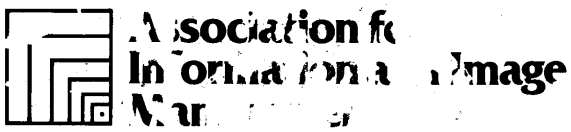
New York State Documents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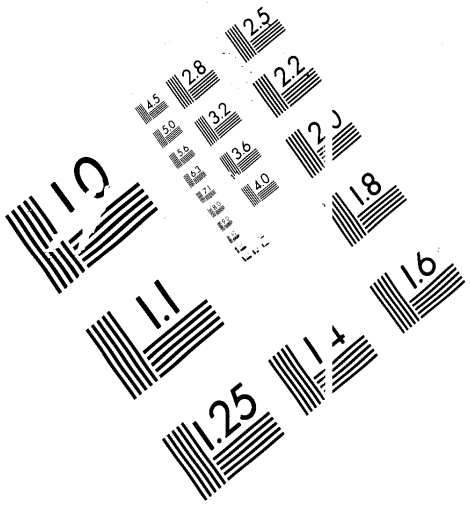

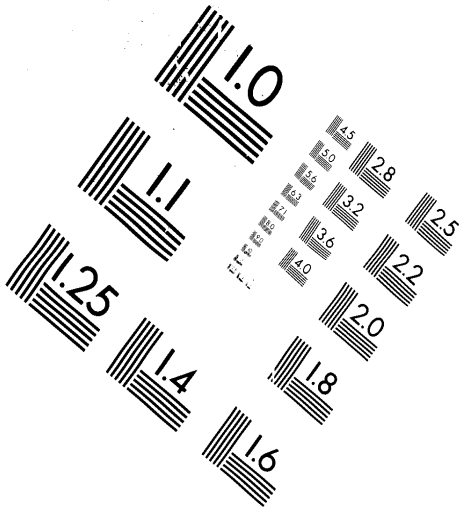

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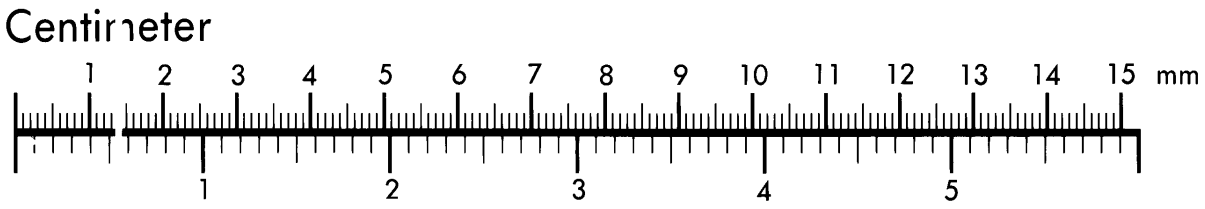
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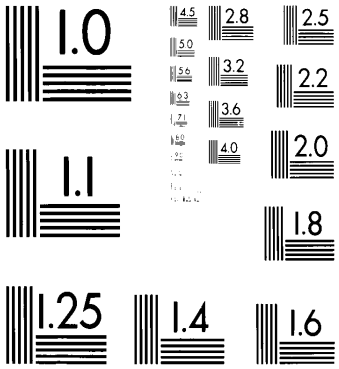
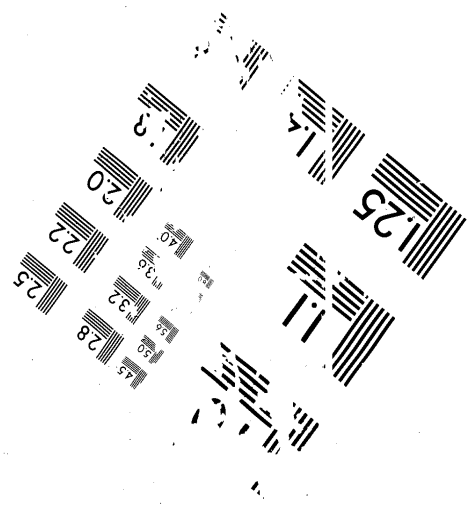
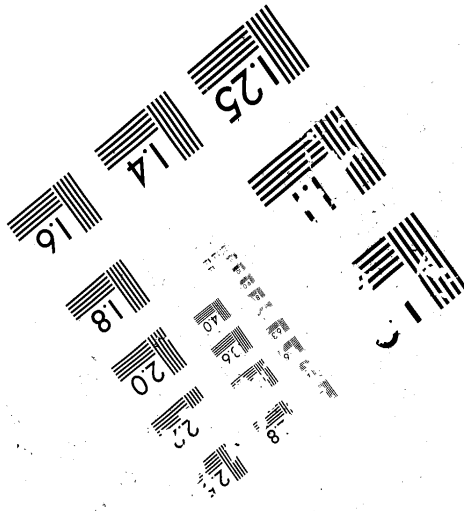






New York State
Department of Environmental Conservation

Division of Water

Halfway Creek

Biological Assessment

1999 Survey

GEORGE E. PATAKI, *Governor*

JOHN P. CAHILL, *Commissioner*

BIOLOGICAL STREAM ASSESSMENT

Halfway Creek
Warren and Washington Counties, New York

Survey date: September 23, 1999
Report date: September 22, 2000

Robert W. Bode
Margaret A. Novak
Lawrence E. Abele
Diana L. Heitzman
Douglas Carlson

Stream Biomonitoring Unit
Bureau of Watershed Assessment and Research
Division of Water
NYS Department of Environmental Conservation
Albany, New York

CONTENTS

Stream: Halfway Creek, Warren County, New York

Reach: Above Glens Falls to Fort Ann, New York

Background:

The Stream Biomonitoring Unit conducted biological sampling on Halfway Creek on September 23, 1999. The purpose of the sampling was to assess general water quality and determine the cause and extent of any water quality problems. Traveling kick samples were taken in riffle areas at six sites, using methods described in the Quality Assurance document (Bode et al., 1996) and summarized in Appendix I. The contents of each sample were field-inspected to determine major groups of organisms present, and then preserved in alcohol for laboratory inspection of a 100-specimen subsample. Water quality assessments were based on resident macroinvertebrates (aquatic insects, worms, mollusks, crustaceans). Community parameters used in the determination of water quality included species richness, biotic index, EPT value, and percent model affinity (see Appendices II and III). Table 3 provides a listing of sampling sites, Table 4 provides a listing of all macroinvertebrate species collected in the present survey, and Table 5 provides a listing of fish data reports. This is followed by macroinvertebrate data reports, including individual site descriptions and raw invertebrate data from each site.

Appreciation is expressed to Jim Lieberum (Warren County Soil and Water Conservation District) and Les Saltsman (NYS DEC Fisheries, Region 5) for their assistance in this survey.

Results and Conclusions:

1. Water quality in Halfway Creek ranged from non-impacted to slightly impacted, and is considered good to very good. A substantial decline in water quality occurs in the reach downstream of the city of Glens Falls. PAHs (polycyclic aromatic hydrocarbons) in crayfish tissues were elevated at many stream locations, and were highest downstream of Glens Falls, likely due to urban runoff. Three tributaries are suspected sources of inputs from runoff.

2. Fish communities in Halfway Creek were dominated by coolwater species, with few gamefish species present. Water quality assessments based on fish communities correlated well with assessments based on macroinvertebrate communities for most sites.

Discussion:

Halfway Creek was previously sampled by the Stream Biomonitoring Unit in 1998 at the Fort Ann site (Station 6), as part of the Rotating Intensive Basin Studies statewide monitoring. The results of that sampling showed slight impact, likely from agricultural nonpoint source runoff. The present survey was conducted as a result of that study, to delineate and define any water quality problems in Halfway Creek.

Twelve miles of Halfway Creek are listed on the Priority Waterbodies List (NYS DEC, 1996), 3 miles in Warren County and 9 miles in Washington County. The primary use impairments listed are fish propagation and fish survival, and the primary pollutants listed are thermal effects from urban runoff, heavy sediment loads, and sand from road sanding. Cemetery Brook, a tributary of Halfway Creek, is listed for possible siltation from construction.

Results of the present study show water quality ranging from non-impacted to slightly impacted (Figure 1). The principal decline in water quality occurs just downstream of Route 9 (Station 2) and upstream of Meadowbrook Road. Thus the upstream 6 stream miles above Glens Falls are considered non-impacted, and the lower 20.9 miles below Glens Falls are considered slightly impacted. The causes of impairment appear to encompass nutrient enrichment, organic enrichment, unknown municipal/industrial inputs, and siltation (Table 1).

The most likely sources of urban runoff between Route 9 and Meadowbrook Road (Stations 2 and 3) are from three tributaries: Cemetery Brook, which follows Quaker Road, the "Crandall Park trib", draining downtown Glens Falls, and the "ACC (Adirondack Community College) trib", entering Halfway Creek just upstream of Meadowbrook Road (Station 3). Further sampling would be needed to determine the particular contributions of each of these tributaries. Collectively they contribute elevated nutrients, fecal coliforms, sediment, and road and parking lot runoff (Jim Lieberum , pers. comm.).

Tissue analysis was conducted on crayfish collected at the 6 sampling sites. Tissues were analyzed for metals, PCBs, organochlorine pesticides, and PAHs (polycyclic aromatic hydrocarbons). No crayfish were found to have elevated levels of metals or PCBs. Two sites, Stations 3 and 4, showed DDE present but less than minimum reportable levels. PAH analysis showed elevated levels at all 5 sites analyzed for (Figure 3, Table 2); no PAH analysis was performed for Station 2.

PAHs constitute a class of organic compounds characterized by two or more benzene rings. PAHs with lower molecular weights exhibit acute toxicity but are considered noncarcinogenic; higher weight PAHs are less toxic, but have been shown to be carcinogenic to fish and other aquatic life. PAHs are typically produced by the incomplete combustion of petroleum products, wood, and other organic materials. Major sources of PAHs in surface waters include airborne deposition, municipal wastewater discharges, and urban storm runoff. PAHs were elevated in all Halfway Creek samples, and were highest at Station 3, downstream of Glens

Falls. This is a likely indicator of urban runoff from Glens Falls, and is considered to be at least partially responsible for the poorer community found at this site.

Fish sampling was conducted in Halfway Creek to coordinate with the macroinvertebrate sampling sites for this survey by Douglas Carlson, using methods described in Appendix XI. Fish communities were dominated by coolwater species, although few gamefish species were present. Trout were caught at only one site, and the stocking policy carried out by DEC Region 5 is expected to have low holdover due to habitat. Water quality assessments based on fish communities correlated well with assessments based on macroinvertebrate communities for Stations 1-3, while downstream Stations 4-6 were rated better based on fish communities than macroinvertebrate communities.

Compared to results of macroinvertebrate sampling conducted at the Fort Ann site (Station 6) in 1998, results of the present sampling appear poorer, although both years resulted in overall assessments of slightly impacted. Some differences may be flow-related; 1999 was considered a drought year, although a heavy flood occurred one week prior to sampling, while 1998 flows were normal to high. Long-term sampling, especially at Stations 2 and 3, would be needed to determine year-to-year water quality patterns in Halfway Creek.

Literature Cited:

Bode, R. W., M. A. Novak, and L. E. Abele. 1996. Quality assurance work plan for biological stream monitoring in New York State. New York State Department of Environmental Conservation, Technical Report, 89 pages.

New York State Department of Environmental Conservation. 1996. The 1996 priority waterbodies list for the Lake Champlain basin. NYS DEC Technical bulletin, 128 pages.

Overview of field data:

On the date of sampling, September 23, 1999, Halfway Creek at the sites sampled was 4-20 meters wide, 0.1-0.4 meters deep, and had current speeds of 100-140 cm/sec in riffles. Dissolved oxygen was 8.5-10.2 mg/l, specific conductance was 34-369 µmhos, pH was 6.9-7.6, and the temperature was 11.7-13.1 °C (53-56 °F). Measurements for each site are found on the field data summary sheets.

Figure 1. Biological Assessment Profile of index values, Halfway Creek, 1999. Values are plotted on a normalized scale of water quality. The line connects the mean of the four values for each site, representing species richness, EPT richness, Hilsenhoff Biotic Index, and Percent Model Affinity. See Appendix IV for more complete explanation.

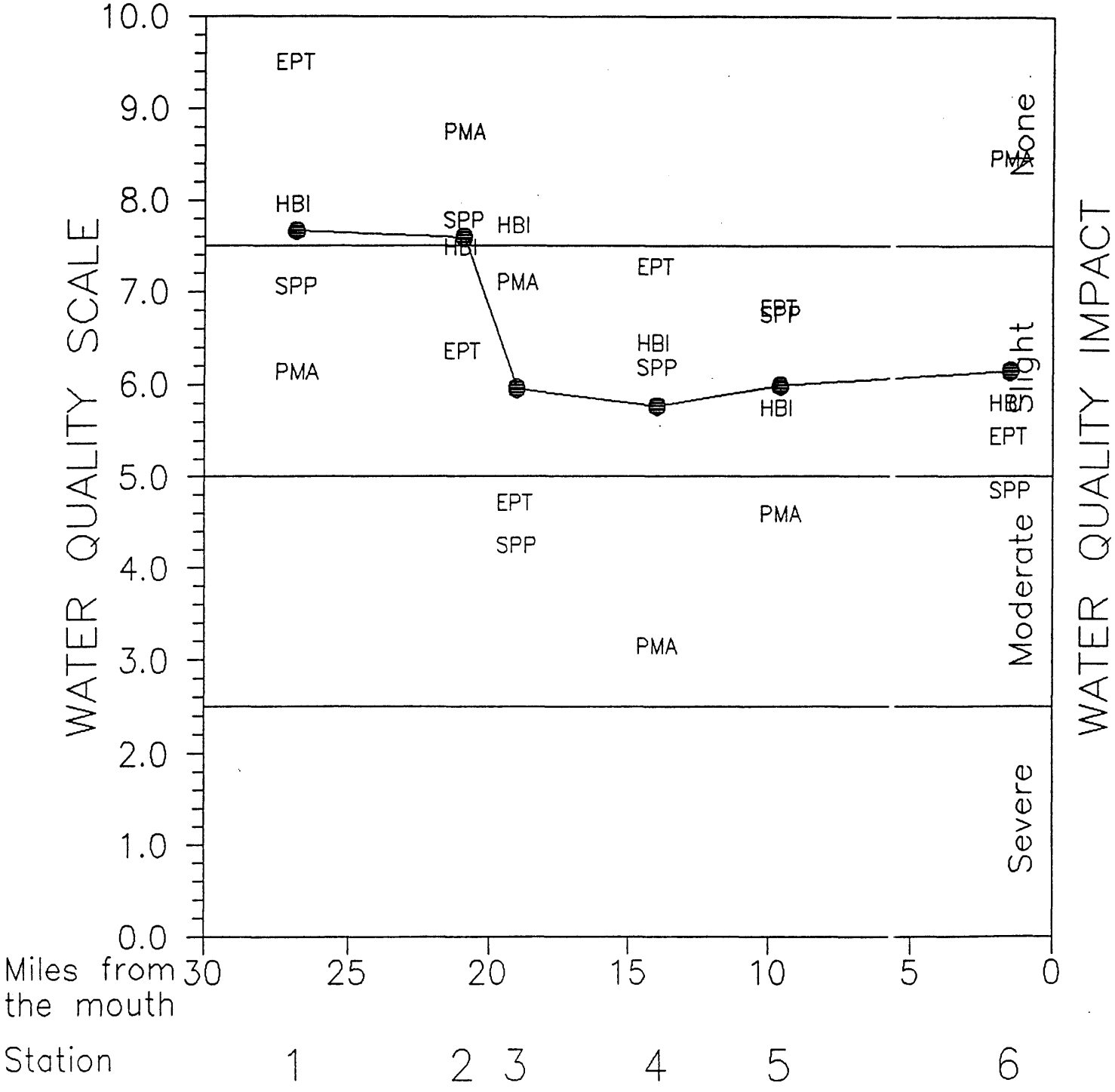


Figure 2. Biological Assessment Profile of index values for macroinvertebrates and fish, Halfway Creek, 1999. Values are plotted on a normalized scale of water quality. See Appendix III for macroinvertebrate indices, and Appendix XI for fish indices.

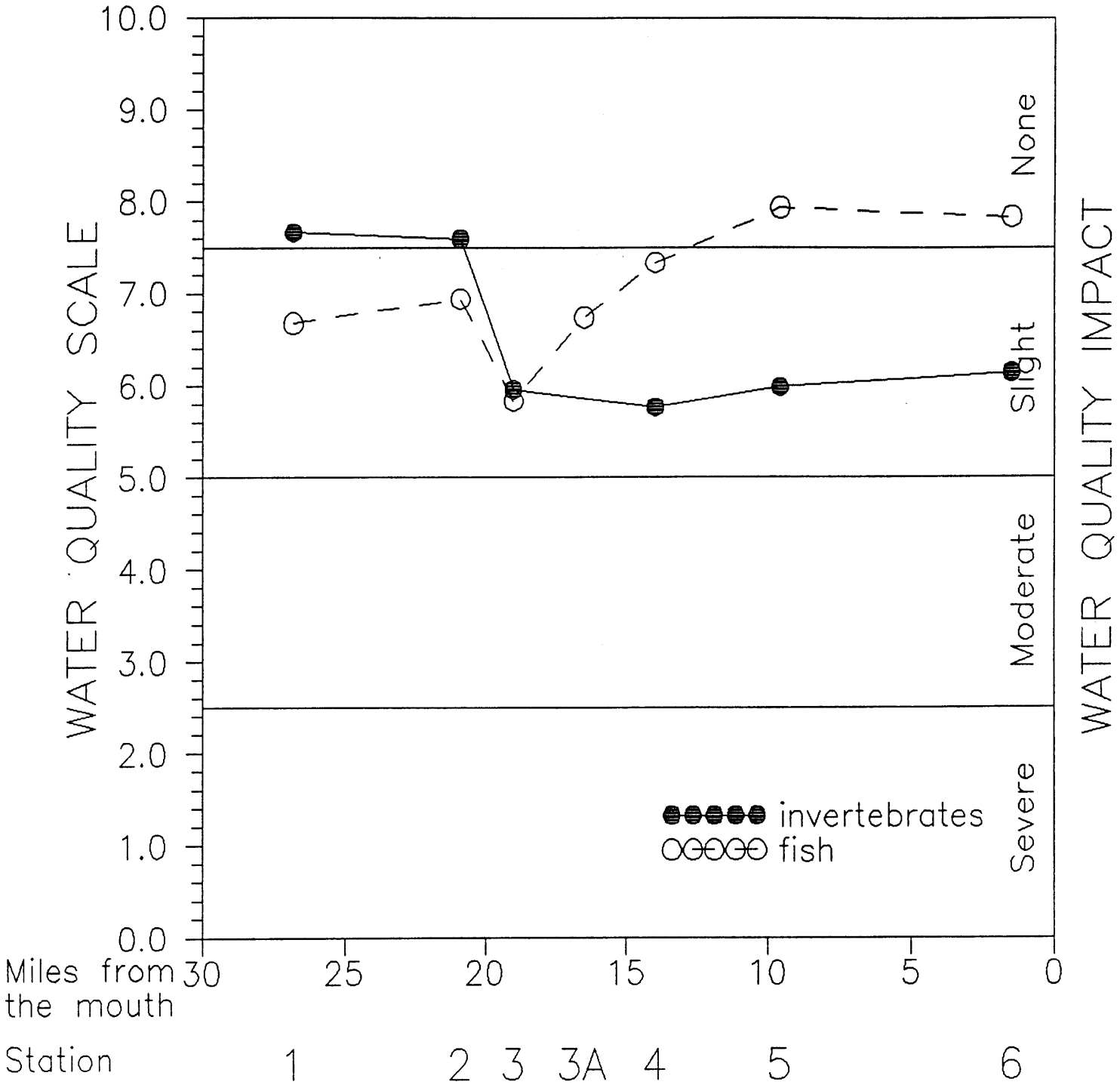


Table 1. Impact Source Determination, Halfway Creek, 1999. Numbers represent similarity to community type models for each impact category. The highest similarity at each station is highlighted. Similarities less than 50% are less conclusive.

	STATION					
Community Type	HALF-1	HALF-2	HALF-3	HALF-4	HALF-5	HALF-6
Natural: minimal human impacts	43	52	40	32	32	40
Nutrient additions; mostly nonpoint, agricultural	58	35	53	49	41	34
Toxic: industrial, municipal, or urban run-off	37	44	41	37	35	28
Organic: sewage effluent, animal wastes	44	47	58	47	37	32
Complex: municipal/industrial	45	40	50	52	47	37
Siltation	38	58	47	40	48	62
Impoundment	56	50	62 *	62 *	38	50

* these impoundment values are considered spurious

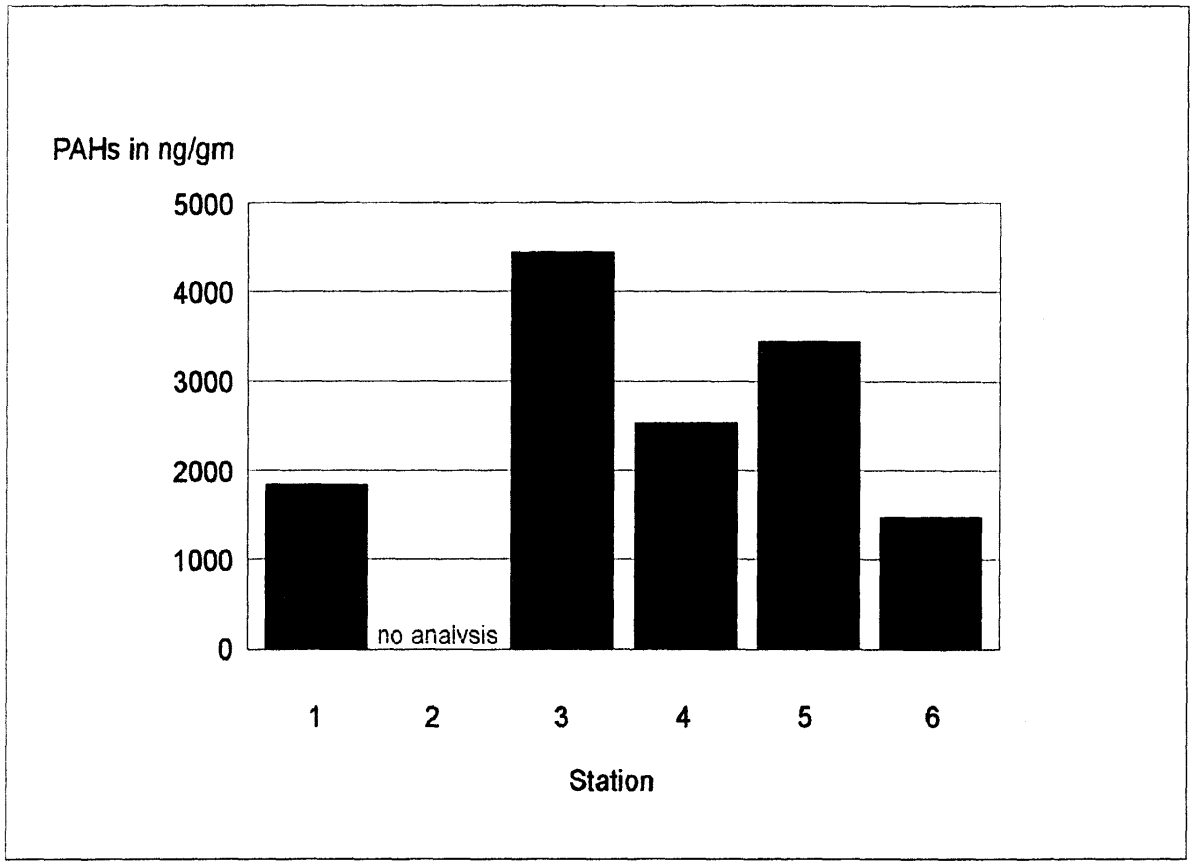


Figure 3. PAHs in Invertebrates Collected in Halfway Creek, September 23, 1999 (ng/gm; ppb).

TABLE 2.	PAHs in crayfish in Halfway Creek, September 23, 19)9.				
	HALF-1	HALF-3	HALF-4	HALF-5	IALF-6
Phenanthrene	190 *	530 *	350 *	480 *	130 *
Anthracene	24	28	27	16	
Fluoranthene	7	66	20	28	
Pyrene	440 *	1100 *	660 *	930 *	370 *
Benzo (a) anthracene	710 *	1600 *	880 *	1100 *	550 *
Chrysene	470 *	1100 *	590 *	880 *	350 *
Benzo (b) fluoranthene	2	6	1	1	
Benzo (k) fluoranthene	1	3	1	<	
Benzo (a) pyrene	<	1	1	1	
Dibenz (A,H) anthracene	<	1	1	1	
Benzo (ghi) perylene	<	11	3	2	
Indeno (1,2,3-cd) pyrene	<	6	2	<	
TOTAL PAHs	1844	4452	2536	3439	1175

All values in ng/gm (ppb) dry weight
* exceeds provisional level of concern for crayfish
< less than detectable amount

TABLE 3. STATION LOCATIONS FOR HALFWAY CREEK, WASHINGTON COUNTY, NEW YORK (see map).

STATION	LOCATION
01	above Glens Falls 100 meters upstream of Thunderbird Rd bridge 26.8 river miles above the mouth latitude/longitude: 43°20'28" 73°43'43"
02	Glens Falls 20 meters downstream of Rt. 9 bridge 20.9 river miles above the mouth latitude/longitude: 43°19'33"; 73°39'50"
03	Glens Falls 1 meter upstream of Meadowbrook Rd bridge 19.0 river miles above the mouth latitude/longitude: 43°20'30"; 73°38'41"
04	Pattens Mills 50 meters upstream of Patten Mills Rd bridge (closed) 14.0 river miles above the mouth latitude/longitude: 43°22'58"; 73°36'14"
05	Tripoli 2 meters upstream of Farley Rd bridge 9.6 river miles above the mouth latitude/longitude: 43°23'41"; 73°33'26"
06	Fort Ann 50 m below Co. Rt. 16 bridge 1.5 river miles above the mouth latitude/longitude: 43°25'36"; 73°29'50"

Figure 4	Site Overview Map	Halfway Creek

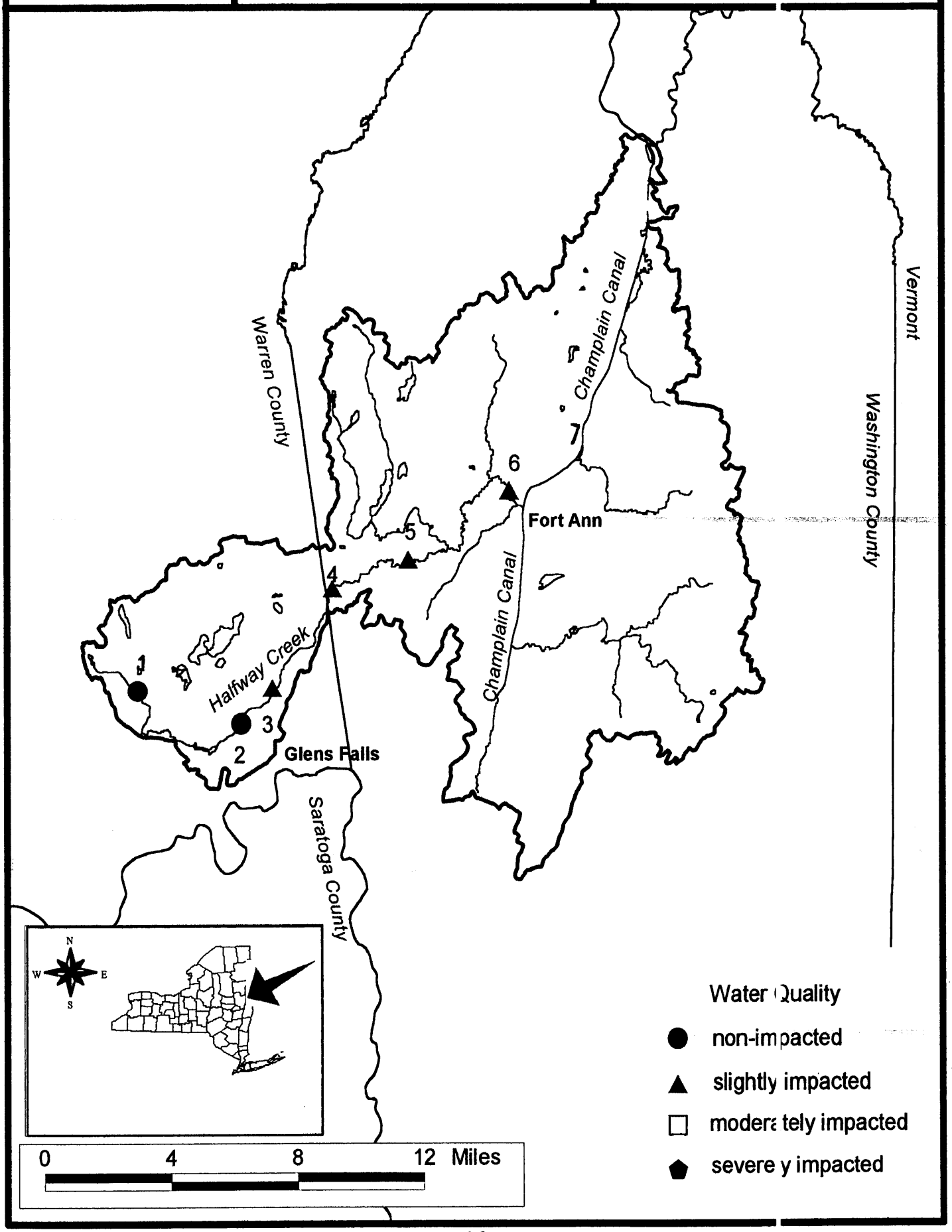


Figure 5a	Site Location Map	Halfway Creek

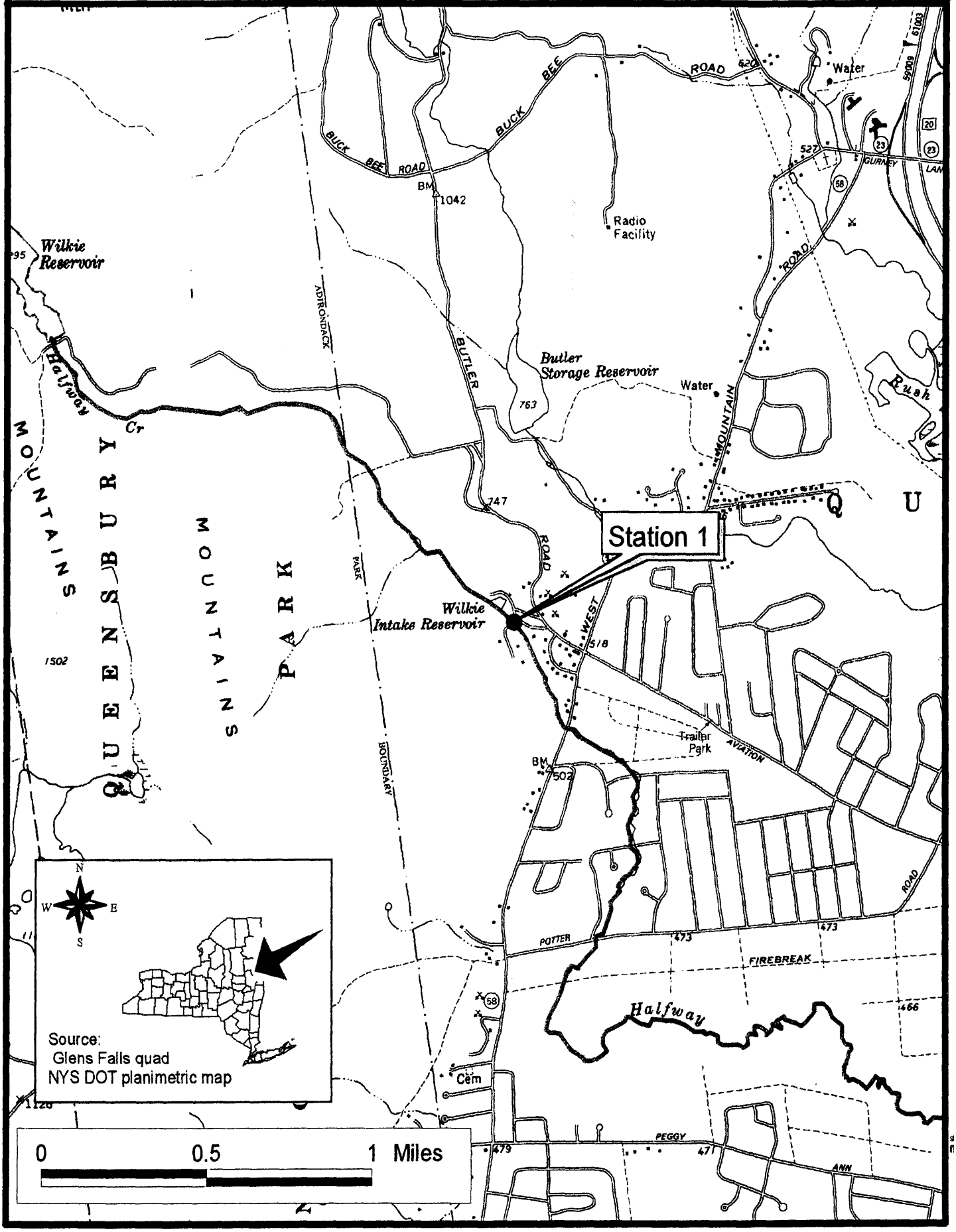


Figure 5b	Site Location Map	Halfway Creek

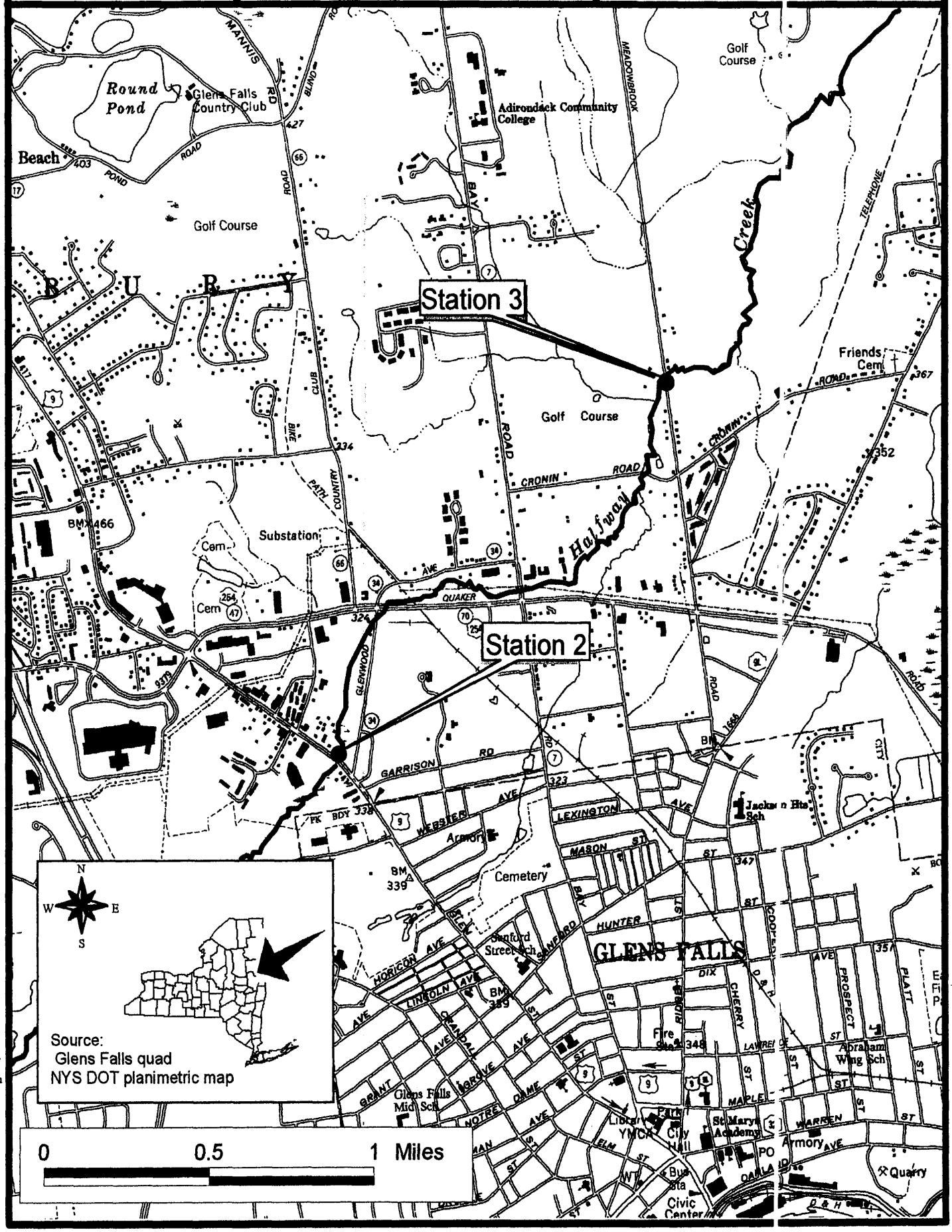


Figure 5c	Site Location Map	Halfway Creek

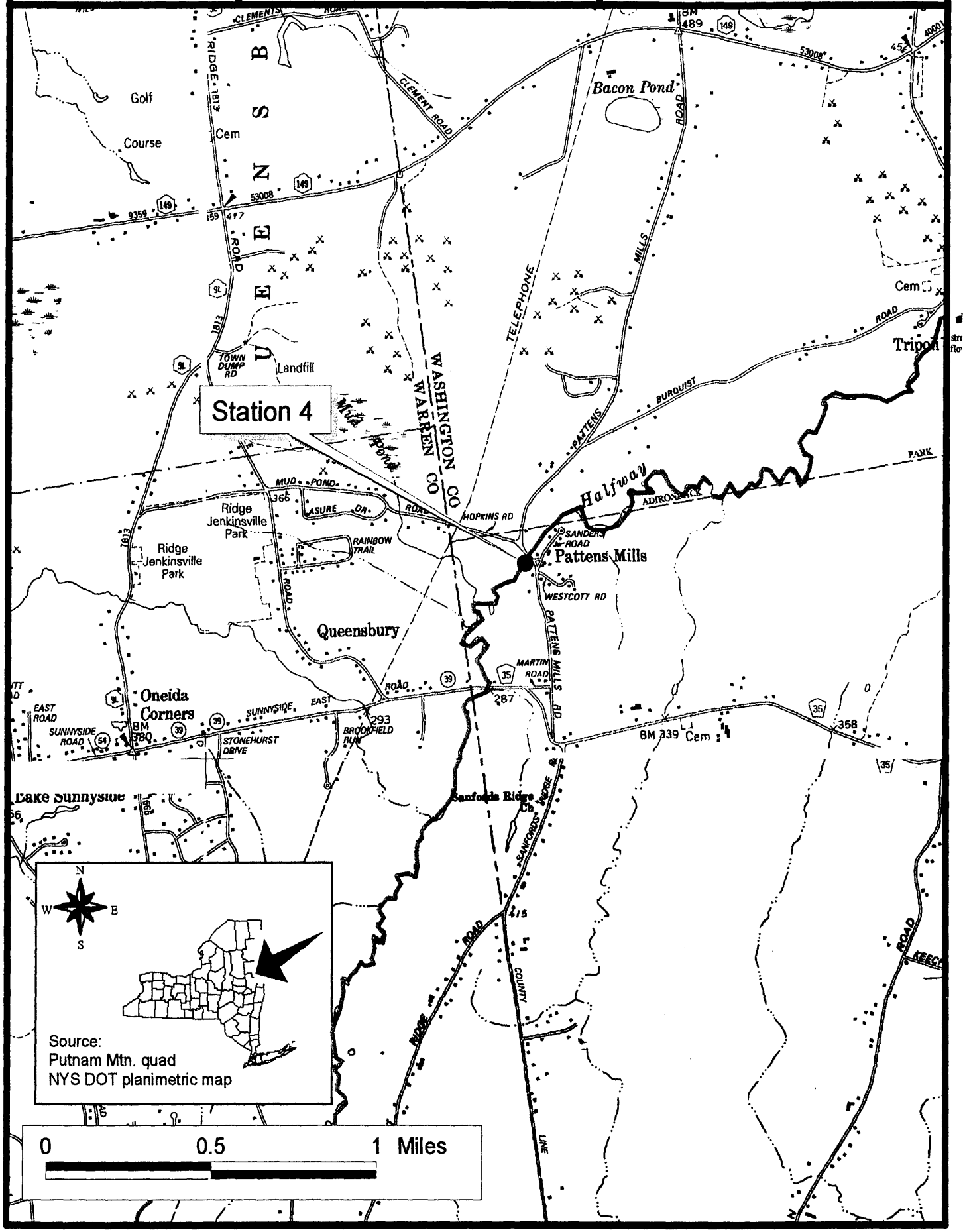


Figure 5d	Site Location Map	Halfway Creek

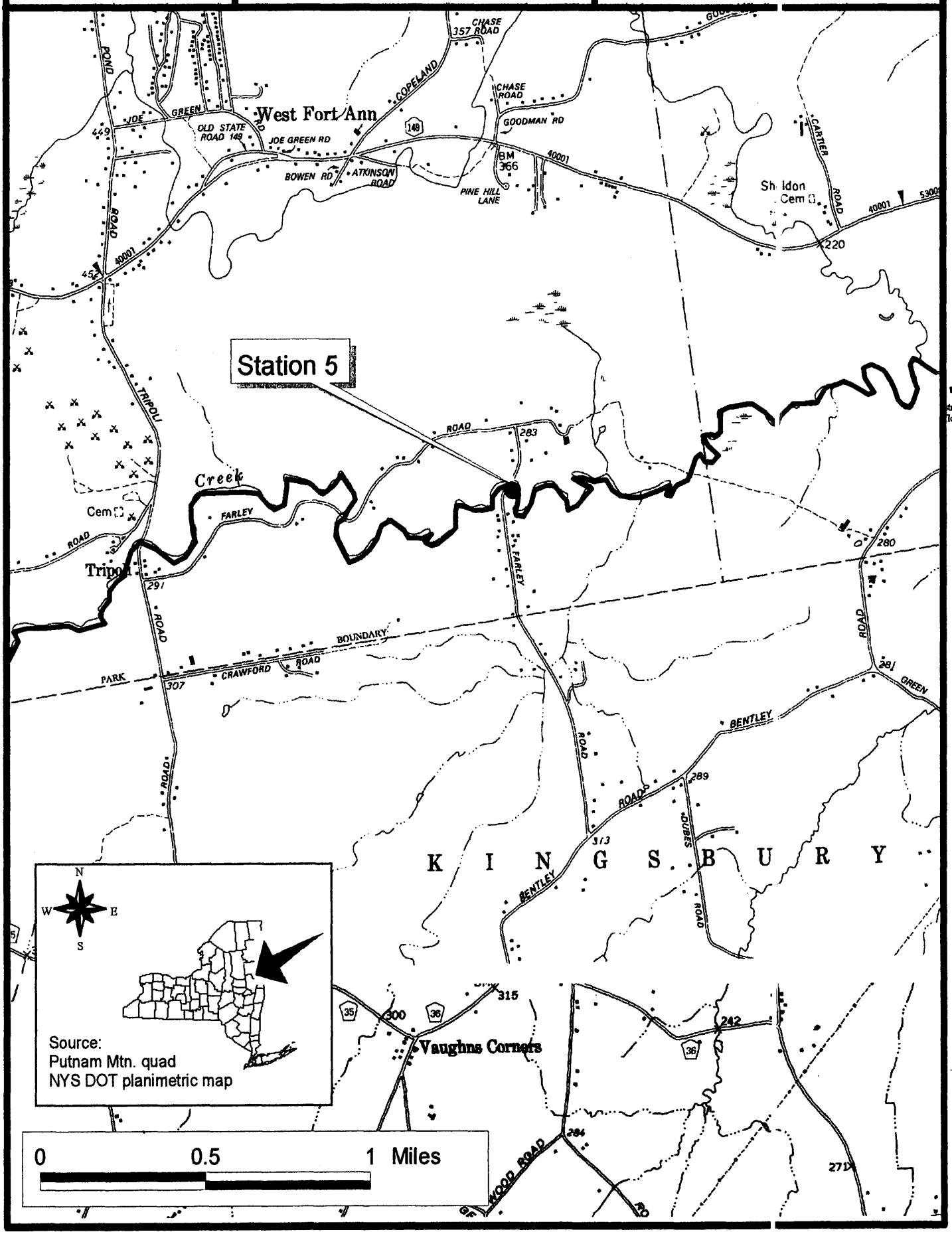


Figure 5e	Site Location Map	Halfway Creek

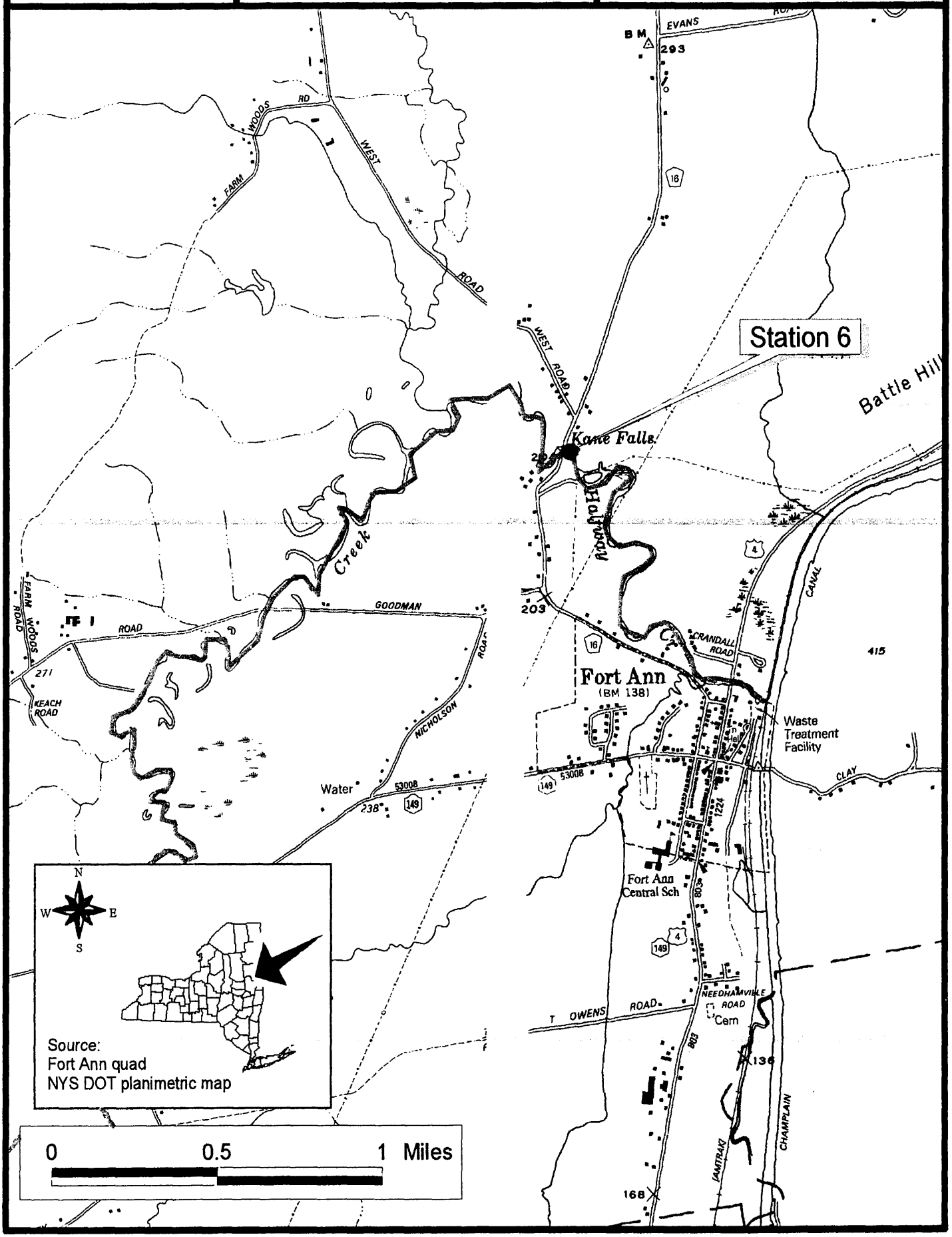


TABLE 4. MACROINVERTEBRATE SPECIES COLLECTED IN HALFWAY Creek, WASHINGTON COUNTY, NEW YORK, SEPTEMBER 23, 1999.

PLATYHELMINTHES
TURBELLARIA
Planariidae
Undetermined Turbellaria
NEMERTEA
Prostoma graecense
ANNELIDA
OLIGOCHAETA
Undetermined Lumbricina
Tubificidae
Undet. Tubificidae w/o cap. setae
Naididae
Nais variabilis
MOLLUSCA
GASTROPODA
Physidae
Physella sp.
PELECYPODA
Sphaeriidae
Sphaerium sp.
ARTHROPODA
CRUSTACEA
ISOPODA
Asellidae
Caecidotea communis
AMPHIPODA
Gammaridae
Gammarus sp.
EPHEMEROPTERA
Isonychiidae
Isonychia sp.
Baetidae
Acentrella sp.
Baetis brunneicolor
Baetis pluto
Heptageniidae
Stenacron interpunctatum
Stenonema modestum
Stenonema terminatum
Stenonema sp.
Undetermined Heptageniidae
Leptophlebiidae
Paraleptophlebia sp.
Ephemerellidae
Serratella sp.
Caenidae
Caenis latipennis
PLECOPTERA
Capniidae
Undetermined Capniidae
Perlidae
Paragnetina media
Perlodidae
COLEOPTERA
Hydrophilidae
Helophorus sp.
Psephenidae
Psephenus herricki
Elmidae
Dubiraphia sp.
Macronychus glabratus
Oulimnius sp.
Promoresia tardella
Stenelmis crenata
MEGALOPTERA
Corydalidae
Nigronia serricornis
TRICHOPTERA
Philopotamidae
Chimarra aterrima?
Dolophilodes sp.
Psychomyiidae
Psychomyia flavida
Polycentropodidae
Neureclipsis sp.
Hydropsychidae
Cheumatopsyche sp.
Diplectrona sp.
Hydropsyche betteni
Hydropsyche bronta
Hydropsyche morosa
Hydropsyche slossonae
Hydropsyche sparna
Rhyacophilidae
Rhyacophila carolina?
Glossosomatidae
Glossosoma sp.
Brachycentridae
Brachycentrus appalachia

TABLE 4. (continued). MACROINVERTEBRATE SPECIES COLLECTED IN HALFWAY Creek, WASHINGTON COUNTY, NEW YORK, SEPTEMBER 23, 1999.

DIPTERA
Tipulidae
Antocha sp.
Hexatoma sp.
Tipula sp.
Ceratopogonidae
Undetermined Ceratopogonidae
Simuliidae
Simulium vittatum
Empididae
Hemerodromia sp.
Chironomidae
Tanypodinae
Thienemannimyia gr. spp.
Diamesinae
Diamesa sp.
Orthocladiinae
Cricotopus bicinctus
Cricotopus tremulus gr.
Cricotopus vierriensis
Eukiefferiella brehmi gr.
Nanocladius (Plecopteracoluthus) downesi
Parachaetocladius sp.
Paracricotopus sp.
Parakiefferiella sp.
Parametriocnemus lundbecki
Rheocricotopus robacki
Tvetenia bavarica gr.
Chironominae
Chironomini
Chironomus sp.
Microtendipes pedellus gr.
Microtendipes rydalensis gr.
Phaenopsectra dyari?
Polypedilum aviceps
Polypedilum fallax gr.
Tanytarsini
Paratanytarsus confusus
Rheotanytarsus distinctissimus gr.
Tanytarsus glabrescens gr.
Tanytarsus guerlus gr.

Table 5. Fishes caught in Halfway Creek, September 24, 1999

	Station number								
	1A	2	3	3A	4	5	6A	6B	6C
Common name									
BLUEBACK HERRING	-	-	-	-	-	-	-	3	-
GIZZARD SHAD	-	-	-	-	-	-	-	3	4
BROWN TROUT	-	-	-	-	-	2	-	-	-
CENTRAL MUDMINNOW	-	-	-	1	-	-	-	-	-
CUTLIPS MINNOW	-	-	1	-	15	3	-	-	-
EASTERN SILVERY MINNOW	-	-	-	-	-	-	-	20	2
GOLDEN SHINER	2	1	-	-	-	-	-	2	1
EMERALD SHINER (?)	-	-	-	-	-	-	4	-	-
COMMON SHINER	-	1	10	-	-	8	-	-	-
ROSYFACE SHINER	-	-	-	-	-	-	-	3	3
SPOTFIN SHINER	-	-	-	-	-	-	-	-	1
MIMIC SHINER	-	-	-	-	-	2	-	-	-
BLUNTNOSE MINNOW	-	-	-	-	-	1	15	1	1
FATHEAD MINNOW	-	-	-	2	1	-	-	-	-
BLACKNOSE DACE	20	80	1	1	5	12	-	-	-
LONGNOSE DACE	1	-	2	-	5	6	-	-	-
CREEK CHUB	25	10	6	-	-	1	-	-	-
WHITE SUCKER	12	20	60	4	3	5	-	-	2
ROCK SILVERSIDE	-	-	-	-	-	-	21	21	19
PUMPKINSEED	1	-	1	-	4	3	1	15	27
SMALLMOUTH BASS	-	-	-	-	-	-	5	4	-
LARGEMOUTH BASS	-	-	-	-	-	-	-	-	4
TESSELLATED DARTER	12	5	20	25	6	-	-	-	-
YELLOW PERCH	-	-	-	-	-	-	1	5	7
LOGPERCH	-	-	-	-	-	-	-	2	4
Individuals	73	117	101	33	39	43	47	79	75
No. species	7	6	8	5	7	10	6	11	12
Weighted SPP	9	6	8	5	5	8	4	9	10
% non-tolerant ind.	47	74	35	79	90	84	68	96	93
Trophic PMA	63	74	60	73	80	73	80	70	68
Profile value	6.67	6.93	5.83	6.73	7.33	7.93	6.26*	8.53*	8.70*

* For Figure 2, the profile values for Stations 6A, 6B, and 6C were averaged to yield a Station 6 value o 7.83.

STREAM SITE:	Halfway Creek Station 1
LOCATION:	Above Glens Falls, New York, 100 m above Thunderbird Road bridge
DATE:	September 23, 1999
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Baetidae	Baetis brunneicolor	3
		Baetis pluto	3
	Heptageniidae	Stenonema sp.	4
		Undetermined Heptageniidae	1
PLECOPTERA	Capniidae	Undetermined Capniidae	1
	Perlodidae	Undetermined Perlodidae	3
COLEOPTERA	Elmidae	Oulimnius sp.	6
		Promoresia tardella	1
MEGALOPTERA	Corydalidae	Nigronia serricornis	2
TRICHOPTERA	Philopotamidae	Chimarra aterrima?	1
		Dolophilodes sp.	9
	Hydropsychidae	Cheumatopsyche sp.	1
		Diplectrona sp.	11
		Hydropsyche betteni	6
		Hydropsyche sparna	20
	Rhyacophilidae	Rhyacophila carolina?	5
	Glossosomatidae	Glossosoma sp.	1
DIPTERA	Tipulidae	Hexatoma sp.	3
	Chironomidae	Thienemannimyia gr. spp.	1
		Diamesa sp.	3
		Parametriocnemus lundbecki	11
		Paraphaenocladius sp.	1
		Tvetenia bavarica gr.	1
		Polypedilum aviceps	1
		Rheotanytarsus distinctissimus gr.	1

SPECIES RICHNESS	25 (good)
BIOTIC INDEX	4.04 (very good)
EPT RICHNESS	14 (very good)
MODEL AFFINITY	56 (good)
ASSESSMENT	non-impacted

DESCRIPTION

This site was 100 meters downstream of the spillway of the Wilkie Intake Reservoir. The site was forested, and the stream habitat was favorable. Some impoundment effects were evident in the macroinvertebrate fauna, as filter-feeding caddisflies were abundant. However, mayflies and stoneflies were well-represented, and the indices resulted in an assessment of non-impacted.

STREAM SITE:	Halfway Creek Station 2		
LOCATION:	Glens Falls, New York, 20 m below Route 9 bridge		
DATE:	September 23, 1999		
SAMPLE TYPE:	Kick sample		
SUBSAMPLE:	100 individuals		
PLATYHELMINTHES			
TURBELLARIA		Undetermined Turbellaria	2
NEMERTEA		Prostoma graecense	1
ANNELIDA			
OLIGOCHAETA		Undetermined Lumbricina	1
	Tubificidae	Undet. Tubificidae w/o cap. set[illegible]e	6
MOLLUSCA			
GASTROPODA	Physidae	Physella sp.	3
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	Caecidotea communis	6
AMPHIPODA	Gammaridae	Gammarus sp.	1
INSECTA			
EPHEMEROPTERA	Baetidae	Acentrella sp.	1
	Heptageniidae	Stenonema modestum	26
	Leptophlebiidae	Paraleptophlebia sp.	1
PLECOPTERA	Perlidae	Paragnetina media	5
COLEOPTERA	Hydrophilidae	Helophorus sp.	1
	Elmidae	Stenelmis crenata	8
MEGALOPTERA	Corydalidae	Nigronia serricornis	2
TRICHOPTERA	Philopotamidae	Dolophilodes sp.	1
	Psychomyiidae	Psychomyia flavida	2
	Hydropsychidae	Cheumatopsyche sp.	4
		Hydropsyche betteni	13
DIPTERA	Tipulidae	Antocha sp.	3
	Ceratopogonidae	Undetermined Ceratopogonidae	2
	Empididae	Hemerodromia sp.	1
	Chironomidae	Thienemannimyia gr. spp.	1
		Cricotopus vierriensis	5
		Nanocladius (Plecopt.) downesi	1
		Parachaetocladius sp.	1
		Polypedilum fallax gr.	1
		Tanytarsus glabrescens gr.	1

SPECIES RICHNESS	27 (very good)
BIOTIC INDEX	4.52 (good)
EPT RICHNESS	8 (good)
MODEL AFFINITY	77 (very good)
ASSESSMENT	non-impacted

DESCRIPTION The kick sample was taken a short distance downstream of the culvert passing under Route 9 in Glens Falls. The habitat was less canopied than that at Station 1, and the substrate contained large percentages of gravel and sand. Specific conductance had greatly increased compared to upstream Station 1. Mayflies, stoneflies, and caddisflies were well-represented, and the indices pointed to non-impacted water quality.

STREAM SITE:	Halfway Creek Station 3
LOCATION:	Glens Falls, New York, 1 m above Meadowbrook Road bridge
DATE:	September 23, 1999
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	Gammarus sp.	3
INSECTA			
EPHEMEROPTERA	Heptageniidae	Stenonema modestum	25
PLECOPTERA	Perlidae	Paragnetina media	1
COLEOPTERA	Elmidae	Dubiraphia sp.	1
		Macronychus glabratus	3
		Stenelmis crenata	2
MEGALOPTERA	Corydalidae	Nigronia serricornis	2
TRICHOPTERA	Philopotamidae	Chimarra aterrima?	1
	Hydropsychidae	Cheumatopsyche sp.	7
		Hydropsyche betteni	40
DIPTERA	Tipulidae	Antocha sp.	1
		Tipula sp.	1
	Empididae	Hemerodromia sp.	2
	Chironomidae	Cricotopus bicinctus	1
		Tvetenia bavarica gr.	9
		Tanytarsus glabrescens gr.	1

SPECIES RICHNESS	16 (poor)
BIOTIC INDEX	4.28 (very good)
EPT RICHNESS	5 (poor)
MODEL AFFINITY	62 (good)
ASSESSMENT	slightly impacted

DESCRIPTION

The sampling site was just upstream of the Meadowbrook Road bridge downstream of Glens Falls. The stream was rather flat in this reach, and the riffle sampled was a swimmers' dam. The macroinvertebrate fauna was heavily dominated by the tolerant filter-feeding caddisfly Hydropsyche betteni. This species comprised 66% of the original sample, but this was reduced to 40% using Quality Assurance techniques. Although mayflies, stoneflies, and caddisflies were present, 3 of the 4 indices dropped substantially, and the summary of indices placed water quality in the range of slight impact.

STREAM SITE:	Halfway Creek Station 4
LOCATION:	Pattens Mills, New York, 50 m above Patten Mills Road bridge
DATE:	September 23, 1999
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia sp.	1
	Baetidae	Baetis pluto	1
PLECOPTERA	Perlidae	Paragnetina media	4
COLEOPTERA	Elmidae	Macronychus glabratus	2
		Stenelmis crenata	1
MEGALOPTERA	Corydalidae	Nigronia serricornis	2
TRICHOPTERA	Philopotamidae	Chimarra aterrima?	2
	Hydropsychidae	Cheumatopsyche sp.	1
		Hydropsyche betteni	40
		Hydropsyche bronta	7
		Hydropsyche morosa	2
		Hydropsyche sparna	17
	Brachycentridae	Brachycentrus appalachia	3
DIPTERA	Tipulidae	Tipula sp.	3
	Simuliidae	Simulium vittatum	1
	Chironomidae	Thienemannimyia gr. spp.	1
		Cricotopus vierriensis	1
		Eukiefferiella brehmi gr.	3
		Paracricotopus sp.	1
		Tvetenia bavarica gr.	5
		Polypedilum aviceps	1
		Rheotanytarsus distinctissimus gr.	1

SPECIES RICHNESS	22 (good)
BIOTIC INDEX	5.35 (good)
EPT RICHNESS	10 (good)
MODEL AFFINITY	38 (poor)
ASSESSMENT	slightly impacted

DESCRIPTION

This site was located 50 meters upstream of the Patten Mills Road bridge in Patten Mills. Although the stream was flat, the current speed was swift, and a swimmers' cream was sampled, similar to that at Station 3. The fauna was strongly dominated by the caddisfly Hydropsyche betteni, as at Station 3. Mayflies and stoneflies were also present. The index values placed the water quality assessment as slightly impacted.

STREAM SITE:	Halfway Creek Station 5
LOCATION:	Tripoli, New York, 2 m above Farley Road bridge
DATE:	September 23, 1999
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	Gammarus sp.	11
INSECTA			
EPHEMEROPTERA	Heptageniidae	Stenonema modestum	2
	Ephemerellidae	Serratella sp.	3
PLECOPTERA	Perlidae	Paragnetina media	1
COLEOPTERA	Elmidae	Stenelmis sp.	1
TRICHOPTERA	Philopotamidae	Chimarra aterrima?	1
	Polycentropodidae	Neureclipsis sp.	1
	Hydropsychidae	Cheumatopsyche sp.	15
		Hydropsyche betteni	1
		Hydropsyche bronta	5
		Hydropsyche sparna	3
DIPTERA	Tipulidae	Antocha sp.	1
		Tipula sp.	1
	Empididae	Hemerodromia sp.	2
	Chironomidae	Cricotopus vierriensis	7
		Parakiefferiella sp.	3
		Rheocricotopus robacki	1
		Chironomus sp.	8
		Microtendipes pedellus gr.	12
		Microtendipes rydalensis gr.	3
		Phaenopsectra dyari?	1
		Paratanytarsus confusus	3
		Tanytarsus glabrescens gr.	10
		Tanytarsus guerlus gr.	4

SPECIES RICHNESS	24 (good)
BIOTIC INDEX	5.90 (good)
EPT RICHNESS	9 (good)
MODEL AFFINITY	47 (poor)
ASSESSMENT	slightly impacted

DESCRIPTION

The kick sample was taken just above the Farley Road bridge in Tripoli. The bridge and culverts were new, and it was questioned whether the stream rocks had been in place long enough for colonization, but the invertebrate fauna appeared well-established. The indices were similar to those at the upstream Stations 3 and 4, and water quality was similarly assessed as slightly impacted.

STREAM SITE:	Halfway Creek Station 6
LOCATION:	Fort Ann, New York, 50 m below Co. Rd. 16 bridge
DATE:	September 23, 1999
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ANNELIDA			
OLIGOCHAETA	Naididae	Nais variabilis	1
MOLLUSCA			
PELECYPODA	Sphaeriidae	Sphaerium sp.	14
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	Caecidotea sp.	1
AMPHIPODA	Gammaridae	Gammarus sp.	14
INSECTA			
EPHEMEROPTERA	Heptageniidae	Stenacron interpunctatum	30
		Stenonema modestum	6
		Stenonema terminatum	2
	Caenidae	Caenis latipennis	4
COLEOPTERA	Psephenidae	Psephenus herricki	1
	Elmidae	Dubiraphia sp.	2
		Stenelmis crenata	4
TRICHOPTERA	Hydropsychidae	Cheumatopsyche sp.	14
		Hydropsyche betteni	1
	Chironomidae	Cricotopus bicinctus	2
		Parakiefferiella sp.	1
		Chironomus sp.	1
		Microtendipes pedellus gr.	1
		Tanytarsus guerlus gr.	1

SPECIES RICHNESS	18 (poor)
BIOTIC INDEX	5.86 (good)
EPT RICHNESS	6 (good)
MODEL AFFINITY	74 (very good)
ASSESSMENT	slightly impacted

DESCRIPTION The sampling site was under the bridge of Route 16 near Fort Ann. The stream was flat upstream of this site, but current speed and substrate were considered adequate as habitat. The kick sample yield a community dominated by mayflies, and indices were mostly within the range of slight impact.

LABORATORY DATA SUMMARY

STREAM NAME: Halfway Creek — **DRAINAGE: 10 (Lake Champlain)**
DATE SAMPLED: September 23, 1999 — **COUNTY: Warren, Washington**
SAMPLING METHOD: Traveling Kick

STATION / LOCATION	01 above Glens Falls	02 Glens Falls	03 below Glens Falls	04 Pattens Mills
DOMINANT SPECIES/%CONTRIBUTION/TOLERANCE/COMMON NAME				
1.	Hydropsyche sparna 20% facultative caddisfly	Stenonema modestum 26% intolerant mayfly	Hydropsyche betteni 40% facultative caddisfly	Hydropsyche betteni 40% facultative caddisfly
Intolerant = not tolerant of poor water quality; Facultative = occurring over a wide range of water quality; Tolerant = tolerant of poor water quality. 2.	Diplectrona sp. 11% facultative caddisfly	Hydropsyche betteni 13% facultative caddisfly	Stenonema modestum 25% intolerant mayfly	Hydropsyche sparna 17% facultative caddisfly
3.	Parametriocnemus lundbecki 11% facultative midge	Stenelmis crenata 8% facultative riffle beetle	Tvetenia bavarica gr. 9% facultative midge	Hydropsyche bronta 7% facultative caddisfly
4.	Dolophilodes sp. 9% intolerant caddisfly	Undt. Tubificidae w/o cap. setae 6% tolerant worm	Cheumatopsyche sp. 7% facultative caddisfly	Tvetenia bavarica gr. 5% facultative midge
5.	Oulimnius sp. 6% facultative beetle	Caecidotea communis 6% tolerant sowbug	Gammarus sp. 3% facultative scud	Paragnetina media 4% facultative stonefly
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESES)				
Chironomidae (midges)	19 (7)	10 (6)	11 (3)	13 (7)
Trichoptera (caddisflies)	54 (8)	20 (4)	48 (3)	72 (7)
Ephemeroptera (mayflies)	11 (4)	28 (3)	25 (1)	2 (2)
Plecoptera (stoneflies)	4 (2)	5 (1)	1 (1)	4 (1)
Coleoptera (beetles)	7 (2)	9 (2)	6 (3)	3 (2)
Oligochaeta (worms)	0 (0)	7 (2)	0 (0)	0 (0)
Other (**)	5 (2)	21 (9)	9 (5)	6 (3)
TOTAL	100 (25)	100 (27)	100 (16)	100 (22)
SPECIES RICHNESS	25 (good)	27 (very good)	16 (poor)	22 (good)
HBI INDEX	4.04 (very good)	4.52 (good)	4.28 (very good)	5.35 (good)
EPT RICHNESS	14 (very good)	8 (good)	5 (poor)	10 (good)
PERCENT MODEL AFFINITY	56 (good)	77 (very good)	62 (good)	38 (poor)
FIELD ASSESSMENT	non-impacted	slightly impacted	slightly impacted	slightly impacted
OVERALL ASSESSMENT	non-impacted	non-impacted	slightly impacted	slightly impacted

** crane flies, Megaloptera, snails, flatworms

LABORATORY DATA SUMMARY

STREAM NAME: Halfway Creek — **DRAINAGE: 10 (Lake Champlain)**
DATE SAMPLED: September 23, 1999 — **COUNTY: Warren, Washington**
SAMPLING METHOD: Traveling Kick

STATION LOCATION	05 Tripoli	06 Fort Ann		
DOMINANT SPECIES/%CONTRIBUTION/TOLERANCE/COMMON NAME				
1.	Cheumatopsyche sp. 15% facultative caddisfly	Stenacron interpunctatum 30% facultative mayfly		
Intolerant = not tolerant of poor water quality; Facultative = occurring over a wide range of water quality; Tolerant = tolerant of poor water quality. 2.	Microtendipes pedellus gr. 12% facultative midge	Sphaerium sp. 14% facultative fingernail clam		
3.	Gammarus sp. 11% facultative scud	Gammarus sp. 14% facultative scud		
4.	Tanytarsus glabrescens gr. 10% facultative midge	Cheumatopsyche sp. 14% facultative caddisfly		
5.	Chironomus sp. 8% tolerant midge	Stenonema modestum 6% intolerant mayfly		
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESES)				
Chironomidae (midges)	52 (10)	6 (5)		
Trichoptera (caddisflies)	26 (6)	15 (2)		
Ephemeroptera (mayflies)	5 (2)	42 (4)		
Plecoptera (stoneflies)	1 (1)	0 (0)		
Coleoptera (beetles)	1 (1)	7 (3)		
Oligochaeta (worms)	0 (0)	1 (1)		
Other (**)	15 (4)	29 (3)		
TOTAL	100 (24)	100 (18)		
SPECIES RICHNESS	24 (good)	18 (poor)		
HBI INDEX	5.90 (good)	5.86 (good)		
EPT RICHNESS	9 (good)	6 (good)		
PERCENT MODEL AFFINITY	47 (poor)	74 (very good)		
FIELD ASSESSMENT	slightly impacted	slightly impacted		
OVERALL ASSESSMENT	slightly impacted	slightly impacted		

** crane flies, scuds, fingernail clams

FIELD DATA SUMMARY

STREAM NAME: Halfway Creek

REACH: above Glens Falls to Fort Ann

FIELD PERSONNEL: Bode, Andrews DATE SAMPLED: 09/23/99

STATION	01	02	03	04
ARRIVAL TIME	9:40	10:15	10:55	11:30
LOCATION	above Glens Falls	Glens Falls	below Glens Falls	Pattens Mills
PHYSICAL CHARACTERISTICS				
Width (meters)	4	5	6	12
Depth (meters)	0.1	0.2	0.3	0.3
Current speed (cm per second)	100	100	120	140
Substrate (%)				
rock (> 10 in. or bedrock)	10	10	10	10
rubble (2.5 - 10 in.)	40	20	30	30
gravel (0.08 - 2.5 in.)	30	30	20	30
sand (0.06 - 2.0 mm)	20	30	20	20
silt (0.004 - 0.06 mm)	0	10	20	10
clay (< 0.004 mm)	0	0	0	0
Embeddedness (%)	20	20	10	10
CHEMICAL MEASUREMENTS				
Temperature (C)	12.6	13.1	11.7	12.1
Specific Conductance (umhos)	34	361	369	318
Dissolved Oxygen (mg / l)	10.0	9.6	9.5	8.5
pH	6.9	7.3	7.4	7.4
BIOLOGICAL ATTRIBUTES				
Canopy (%)	100	20	10	10
Aquatic Vegetation				
algae - suspended in water column				
algae - attached, filamentous			present	
algae - diatoms				
macrophytes or moss				
Occurrence of Macroinvertebrates				
Ephemeroptera (mayflies)	X	X	X	X
Plecoptera (stoneflies)	X	X	X	X
Trichoptera (caddisflies)	X	X	X	X
Coleoptera (beetles)				X
Megaloptera (dobsonflies, alderflies)	X	X	X	X
Odonata (dragonflies, damselflies)			X	X
Chironomidae (midges)	X			X
Simuliidae (black flies)				
Decapoda (crayfish)	X	X	X	X
Gammaridae (scuds)			X	
Mollusca (snails, clams)				
Oligochaeta (worms)				
Other		X		
FIELD ASSESSMENT	non	slt	slt	slt

FIELD DATA SUMMARY

STREAM NAME: Halfway Creek

REACH: above Glens Falls to Fort Ann

FIELD PERSONNEL: Bode, Andrews DATE SAMPLED: 09/23/99

STATION	05	06		
ARRIVAL TIME	12:15	1:10		
LOCATION	Tripoli	Fort Ann		
PHYSICAL CHARACTERISTICS				
Width (meters)	12	20		
Depth (meters)	0.4	0.4		
Current speed (cm per second)	100	100		
Substrate (%)				
rock (> 10 in. or bedrock)	0	0		
rubble (2.5 - 10 in.)	40	40		
gravel (0.08 - 2.5 in.)	20	20		
sand (0.06 - 2.0 mm)	20	20		
silt (0.004 - 0.06 mm)	20	20		
clay (< 0.004 mm)	0	0		
Embeddedness (%)	-	20		
CHEMICAL MEASUREMENTS				
Temperature (C)	12.5	12.9		
Specific Conductance (umhos)	308	216		
Dissolved Oxygen (mg / l)	9.8	10.2		
pH	7.6	7.3		
BIOLOGICAL ATTRIBUTES				
Canopy (%)	10	10		
Aquatic Vegetation				
algae - suspended in water column				
algae - attached, filamentous				
algae - diatoms				
macrophytes or moss				
Occurrence of Macroinvertebrates				
Ephemeroptera (mayflies)	X	X		
Plecoptera (stoneflies)	X	X		
Trichoptera (caddisflies)	X	X		
Coleoptera (beetles)		X		
Megaloptera (dobsonflies, alderflies)		X		
Odonata (dragonflies, damselflies)				
Chironomidae (midges)	X	X		
Simuliidae (black flies)				
Decapoda (crayfish)		X		
Gammaridae (scuds)		X		
Mollusca (snails, clams)		X		
Oligochaeta (worms)				
Other		X		
FIELD ASSESSMENT	slt	slt		

Appendix I. BIOLOGICAL METHODS FOR KICK SAMPLING

A. Rationale. The use of the standardized kick sampling method provides a biological assessment technique that lends itself to rapid assessments of stream water quality.

B. Site Selection. Sampling sites are selected based on these criteria: (1) The sampling location should be a riffle with a substrate of rubble, gravel, and sand. Depth should be one meter or less, and current speed should be at least 0.4 meters per second. (2) The site should have comparable current speed, substrate type, embeddedness, and canopy cover to both upstream and downstream sites to the degree possible. (3) Sites are chosen to have a safe and convenient access.

C. Sampling. Macroinvertebrates are sampled using the standardized traveling kick method. An aquatic net is positioned in the water at arms' length downstream and the stream bottom is disturbed by foot, so that the dislodged organisms are carried into the net. Sampling is continued for a specified time and for a specified distance in the stream. Rapid assessment sampling specifies sampling 5 minutes for a distance of 5 meters. The net contents are emptied into a pan of stream water. The contents are then examined, and the major groups of organisms are recorded, usually on the ordinal level (e.g., stoneflies, mayflies, caddisflies). Larger rocks, sticks, and plants may be removed from the sample if organisms are first removed from them. The contents of the pan are poured into a U.S. No. 30 sieve and transferred to a quart jar. The sample is then preserved by adding 95% ethyl alcohol.

D. Sample Sorting and Subsampling. In the laboratory the sample is rinsed with tap water in a U.S. No. 40 standard sieve to remove any fine particles left in the residues from field sieving. The sample is transferred to an enamel pan and distributed homogeneously over the bottom of the pan. A small amount of the sample is randomly removed with a spatula, rinsed with water, and placed in a petri dish. This portion is examined under a dissecting stereo microscope and 100 organisms are randomly removed from the debris. As they are removed, they are sorted into major groups, placed in vials containing 70 percent alcohol, and counted. The total number of organisms in the sample is estimated by weighing the residue from the picked subsample and determining its proportion of the total sample weight.

E. Organism Identification. All organisms are identified to the species level whenever possible. Chironomids and oligochaetes are slide-mounted and viewed through a compound microscope; most other organisms are identified as whole specimens using a dissecting stereomicroscope. The number of individuals in each species, and the total number of individuals in the subsample is recorded on a data sheet. All organisms from the subsample are archived, either slide-mounted or preserved in alcohol. Following identification of a subsample, if the results are ambiguous, suspected of being spurious, or do not yield a clear water quality assessment, additional subsampling may be required.

Appendix II. MACROINVERTEBRATE COMMUNITY PARAMETERS

1. Species richness. This is the total number of species or taxa found in the sample. Expected ranges for 100-specimen subsamples of kick samples in most streams in New York State are: greater than 26, non-impacted; 19-26, slightly impacted; 11-18, moderately impacted; less than 11, severely impacted.

2. EPT value. EPT denotes the total number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) found in an average 100-organism subsample. These are considered to be mostly clean-water organisms, and their presence generally is correlated with good water quality (Lenat, 1987). Expected ranges from most streams in New York State are: greater than 10, non-impacted; 6-10, slightly impacted; 2-5, moderately impacted; and 0-1, severely impacted.

3. Biotic index. The Hilsenhoff Biotic Index is a measure of the tolerance of the organisms in the sample to organic pollution (sewage effluent, animal wastes) and low dissolved oxygen levels. It is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals. On a 0-10 scale, tolerance values range from intolerant (0) to tolerant (10). For purposes of characterizing species' tolerance, intolerant = 0-4, facultative = 5-7, and tolerant = 8-10. Values are listed in Hilsenhoff (1987); additional values are assigned by the NYS Stream Biomonitoring Unit. The most recent values for each species are listed in the Quality Assurance document (Bode et al., 1996). Ranges for the levels of impact are: 0-4.50, non-impacted; 4.51-6.50, slightly impacted; 6.51-8.50, moderately impacted; and 8.51-10.00, severely impacted.

4. Percent Model Affinity is a measure of similarity to a model non-impacted community based on percent abundance in 7 major groups (Novak and Bode, 1992). Percentage similarity is used to measure similarity to a community of 40% Ephemeroptera, 5% Plecoptera, 10% Trichoptera, 10% Coleoptera, 20% Chironomidae, 5% Oligochaeta, and 10% Other. Ranges for the levels of impact are: >64, non-impacted; 50-64, slightly impacted; 35-49, moderately impacted; and <35, severely impacted.

Bode, R.W., M.A. Novak, and L.E. Abele. 1996. Quality assurance work plan for biological stream monitoring in New York State. NYS DEC technical report, 89 pp.

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. The Great Lakes Entomologist 20(1): 31-39.

Lenat, D. R. 1987. Water quality assessment using a new qualitative collection method for freshwater benthic macroinvertebrates. North Carolina DEM Tech. Report. 12 pp.

Novak, M.A., and R.W. Bode. 1992. Percent model affinity: a new measure of macroinvertebrate community composition. J. N. Am. Benthol. Soc. 11(1):80-85.

Appendix III. LEVELS OF WATER QUALITY IMPACT IN STREAMS.

The description of overall stream water quality based on biological parameters uses a four-tiered system of classification. Level of impact is assessed for each individual parameter, and then combined for all parameters to form a consensus determination. Four parameters are used: species richness, EPT value, biotic index, and percent model affinity. The consensus is based on the determination of the majority of the parameters; since parameters measure different aspects of the community, they cannot be expected to always form unanimous assessments. The ranges given for each parameter are based on 100-organism subsamples of macroinvertebrate riffle kick samples, and also apply to most multiplate samples, with the exception of percent model affinity.

1. Non-impacted

Indices reflect very good water quality. The macroinvertebrate community is diverse, usually with at least 27 species in riffle habitats. Mayflies, stoneflies, and caddisflies are well-represented; the EPT value is greater than 10. The biotic index value is 4.50 or less. Percent model affinity is greater than 64. Water quality should not be limiting to fish survival or propagation. This level of water quality includes both pristine habitats and those receiving discharges which minimally alter the biota.

2. Slightly impacted

Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness usually is 19-26. Mayflies and stoneflies may be restricted, with EPT values of 6-10. The biotic index value is 4.51-6.50. Percent model affinity is 50-64. Water quality is usually not limiting to fish survival, but may be limiting to fish propagation.

3. Moderately impacted

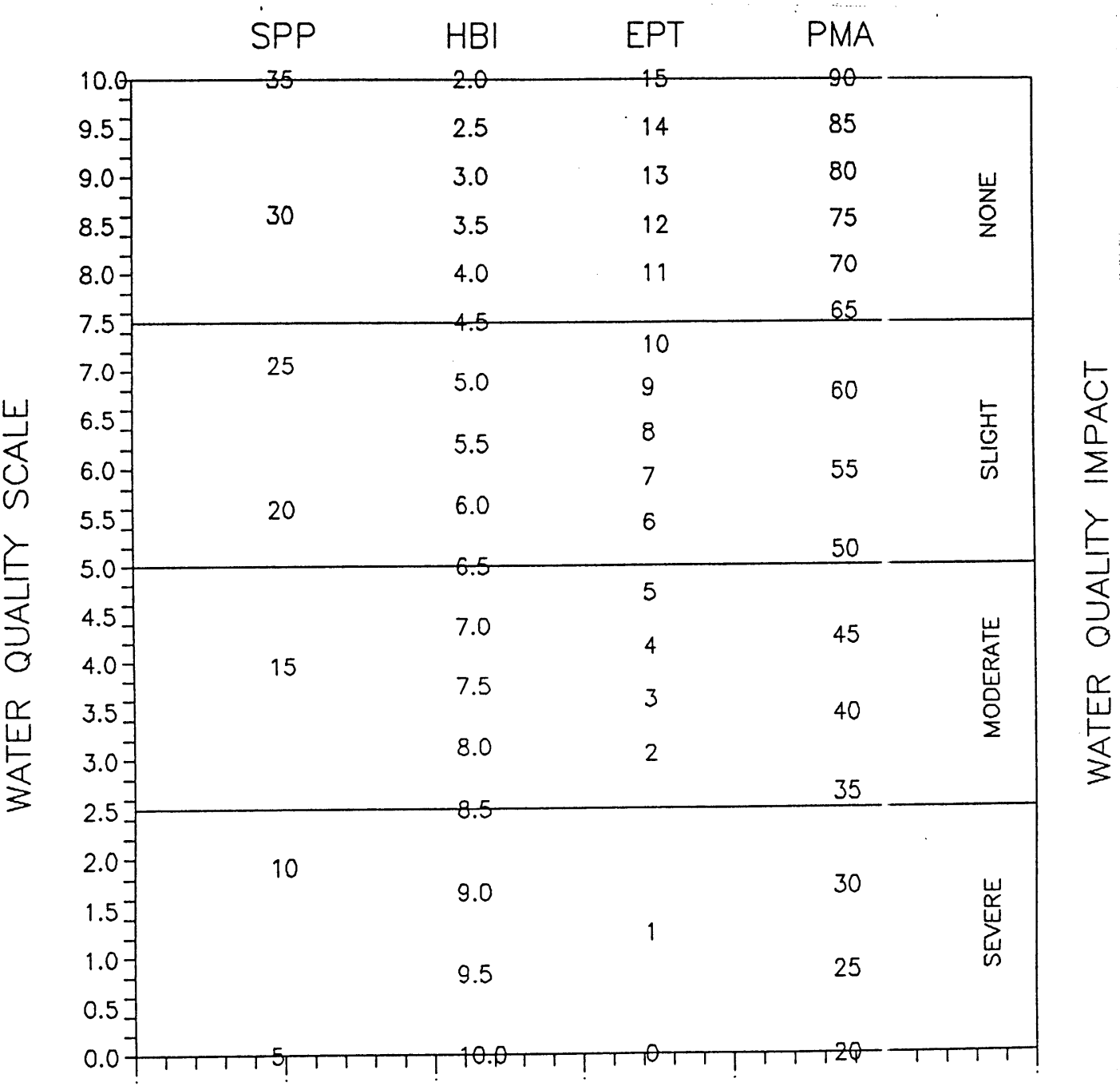
Indices reflect poor water quality. The macroinvertebrate community is altered to a large degree from the pristine state. Species richness usually is 11-18 species. Mayflies and stoneflies are rare or absent, and caddisflies are often restricted; the EPT value is 2-5. The biotic index value is 6.51-8.50. The percent model affinity value is 35-49. Water quality often is limiting to fish propagation, but usually not to fish survival.

4. Severely impacted

Indices reflect very poor water quality. The macroinvertebrate community is limited to a few tolerant species. Species richness is 10 or less. Mayflies, stoneflies, and caddisflies are rare or absent; EPT value is 0-1. The biotic index value is greater than 8.50. Percent model affinity is less than 35. The dominant species are almost all tolerant, and are usually midges and worms. Often 1-2 species are very abundant. Water quality is often limiting to both fish propagation and fish survival.

Appendix IV. BIOLOGICAL ASSESSMENT PROFILE OF INDEX VALUES

The Biological Assessment Profile of index values, developed by Mr. Phil O'Brien, Division of Water, NYS DEC, is a method of plotting biological index values on a common scale of water quality impact. Values from the four indices defined in Appendix II are converted to a common 0-10 scale as shown in the figure below.



To plot survey data, each site is positioned on the x-axis according to river miles from the mouth, and the scaled values for the four indices are plotted on the common scale. The mean scale value of the four indices is represented by a circle; this value is used for graphing trends between sites, and represents the assessed impact for each site.

Appendix V

WATER QUALITY ASSESSMENT CRITERIA

for non-navigable flowing waters

	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity#	Diversity*
Non-Impacted	>26	0.00-4.50	>10	>64	>4
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	3.01-4.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	2.01-3.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	0.00-2.00

Percent model affinity criteria are used for traveling kick samples but not for multiplate samples.

* Diversity criteria are used for multiplate samples but not for traveling kick samples.

WATER QUALITY ASSESSMENT CRITERIA

for navigable flowing waters

	Species Richness	Hilsenhoff Biotic Index	EPT Value	Diversity
Non-Impacted	>21	0.00-7.00	>5	>3.00
Slightly Impacted	17-21	7.01-8.00	4-5	2.51-3.00
Moderately Impacted	12-16	8.01-9.00	2-3	2.01-2.50
Severely Impacted	0-11	9.01-10.00	0-1	0.00-2.00

Appendix VI.

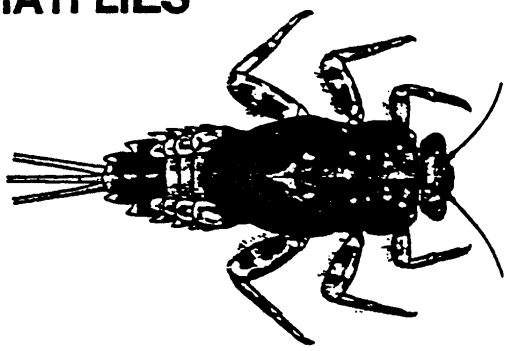
THE TRAVELING KICK SAMPLE

Rocks and sediment in the stream riffle are dislodged by foot upstream of a net; dislodged organisms are carried by the current in the net. Sampling is continued for a specified time, gradually moving downstream to cover a specified distance.

AQUATIC MACROINVERTEBRATES THAT USUALLY INDICATE GOOD WATER QUALITY

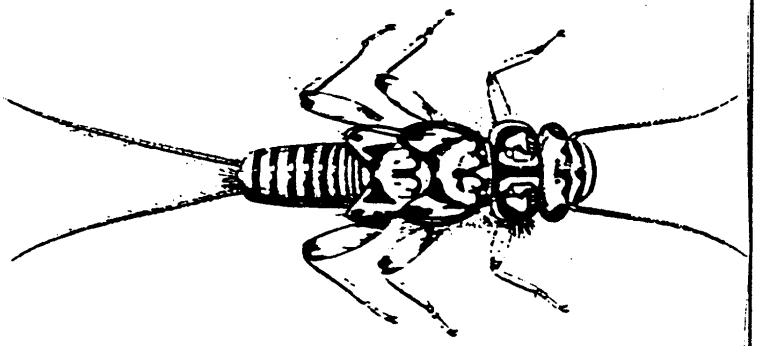
MAYFLIES

Mayfly nymphs are often the most numerous organisms found in clean streams. They are sensitive to most types of pollution, including low dissolved oxygen (less than 5 ppm), chlorine, ammonia, metals, pesticides, and acidity. Most mayflies are found clinging to the undersides of rocks.



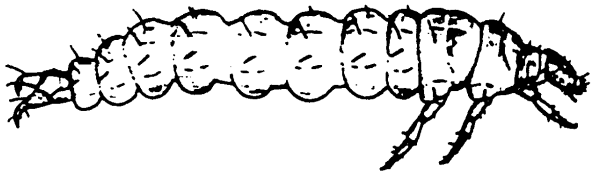
STONEFLIES

Stonefly nymphs are mostly limited to cool, well-oxygenated streams. They are sensitive to most of the same pollutants as mayflies except acidity. They are usually much less numerous than mayflies. The presence of even a few stoneflies in a stream suggests that good water quality has been maintained for several months.



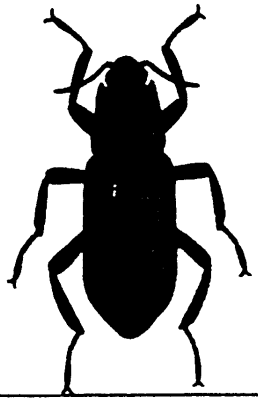
CADDISFLIES

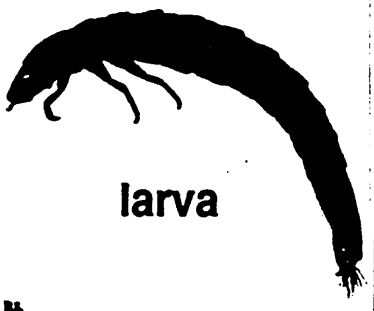
Caddisfly larvae often build a portable case of sand, stones, sticks, or other debris. Many caddisfly larvae are sensitive to pollution, although a few are tolerant. One family spins nets to catch drifting plankton, and is often numerous in recovery zones below sewage discharges.



BEETLES

The most common beetles in streams are riffle beetles and water pennies. Most of these require a swift current and an adequate supply of oxygen, and are generally considered clean-water indicators.





larva

adult

Illustrations by Arwin Provonsha
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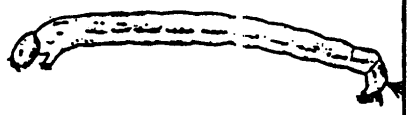
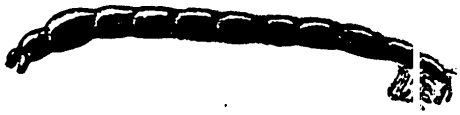
AQUATIC MACROINVERTEBRATES THAT USUALLY INDICATE POOR WATER QUALITY

MIDGES

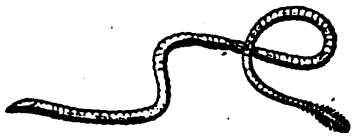
Midges are the most common aquatic flies. The larvae occur in almost any aquatic situation. Many species are very tolerant to pollution; most of these are red and are called "bloodworms". Other species filter suspended food particles, and are numerous in sewage recovery zones.

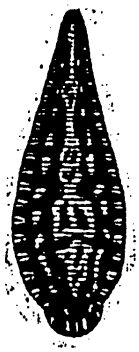




WORMS

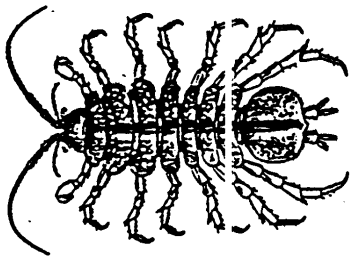
The segmented worms include the leeches and the small aquatic earthworms. The latter are more common, though usually unnoticed. They burrow in the substrate and feed on bacteria in the sediment. They can thrive under conditions of severe pollution and very low oxygen levels, and are thus valuable pollution indicators. Many leeches are also tolerant of poor water quality.





SOWBUGS

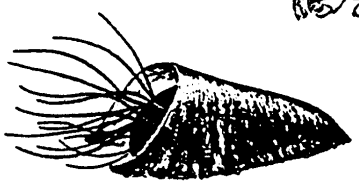
Aquatic sowbugs are crustaceans that are often numerous in situations of high organic content and low oxygen levels. When numerous they can indicate a stream segment in the recovery stage of sewage pollution.



BLACK FLIES

Black fly larvae have specialized structures for filtering plankton and bacteria from the water, and require a strong current. Some species are numerous in the decomposition and recovery zones of sewage pollution, while others are intolerant of pollutants.

larva



pupa

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APPENDIX VIII. THE RATIONALE OF BIOLOGICAL MONITORING

Biological monitoring as applied here refers to the use of resident benthic macroinvertebrate communities as indicators of water quality. Macroinvertebrates are larger-than-microscopic invertebrate animals that inhabit aquatic habitats; freshwater forms are primarily aquatic insects, worms, clams, snails, and crustaceans.

Concept

Nearly all streams are inhabited by a community of benthic macroinvertebrates. The species comprising the community each occupy a distinct niche defined and limited by a set of environmental requirements. The composition of the macroinvertebrate community is thus determined by many factors, including habitat, food source, flow regime, temperature, and water quality. The community is presumed to be controlled primarily by water quality if the other factors are determined to be constant or optimal. Community components which can change with water quality include species richness, diversity, balance, abundance, and presence/absence of tolerant or intolerant species. Various indices or metrics are used to measure these community changes. Assessments of water quality are based on metric values of the community, compared to expected metric values.

Advantages

The primary advantages to using macroinvertebrates as water quality indicators are:

1) they are sensitive to environmental impacts
2) they are less mobile than fish, and thus cannot avoid discharges
3) they can indicate effects of spills, intermittent discharges, and lapses in treatment
4) they are indicators of overall, integrated water quality, including synergistic effects and substances lower than detectable limits
5) they are abundant in most streams and are relatively easy and inexpensive to sample
6) they are able to detect non-chemical impacts to the habitat, e.g. siltation or thermal changes
7) they are vital components of the aquatic ecosystem and important as a food source for fish
8) they are more readily perceived by the public as tangible indicators of water quality
9) they can often provide an on-site estimate of water quality
10) they can often be used to identify specific stresses or sources of impairment
11) they can be preserved and archived for decades, allowing for direct comparison of specimens
12) they bioaccumulate many contaminants, so that analysis of their tissues is a good monitor of toxic substances in the aquatic food chain

Limitations

Biological monitoring is not intended to replace chemical sampling, toxicity testing, or fish surveys. Each of these measurements provides information not contained in the others. Similarly, assessments based on biological sampling should not be taken as being representative of chemical sampling. Some substances may be present in levels exceeding ambient water quality criteria, yet have no apparent adverse community impact.

APPENDIX IX. GLOSSARY

assessment: a diagnosis or evaluation of water quality

benthos: organisms occurring on or in the bottom substrate of a waterbody

biomonitoring: the use of biological indicators to measure water quality

community: a group of populations of organisms interacting in a habitat

drainage basin: an area in which all water drains to a particular waterbody; watershed

EPT value: the number of species of mayflies, stoneflies, and caddisflies in a sample

facultative: occurring over a wide range of water quality; neither tolerant nor intolerant of poor water quality

fauna: the animal life of a particular habitat

impact: a change in the physical, chemical, or biological condition of a waterbody

impairment: a detrimental effect caused by an impact

index: a number, metric, or parameter derived from sample data used as a measure of water quality

intolerant: unable to survive poor water quality

macroinvertebrate: a larger-than-microscopic invertebrate animal that lives at least part of its life in aquatic habitats

multiplate: multiple-plate sampler, a type of artificial substrate sampler of aquatic macroinvertebrates

organism: a living individual

rapid bioassessment: a biological diagnosis of water quality using field and laboratory analysis designed to allow assessment of water quality in a short turn-around time; usually involves kick sampling and laboratory subsampling of the sample

riffle: wadeable stretch of stream usually with a rubble bottom and sufficient current to have the water surface broken by the flow; rapids

species richness: the number of macroinvertebrate species in a sample or subsample

station: a sampling site on a waterbody

survey: a set of samplings conducted in succession along a stretch of stream

tolerant: able to survive poor water quality

APPENDIX X. METHODS FOR IMPACT SOURCE DETERMINATION

Definition Impact Source Determination (ISD) is the procedure for identifying types of impacts that exert deleterious effects on a waterbody. While the analysis of benthic macroinvertebrate communities has been shown to be an effective means of determining severity of water quality impacts, it has been less effective in determining what kind of pollution is causing the impact. Impact Source Determination uses community types or models to ascertain the primary factor influencing the fauna.

Development of methods The method found to be most useful in differentiating impacts in New York State streams was the use of community types, based on composition by family and genus. It may be seen as an elaboration of Percent Model Affinity (Novak and Bode, 1992), which is based on class and order. A large database of macroinvertebrate data was required to develop ISD methods. The database included several sites known or presumed to be impacted by specific impact types. The impact types were mostly known by chemical data or land use. These sites were grouped into the following general categories: agricultural nonpoint, toxic-stressed, sewage (domestic municipal), sewage/toxic, siltation, impoundment, and natural. Each group initially contained 20 sites. Cluster analysis was then performed within each group, using percent similarity at the family or genus level. Within each group four clusters were identified, each cluster usually composed of 4-5 sites with high biological similarity. From each cluster a hypothetical model was then formed to represent a model cluster community type; sites within the cluster had at least 50 percent similarity to this model. These community type models formed the basis for Impact Source Determination (see tables following). The method was tested by calculating percent similarity to all the models, and determining which model was the most similar to the test site. Some models were initially adjusted to achieve maximum representation of the impact type. New models are developed when similar communities are recognized from several streams.

Use of the ISD methods Impact Source Determination is based on similarity to existing models of community types (see tables following). The model that exhibits the highest similarity to the test data denotes the likely impact source type, or may indicate "natural", lacking an impact. In the graphic representation of ISD, only the highest similarity of each source type is identified. If no model exhibits a similarity to the test data of greater than 50%, the determination is inconclusive. The determination of impact source type is used in conjunction with assessment of severity of water quality impact to provide an overall assessment of water quality.

Limitations These methods were developed for data derived from 100-organism subsamples of traveling kick samples from riffles of New York State streams. Application of the methods for data derived from other sampling methods, habitats, or geographical areas would likely require modification of the models.

NATURAL

	A	B	C	D	E	F	G	H	I	J	K	L	M
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	-	-	5	-	5	-	5	5	-	-	-	5	5
HIRUDINEA	-	-	-	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
ASELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
GAMMARIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
Isonychia	5	5	-	5	20	-	-	-	-	-	-	-	-
BAETIDAE	20	10	10	10	10	5	10	10	10	10	5	15	40
HEPTAGENIIDAE	5	10	5	20	10	5	5	5	5	10	10	5	5
LEPTOPHLEBIIDAE	5	5	-	-	-	-	-	-	5	-	-	25	5
EPHEMERELLIDAE	5	5	5	10	-	10	10	30	-	5	-	10	5
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	5	5	-	5	5	15	5	5	5	5
Psephenus	5	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus	5	-	20	5	5	-	5	5	5	5	-	-	-
Promoresia	5	-	-	-	-	-	25	-	-	-	-	-	-
Stenelmis	10	5	10	10	5	-	-	-	10	-	-	-	5
PHILOPOTAMIDAE	5	20	5	5	5	5	5	-	5	5	5	5	5
HYDROPSYCHIDAE	10	5	15	15	10	10	5	5	10	15	5	5	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	5	5	-	-	-	20	-	5	5	5	5	5	-
SIMULIIDAE	-	-	-	5	5	-	-	-	-	5	-	-	-
Simulium vittatum	-	-	-	-	-	-	-	-	-	-	-	-	-
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
TIPULIDAE	-	-	-	-	-	-	-	-	5	-	-	-	-
CHIRONOMIDAE													
Tanypodinae	-	5	-	-	-	-	-	-	5	-	-	-	-
Diamesinae	-	-	-	-	-	-	5	-	-	-	-	-	-
Cardiocladius	-	5	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	5	5	-	-	10	-	-	5	-	-	5	5	5
Eukiefferiella/ Tvetenia	5	5	10	-	-	5	5	5	-	5	-	5	5
Parametriocnemus	-	-	-	-	-	-	-	5	-	-	-	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	20	-	-	10	20	20	5	-
Polypedilum (all others)	5	5	5	5	5	-	5	5	-	-	-	-	-
Tanytarsini	-	5	10	5	5	20	10	10	10	10	40	5	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100

NONPOINT NUTRIENTS, PESTICIDES

	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	-	-	-	5	-	-	-	-	-	15
HIRUDINEA	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	5	-	-	-	-	-	-
ASELLIDAE	-	-	-	-	-	-	-	-	-	-
GAMMARIDAE	-	-	-	5	-	-	-	-	-	-
Isonychia	-	-	-	-	-	-	-	5	-	-
BAETIDAE	5	15	20	5	20	10	10	5	10	5
HEPTAGENIIDAE	-	-	-	-	5	5	5	5	-	5
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	5	-	-
Caenis/Tricorythodes	-	-	-	-	5	-	-	5	-	5
PLECOPTERA	-	-	-	-	-	-	-	-	-	-
Psephenus	5	-	-	5	-	5	5	-	-	-
Optioservus	10	-	-	5	-	-	15	5	-	5
Promoresia	-	-	-	-	-	-	-	-	-	-
Stenelmis	15	15	-	10	15	5	25	5	10	5
PHILOPOTAMIDAE	15	5	10	5	-	25	5	-	-	-
HYDROPSYCHIDAE	15	15	15	25	10	35	20	45	20	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	5	-	15	5	5	-	-	-	40	-
Simulium vittatum	-	-	-	-	-	-	-	-	5	-
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-
TIPULIDAE	-	-	-	-	-	-	-	-	-	5
CHIRONOMIDAE										
Tanypodinae	-	-	-	-	-	-	5	-	-	5
Cardiocladius	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	10	15	10	5	-	-	-	-	5	5
Eukiefferiella/ Tvetenia	-	15	10	5	-	-	-	-	5	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-
Microtendipes	-	-	-	-	-	-	-	-	-	20
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	10	20	10	5	10	5	5
Tanytarsini	10	10	10	5	20	5	5	10	-	10
TOTAL	100	100	100	100	100	100	100	100	100	100

	TOXIC					
	A	B	C	D	E	F
PLATYHELMINTHES	-	-	-	-	5	-
OLIGOCHAETA	-	10	20	5	5	15
HIRUDINEA	-	-	-	-	-	-
GASTROPODA	-	5	-	-	-	5
SPHAERIIDAE	-	-	-	-	-	-
ASELLIDAE	10	10	-	20	10	5
GAMMARIDAE	5	-	-	-	5	5
Isonychia	-	-	-	-	-	-
BAETIDAE	15	10	20	-	-	5
HEPTAGENIIDAE	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-
Caenis/Tricorythodes	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-
Promoresia	-	-	-	-	-	-
Stenelmis	10	15	-	40	35	5
PHILOPOTAMIDAE	10	-	-	-	-	-
HYDROPSYCHIDAE	20	10	15	10	35	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-
Simulium vittatum	-	20	-	-	-	5
EMPIDIDAE	-	-	-	-	-	-
CHIRONOMIDAE						
Tanypodinae	5	10	-	-	-	25
Cardiocladius	-	-	-	-	-	-
Cricotopus/ Orthocladius	15	10	25	10	5	10
Eukiefferiella/ Tvetenia	-	-	20	10	-	-
Parametriocnemus	-	-	-	5	-	-
Chironomus	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-
Polypedilum (all others)	10	-	-	-	-	5
Tanytarsini	-	-	-	-	-	5
TOTAL	100	100	100	100	100	100

SEWAGE EFFLUENT, ANIMAL WASTES

	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	5	35	15	10	10	35	40	10	20	15
HIRUDINEA	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	10	-	-	-	-	-	-
ASELLIDAE	5	10	-	10	10	10	10	50	-	5
GAMMARIDAE	-	-	-	-	-	10	-	10	-	-
Isonychia	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	10	5	-	-	-	-	5	-
HEPTAGENIIDAE	10	10	10	-	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	5	-
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-	-	-	5	-
Promoresia	-	-	-	-	-	-	-	-	-	-
Stenelmis	15	-	10	10	-	-	-	-	-	-
PHILOPOTAMIDAE	-	-	-	-	-	-	-	-	-	-
HYDROPSYCHIDAE	45	-	10	10	10	-	-	10	5	-
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	-	-	-	-
Simulium vittatum	-	-	-	25	10	35	-	-	5	5
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE										
Tanypodinae	-	5	-	-	-	-	-	-	5	5
Cardiocladius	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	-	10	15	-	-	10	10	-	5	5
Eukiefferiella/ Tvetenia	-	-	10	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	10	-	-	60
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	10	60	-	30	10	5	5
Tanytarsini	10	10	10	10	-	-	-	10	40	-
TOTAL	100	100	100	100	100	100	100	100	100	100

MUNICIPAL/INDUSTRIAL

	A	B	C	D	E	F	G
PLATYHELMINTHES	-	40	-	-	-	5	-
OLIGOCHAETA	20	20	70	10	-	20	-
HIRUDINEA	-	5	-	-	-	-	-
GASTROPODA	-	-	-	-	-	5	-
SPHAERIIDAE	-	5	-	-	-	-	-
ASELLIDAE	10	5	10	10	15	5	-
GAMMARIDAE	40	-	-	-	15	-	5
Isonychia	-	-	-	-	-	-	-
BAETIDAE	5	-	-	-	5	-	10
HEPTAGENIIDAE	5	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-
Caenis/Tricorythodes	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-	-
Promoresia	-	-	-	-	-	-	-
Stenelmis	5	-	-	10	5	-	5
PHILOPOTAMIDAE	-	-	-	-	-	-	-
HYDROPSYCHIDAE	10	-	-	50	20	-	40
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	-
Simulium vittatum	-	-	-	-	-	-	20
EMPIDIDAE	-	5	-	-	-	-	-
CHIRONOMIDAE							
Tanypodinae	-	10	-	-	5	15	-
Cardiocladius	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	5	10	20	-	5	10	5
Eukiefferiella/ Tvetenia	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-
Polypedilum (all others)	-	-	-	10	20	40	10
Tanytarsini	-	-	-	10	10	-	5
TOTAL	100	100	100	100	100	100	100

	SILTATION					IMPOUNDMENT									
	A	B	C	D	E	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	10	-	10	-	5	-	50	10	-
OLIGOCHAETA	5	-	20	10	5	5	-	40	5	10	5	10	5	5	-
HIRUDINEA	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	10	-	5	5	-	-	-	-
SPHAERIIDAE	-	-	-	5	-	-	-	-	-	-	-	-	5	25	-
ASELLIDAE	-	-	-	-	-	-	5	5	-	10	5	5	5	-	-
GAMMARIDAE	-	-	-	10	-	-	-	10	-	10	50	-	5	10	-
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	20	5	-	-	5	-	5	-	-	5	-	-	5
HEPTAGENIIDAE	5	10	-	20	5	5	5	-	5	5	5	5	-	5	5
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenis/Tricorythodes	5	20	10	5	15	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Optioservus	5	10	-	-	-	-	-	-	-	-	-	-	-	5	-
Promoresia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenelmis	5	10	10	5	20	5	5	10	10	-	5	35	-	5	10
PHILOPOTAMIDAE	-	-	-	-	-	5	-	-	5	-	-	-	-	-	30
HYDROPSYCHIDAE	25	10	-	20	30	50	15	10	10	10	10	20	5	15	20
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
SIMULIIDAE	5	10	-	-	5	5	-	5	-	35	10	5	-	-	15
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE															
Tanypodinae	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Cardiocladius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	25	-	10	5	5	5	25	5	-	10	-	5	10	-	-
Eukiefferiella/ Tvetenia	-	-	10	-	5	5	15	-	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	5	5	5	-	-	20	-	-	5	5	5	5
Tanytarsini	10	10	10	10	5	5	10	5	30	-	-	5	10	10	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

APPENDIX XI. METHODS FOR ASSESSMENT OF WATER QUALITY USING FISH

A. Sampling

Sampling in wadeable streams consists of electrofishing for approximately 20 minutes, attempting to sample one pool and one riffle. A backpack electroshocker is used. All fish are identified and enumerated at the site and released.

B. Analysis of data.

Methods for interpretation of fish data with regard to water quality have not yet been standardized for northeastern streams. Three indices are presently used to assess water quality.

1. Species richness, weighted. Species richness is weighted by stream size using the following provisional formula: for stream width 1-4 meters, value= x+2, where x= richness; for 5-9 meters, x; for 10-19 meters, x-2; for >20 meters; x-4.

2. Percent Non-tolerant Individuals. This is the percentage of the total individuals that are species considered intolerant or intermediate to environmental perturbations; this measure is the inverse of percent tolerant individuals. Tolerance is based on listing in EPA's Rapid Bioassessment Protocols (Plafkin et al., 1989) with the exception of Blacknose Dace, which are here considered intermediate rather than tolerant.

3. Percent Model Affinity, by trophic class. This is the highest percentage similarity to any of five models of non-impacted fish communities, by trophic class. The models are:

	A	B	C	D	E
Top carnivores	80	50	40	10	10
Insectivores	10	30	20	20	50
Blacknose dace	-	10	-	50	10
Generalist feeders	10	10	40	20	20
Herbivores	-	-	-	-	10

Trophic class for each species is listed in Halliwell et al. (1999).

The overall assessment of water quality is assigned by the profile value. This value = (weighted richness value + 0.1[% non-tolerant individuals] + 0.1[Percent model affinity]) /3

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Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. U.S. EPA Office of Water.