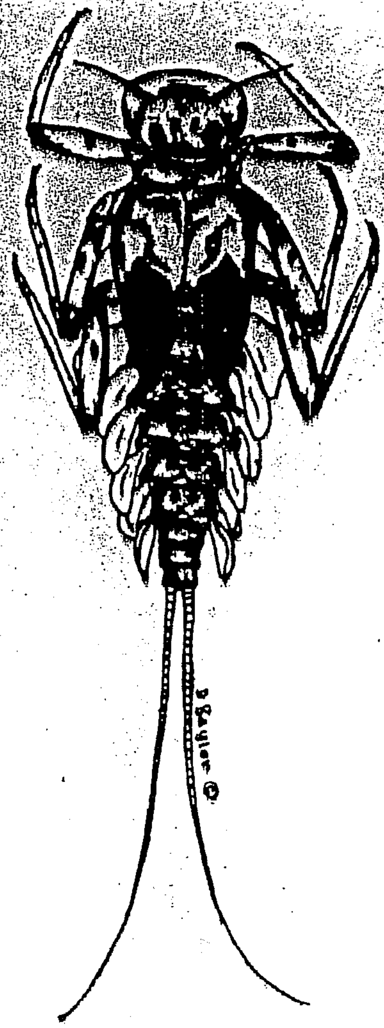
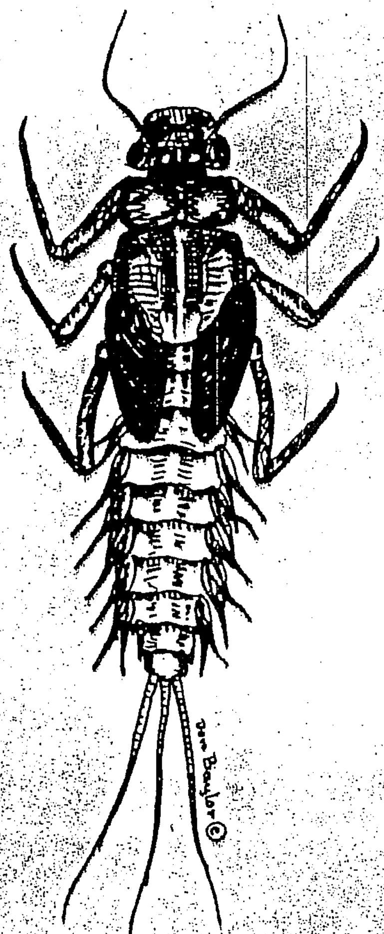
BENTHIC MACROINVERTEBRATES
OF
SWIFTWATER CREEK
OCTOBER 30, 1997
FOR
LAKE SWIFTWATER ASSOCIATION





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BENTHIC MACROINVERTEBRATES OF SWIFTWATER CREEK, OCTOBER 30, 1997

INTRODUCTION

At the request of Lake Swiftwater Association, Aquatic Resource Consulting was authorized to sample benthic macroinvertebrates at four stations on Swiftwater Creek, Monroe County, PA. Authorization was given through F. X. Brown Associates, Inc. as an adjunct to a study of Swiftwater Lake. The purpose of this study was to evaluate water quality upstream from Swiftwater Lake and to compare results to those obtained at the same stations in a 1986 study for Swiftwater Preserve (Baylor,1986).

BACKGROUND

Aquatic macroinvertebrates are preferred indicators of stream water quality because of their limited mobility, one to three year life cycles, and specific sensitivities to pollutants. Clean streams usually support numerous species of invertebrates, theoretically equal in numeric representation. Impairment may be indicated by low taxa richness, shifts in community balance toward dominance of pollution-tolerant forms, or overall scarcity of invertebrates. (Plafkin, et al. 1989): in order to assure an accurate assessment of environmental conditions, recent work in bio-monitoring has stressed the need to use several parameters, or metrics, to measure components of community structure.

Number of Taxa

Taxa richness (number of different kinds of organisms) measures the health of the benthic community through the variety of species present. Generally, number of species increases with improved water quality. Variability in natural habitat, however, affects this number.

EPT Index

The insect orders Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies), collectively referred to as EPT, are generally considered pollution sensitive (Plafkin et al. 1989). Thus the number of taxa within the EPT groups (EPT index) is used to evaluate health of the benthic community - the more EPT taxa present, the better the water quality indicated.

METHODS

Sampling methods followed those recommended by Hilsenhoff (1982) and the Environmental Protection Agency (Weber, 1973). At each station, a riffle area was sampled with a kick screen device of 521 micron nytex until more than 100 organisms were collected. The substrate was disturbed with a four pronged cultivator tool and by hand to dislodge organisms into the screen. Rocks were also randomly selected and cleaned by hand to dislodge organisms firmly attached. Organisms were picked from the debris in the field, composited for each station, and preserved in Kahle's solution for transport to the laboratory.

In the laboratory, organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value if known (Environmental Analysts, 1990). Species diversity, equitability, EPT and biotic indeces were calculated for each station according to Hilsenhoff (1987), Weber (1973), and Plafkin et al. (1989).

SAMPLING STATIONS

Four stations were sampled on Swiftwater Creek above Swiftwater Lake (Figure 1). The stations were chosen to re-evaluate four of five stations sampled in 1986. In the 1997 sampling, Station 1 in the previous study on Indian Run tributary was omitted. Description of sampling stations follow:

Station 2 - upstream from Route 611 crossing in the Burrit section, approximately 60 meters downstream from the Route 314 crossing.

Station 3 - in the Woodling section, approximately 40 meters downstream from the Conneaught property.

Station 4 - in the Lower Batten area, in the riffle below the pool adjacent to the former Ed Metzgar residence, now the headquarters of Swiftwater Preserve.

Station 5. - in the Red Rock section, approximately 50 meters downstream from the Route 314 crossing.

RESULTS AND DISCUSSION

1997 Data

A total of 40 species of benthic macroinvertebrates were collected from Swiftwater Creek on October 30, 1997 (Appendix A). Most were pollution sensitive taxa. At each station, all but a few taxa were from the EPT group (Table 2). Biotic index, diversity, and equitability values for all stations fell within clean stream ranges (Table 2 and Figures 3&4). Biotic index values ranged from 1.29 at Station 2 to 1.65 at Station 4 - all in the "Excellent" range, indicating little or no organic pollution. Station 2 had the best biotic index, diversity, and equitability values; but Station 4 had one more total taxon and EPT taxon. In October 1997, all stations were comparable in biotic index, diversity, and equitability; but Station 3 had somewhat fewer taxa and EPT taxa than other stations (Table 2).

The lower numbers of total taxa and EPT taxa at Station 3 in 1997, despite diversity and biotic index values similar to other stations, may be a result of slight environmental differences other than organic (oxygen demanding) impacts.

1997 Data Compared to 1986 Data

Metric values from October 1997 samplings were roughly equivalent to those from May 1986 at stations 2, 4, and 5, suggesting little change in water quality. The slight differences in biotic index and diversity between samplings at these three stations may reflect fall versus spring seasonal variations in benthic communities rather than changes in water quality.

Values from Station 3 indicated improved water quality from 1986 to 1997 (Figures 2&3). Specificallly, in 1986 the biotic index value at Station 3 was notably higher (poorer) than at other stations , though not outside the clean stream range. In 1997, the biotic index value at Station 3 was closer to those from other stations (Figure 3). From 1986 to 1997 at Station 3, diversity improved from 2.55 (below the 3-4 clean stream range) to 3.43 (well within that range). Equitability at Station 3 also imprived considerably from 1986 to 1997. In reading the tables and figures, note that for the biotic index, higher values are poorer; and for diversity and equitability, lower values are poorer.

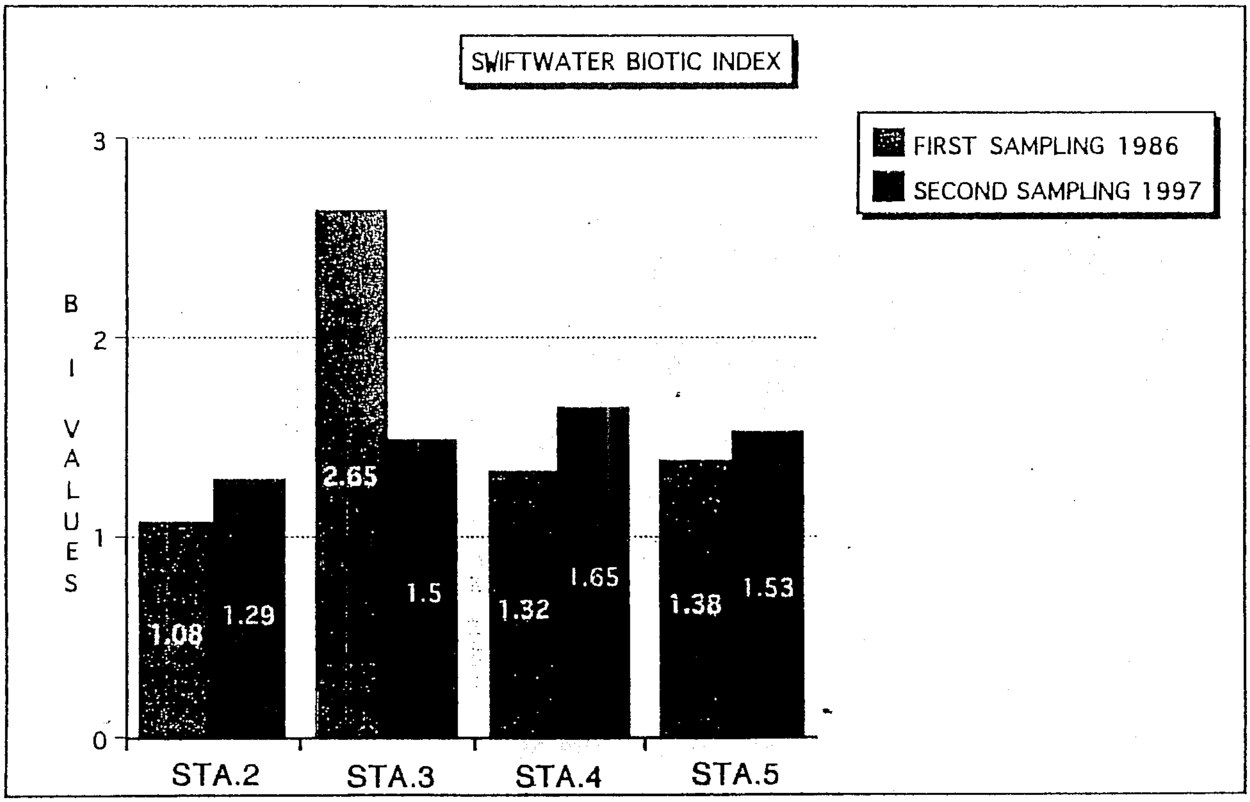

Figure 2. Biotic index values for benthic macroinvertebrate samples at four stations on Swiftwater Creek, May 13, 1986 and October 30, 1997.

Appendix A. Taxa, numbers, and biotic index (BI) value (0-10) of benthic macroinvertebrates from four stations on Swiftwater Creek, October 30, 1997.

TAXA	STATIONS #2	#3	#4	#5	BI
EPHEMEROPTERA (Mayflies)					
Epeorus pluralis	2	-	1	-	0
Ephemerella invaria/rotunda	20	5	10	52	1
E. subvaria	-	-	1	3	1
Stenonema ithaca	-	1	26	1	3
S. vicarium	1	1	7	10	2
S. mediopunctatum	-	-	-	1	3
Paraleptophlebia sp.	7	13	41	41	2
Baetis tricaudatus	3	-	-	-	6
Acentrela turbida	-	-	1	-	-
TRICHOPTERA (caddisflies)					
Apatania incerta	-	-	-	1	3
Brachycentrus solomoni	17	10	6	9	1
Rhyacophila fuscula	10	11	1	4	0
R. torva	2	-	-	-	1
R. manistee	-	-	1	-	1
Dolophilodes distinctus	23	28	16	6	0
Cheumatopsyche sp.	6	2	1	2	5
Ceratopsyche ventura	1	6	-	-	-
C. slossonae	17	24	3	8	4
C. sparna	-	-	19	8	4
C. morosa	-	-	1	2	6
C. sp.	2	-	-	-	-
Hydropsyche betteni	-	-	1	-	6
Polycentropus sp.	1	-	-	1	4
Lepidostoma sp.	1	2	10	4	1
PLECOPTERA (stoneflies)					
Pteronarcys scotti	2	4	-	-	0
Tallaperla sp.	-	1	-	-	0
Phasgonophora capitata	3	1	1	2	2
Isogenoides hansoni	-	-	-	1	0
Acroneuria abnormis	-	-	1	-	0
Cultus decisus	3	-	1	2	2
Sweltsa sp.	22	7	10	6	0
Isoperla decala	-	1	-	-	2
Leuctra sp.	2	-	-	-	0

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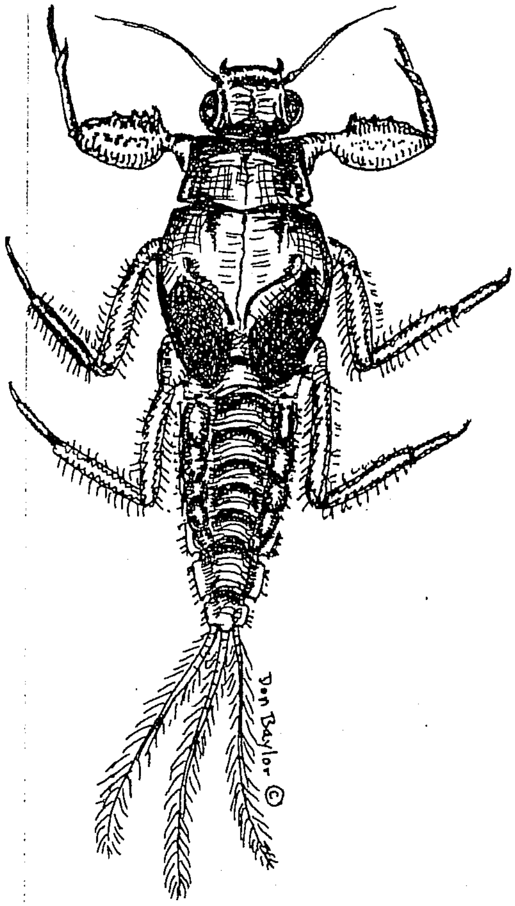

BENTHIC

INVERTEBRATES

OF

SWIFTWATER

May 13, 1986

Submitted by

Donald L. Baylor

for

Aquatic Resource Consulting

BENTHIC INVERTEBRATES OF THE SWIFTWATER DRAINAGE, MARCH 1986

BACKGROUND

On May 13, 1986, at the request of Mr. Perry Pepper, Aquatic Resource Consulting Biologist Don Baylor and an assistant sampled benthic invertebrates at five stations on Swiftwater Creek for Swiftwater Club. This study was a follow-up to the 1985 spring and fall baseline samplings of the Brodhead Drainage in which the station on the Smith section of Swiftwater Creek was indicative of degradation compared to established standards and compared to other stations on the Brodhead Drainage.

SAMPLING STATIONS

Five sampling stations were selected to obtain a profile of water quality longitudinally on Swiftwater Creek and to determine whether degradation was restricted to certain sections of the stream. These stations are shown on the map (Fig. 1) and the photographs (Figs. 1 - 6). They are located as follows:

1. Indian Run branch in the Lockwood section, approximately 30 yards upstream from the confluence with Swiftwater.

2. Burritt section, a short distance upstream from the small spring run that enters in this area.

3. Woodling section, just above the area where the stream has flowed out of its normal channel at high flow - immediately above a backwater where a small spring enters the stream.

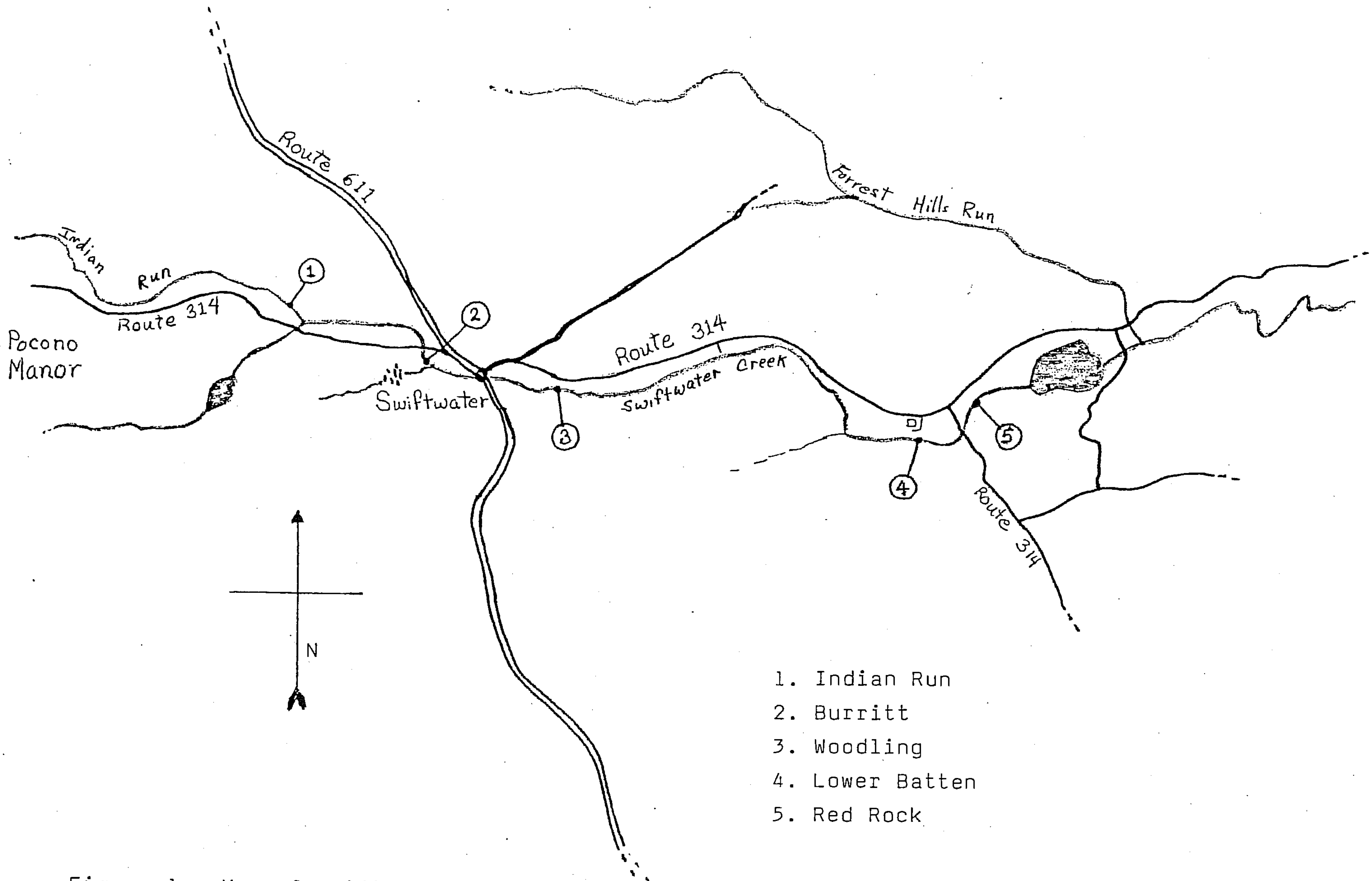

Figure 1. Map of Swiftwater Creek showing sampling stations for the May 13, 1986 invertebrate sampling.

Figure 2. Sampling station #1, Indian Run a short distance above confluence with Swiftwater.

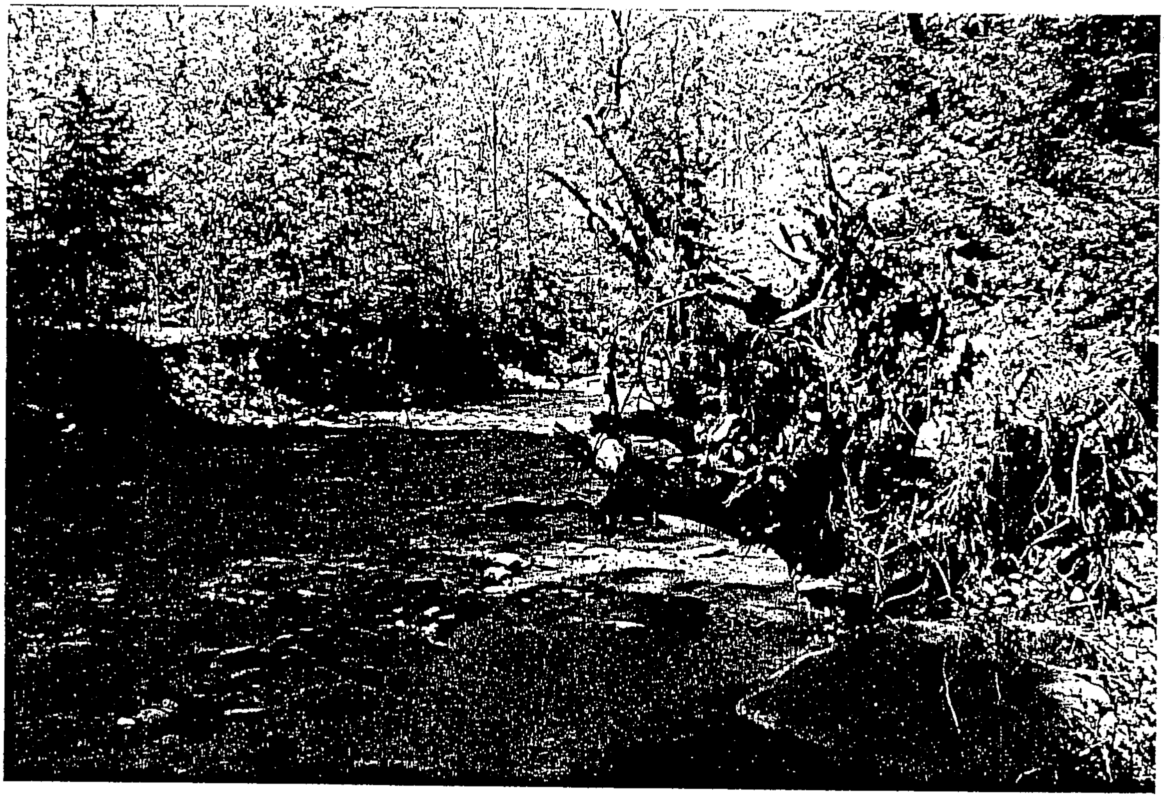

Figure 3. Sampling station #2, Burritt, a short distance upstream from the small spring run that enters in this area.

Figure 4. Sampling station #3, Woodling, just above the area where the stream has flowed out of its normal channel at high flows.

Figure 5. Sampling station #4, Lower Batten, opposite the Ed Metzgar residence.