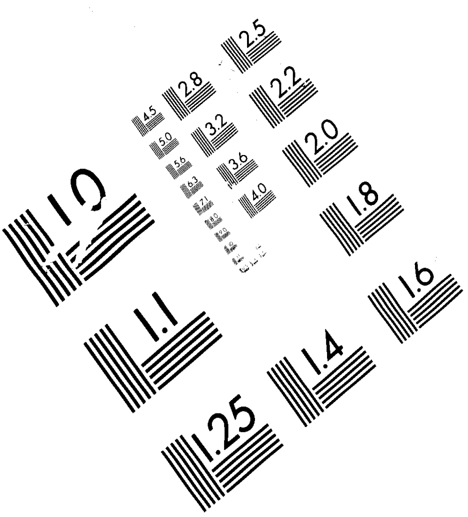

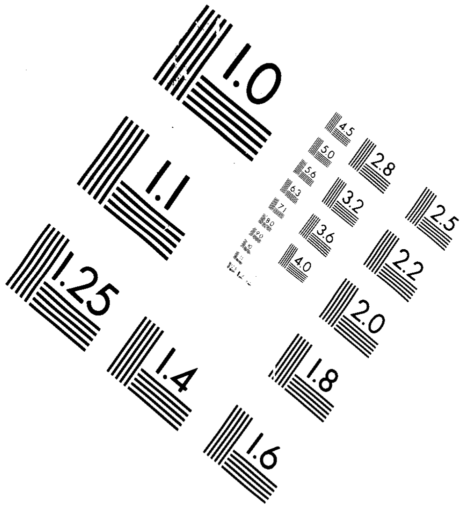

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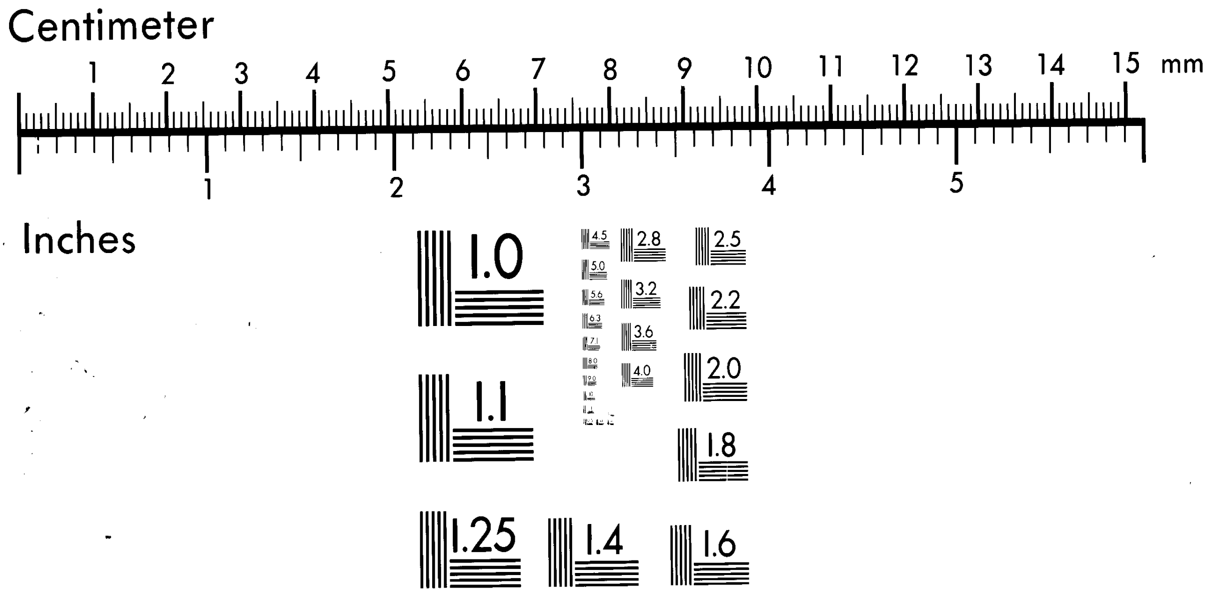
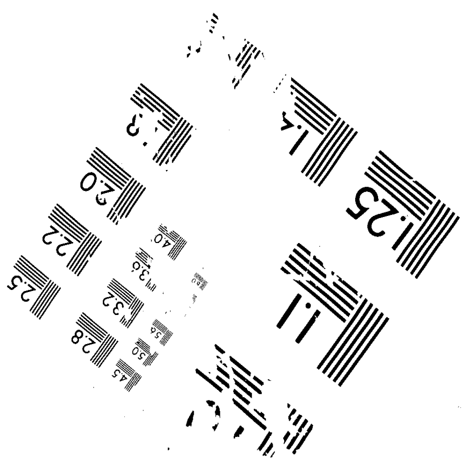
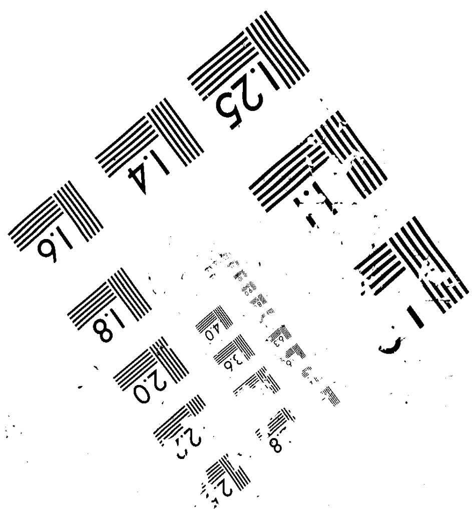






1 of 1

New York State
Department of Environmental Conservation

Division of Water

Ramapo River

Biological Assessment

1998 Survey

GEORGE E. PATAKI, *Governor*

JOHN P. CAHILL, *Commissioner*

BIOLOGICAL STREAM ASSESSMENT

Ramapo River
Orange and Rockland Counties, New York

Survey date: August 25, 1998
Report date: September 25, 1998

Robert W. Bode
Margaret A. Novak
Lawrence E. Abele

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

Stream: Ramapo River, Orange and Rockland Counties, New York

Reach: Harriman to Hillburn, New York

Background:

The Stream Biomonitoring Unit conducted biological sampling on the Ramapo River on August 25, 1998. The purpose of the sampling was to assess water quality in relation to the discharge of the Orange County Sewer District #1, compare to results of previous surveys, and determine possible effects of additional loadings. Traveling kick samples were taken in riffle areas at five 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 2 provides a listing of sampling sites, and Table 3 provides a listing of all macroinvertebrate species collected in the present survey. This is followed by site collection pages, which include the raw invertebrate data from each site and descriptions of each site.

Results and Conclusions:

1. Water quality in the Ramapo River ranged from slightly impacted to moderately impacted. Upstream of Harriman, the river continues to be moderately impacted, likely by urban runoff from Monroe. The Orange County Sewer District # 1 discharge has a very minor and short-lived impact on the river's water quality. Downstream of Harriman, water quality in the river improved steadily downstream to Hillburn. Present conditions are very similar to those documented in 1993.

2. Based on the resident biota found in the present survey, it is predicted that sewage loadings exceeding the plant capacity that result in a poorly treated effluent could have substantial deleterious impact on the water quality of the river downstream.

Discussion:

The Ramapo River was previously sampled by the Stream Biomonitoring Unit in 1986, 1991, and 1993 (Bode et al., 1986, 1991; Novak et al., 1993). These samplings documented successive improvement in water quality following expansion in treatment capacity at the Orange County Sewer District # 1 (OCSD). The plant capacity was increased from 2 to 4 mgd in 1987, although it was still exceeding permit limits at the time of the 1991 sampling. Results of the present sampling, when compared to previous results, show that current water quality is very similar to that found in 1993 (Figure 2). The OCSD discharge currently has a minor and short-lived impact on the river's water quality.

In the present survey, Stations 1 and 2 were not sampled because they were considered to be primarily influenced by the outflow of the impoundment just upstream of the discharge point. Station 4, for which no satisfactory sample was obtained in 1993, was sampled at a slightly different location in the present survey. Station 5 was slow-moving and appeared impounded in the present survey, and no suitable riffle was found to sample. Stations 0, 3, 6, and 7 remain the same as in previous surveys.

A continuing water quality problem in the Ramapo River is the impact documented at the most upstream site (Station 0) in Harriman. The problem constitutes moderate impact, likely caused by multiple municipal/industrial sources. These could include urban runoff from Monroe, golf course runoff, and point sources upstream. As shown by Impact Source Determination (Table 1), the municipal/industrial effects persist from Harriman to Arden. Effects of the OCSD discharge are seen at Station 3, but these effects appear minor and short-lived. The river from Tuxedo Park to Hillburn appears primarily influenced by siltation and nutrient enrichment.

Results from the 1986-1998 samplings of the Ramapo River can be used to predict consequences of additional sewage loadings to the river. The 1986 and 1991 samplings documented impacts occurring under a "Scenario 1" condition, when the OCSD was operating above capacity and/or discharging poorly-treated effluent. The 1993 and 1998 samplings documented the state of the river under "Scenario 2" conditions, with the OCSD operating within capacity and discharging a well-treated effluent. The difference between the two scenarios is clearly seen in Figure 2. If future loadings exceed the plant capacity, the potential exists for backsliding to a Scenario 1 condition, resulting in severe impacts to the river.

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, Albany, NY. NYS DEC Tech. Report, 89 pp.

Bode, R. W., M.A. Novak, and L.E. Abele. 1991. Rapid biological assessment, Ramapo River. New York State Department of Environmental Conservation, Albany, NY. NYS DEC Tech. Report, 25 pp.

Bode, R. W., M.A. Novak, and L.E. Abele. 1986. Rapid biological assessment, Ramapo River. New York State Department of Environmental Conservation, Albany, NY. NYS DEC Tech. Report, 12 pp.

Novak, M.A., R.W. Bode, and L.E. Abele. 1993. Biological stream assessment, Ramapo River. New York State Department of Environmental Conservation, Albany, NY. NYS DEC Tech. Report, 30 pp.

Figure 1. Biological Assessment Profile of index values, Ramapo River, 1998. 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.

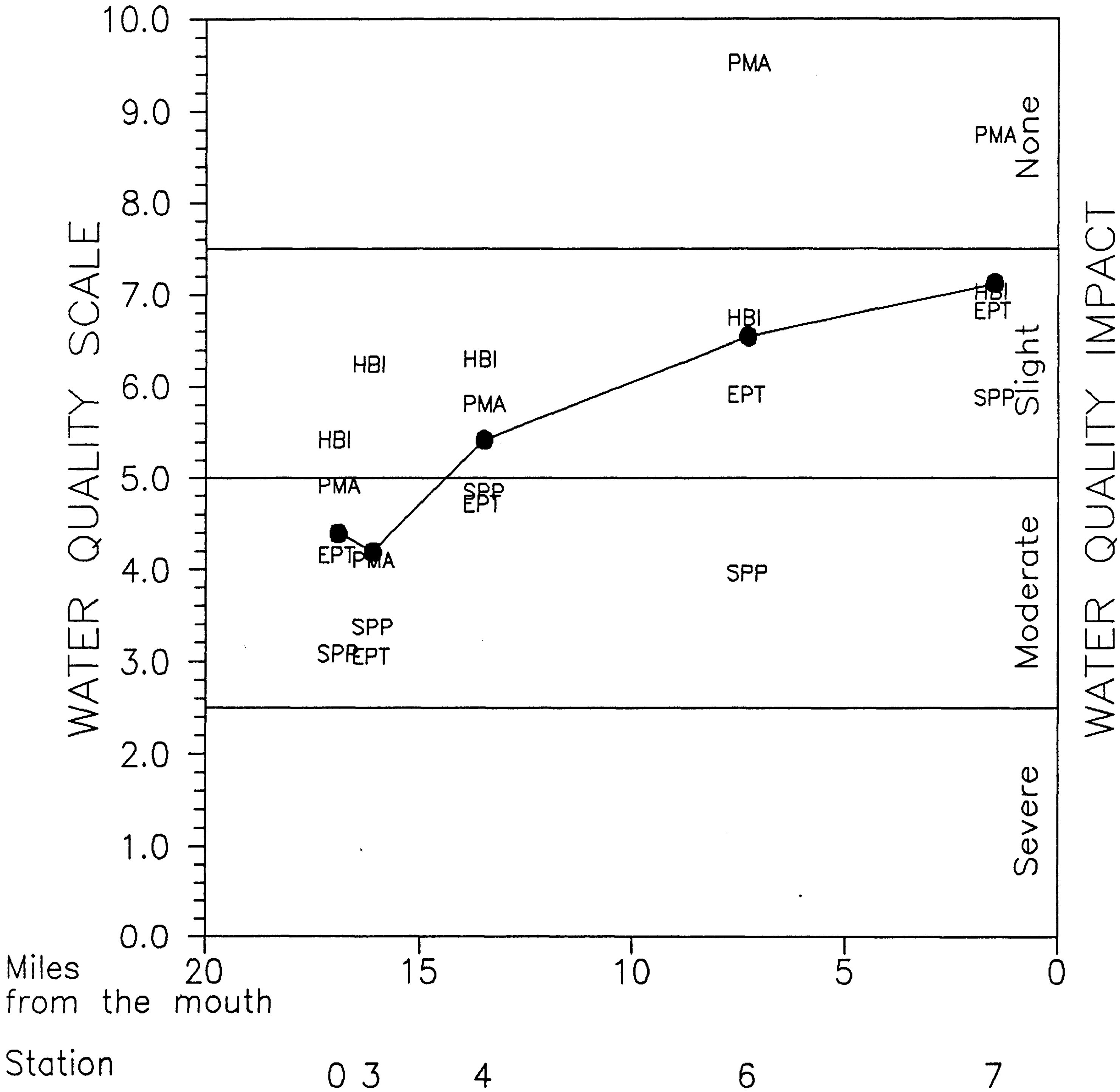


Figure 2. Biological Assessment Profile of index values, Ramapo River, 1986, 1991, 1993, and 1998. The line for each year represents the mean of the four values for each site, plotted on a normalized scale of water quality. See Appendix IV for more complete explanation.

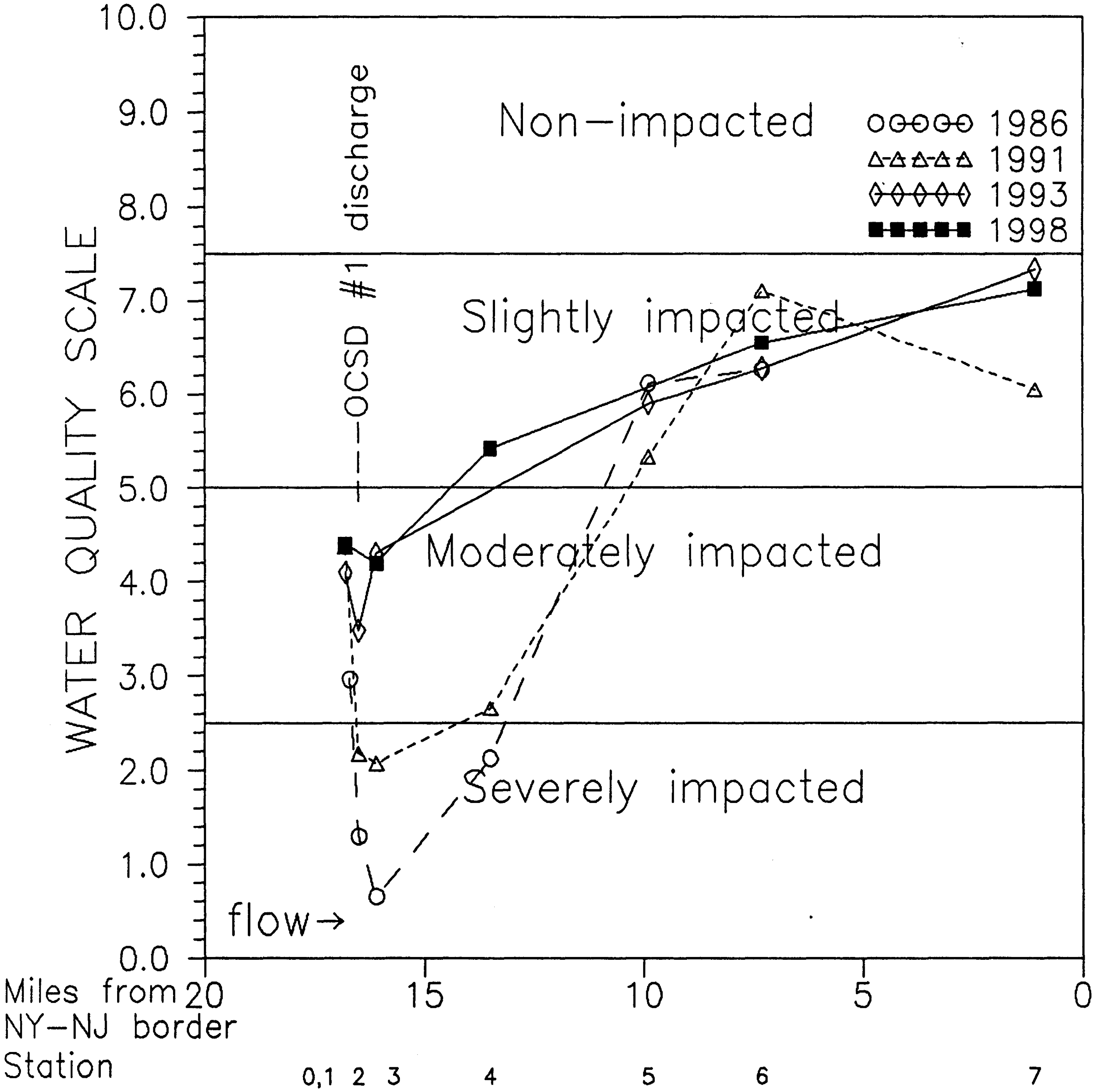


Table 1. Impact Source Determination, Ramapo River, 1998. Numbers represent similarity to community type models for each impact category. The highest similarity at each station is highlighted. Similarities less than 50% are less conclusive. See Appendix X for more complete explanation of ISD.

	STATION				
Community Type	RAMA-0	RAMA-3	RAMA-4	RAMA-6	RAMA-7
Natural: minimal human impacts	37	35	41	48	50
Nutrient additions; mostly nonpoint, agricultural	48	62	54	50	57
Toxic: industrial, municipal, or urban run-off	57	54	51	48	47
Organic: sewage effluent, animal wastes	54	74	50	44	37
Complex: municipal/industrial	70	79	58	47	45
Siltation	41	55	47	66	53
Impoundment	32	68	48	40	32

TABLE 2. STATION LOCATIONS FOR THE RAMAPO RIVER, ORANGE AND ROCKLAND COUNTIES, NEW YORK (see map).

STATION	LOCATION
00	Harriman 20 meters below River Rd. bridge 16.8 miles upstream of the NY-NJ border latitude/longitude: 41°18'44"; 74°08'56"
03	Harriman at Nepera plant bridge 16.1 miles upstream of the NY-NJ border latitude/longitude: 41°18'26"; 74°08'13"
04	Arden 0.2 mi south of Arden bridge; end of Water St. 13.3 miles upstream of the NY-NJ border latitude/longitude: 41°16'25"; 74°09'12"
06	Tuxedo Park 100 meters downstream of East Village Rd. 7.3 miles upstream of the NY-NJ border latitude/longitude: 41°11'43"; 74°11'01"
07	Hillburn 50 meters above 4th St. bridge 1.1 miles upstream of the NY-NJ border latitude/longitude: 41°07'30"; 74°09'54"

Figure 3a	Site location map	Ramapo River

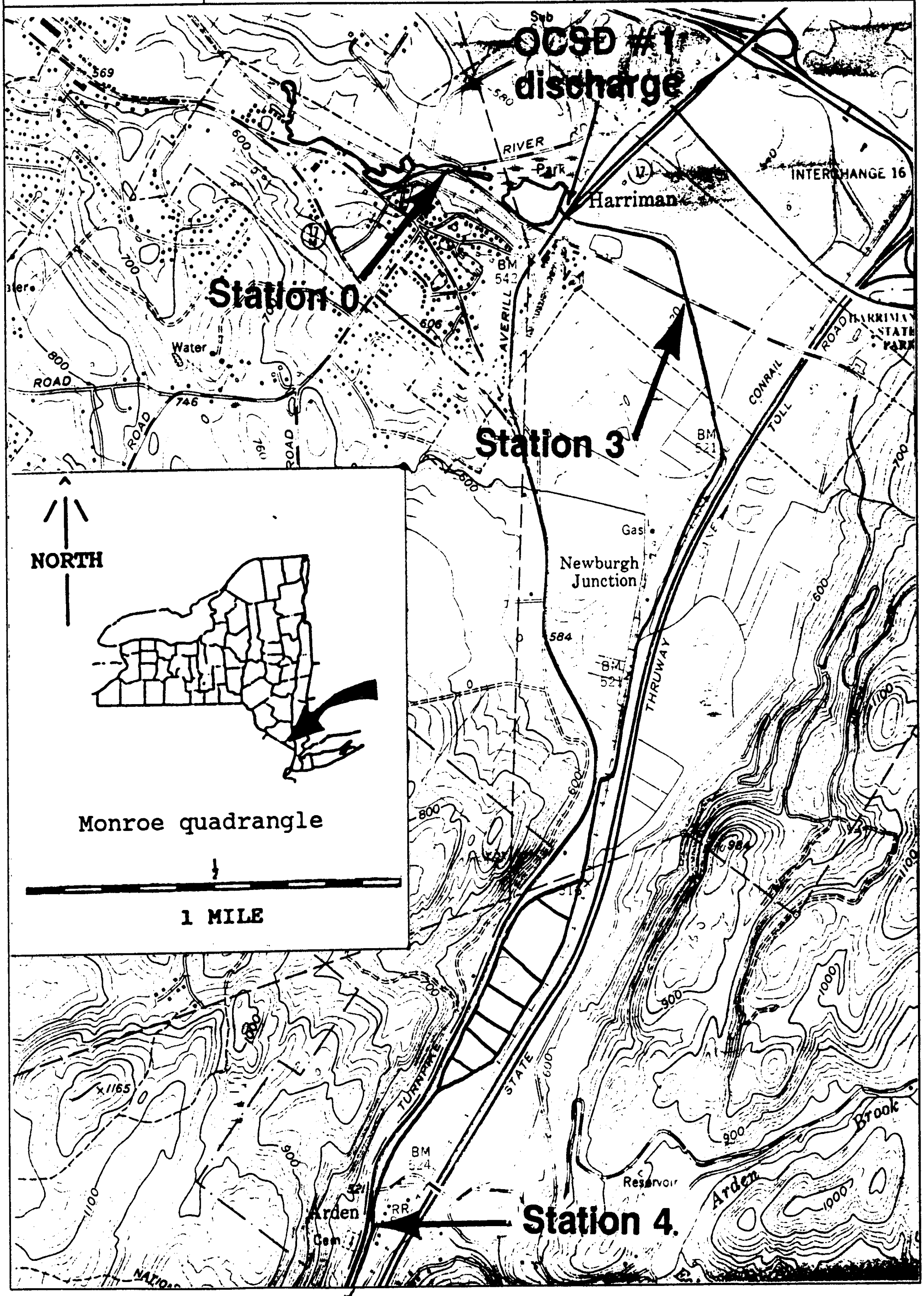


Figure 3b	Site location map	Ramapo River

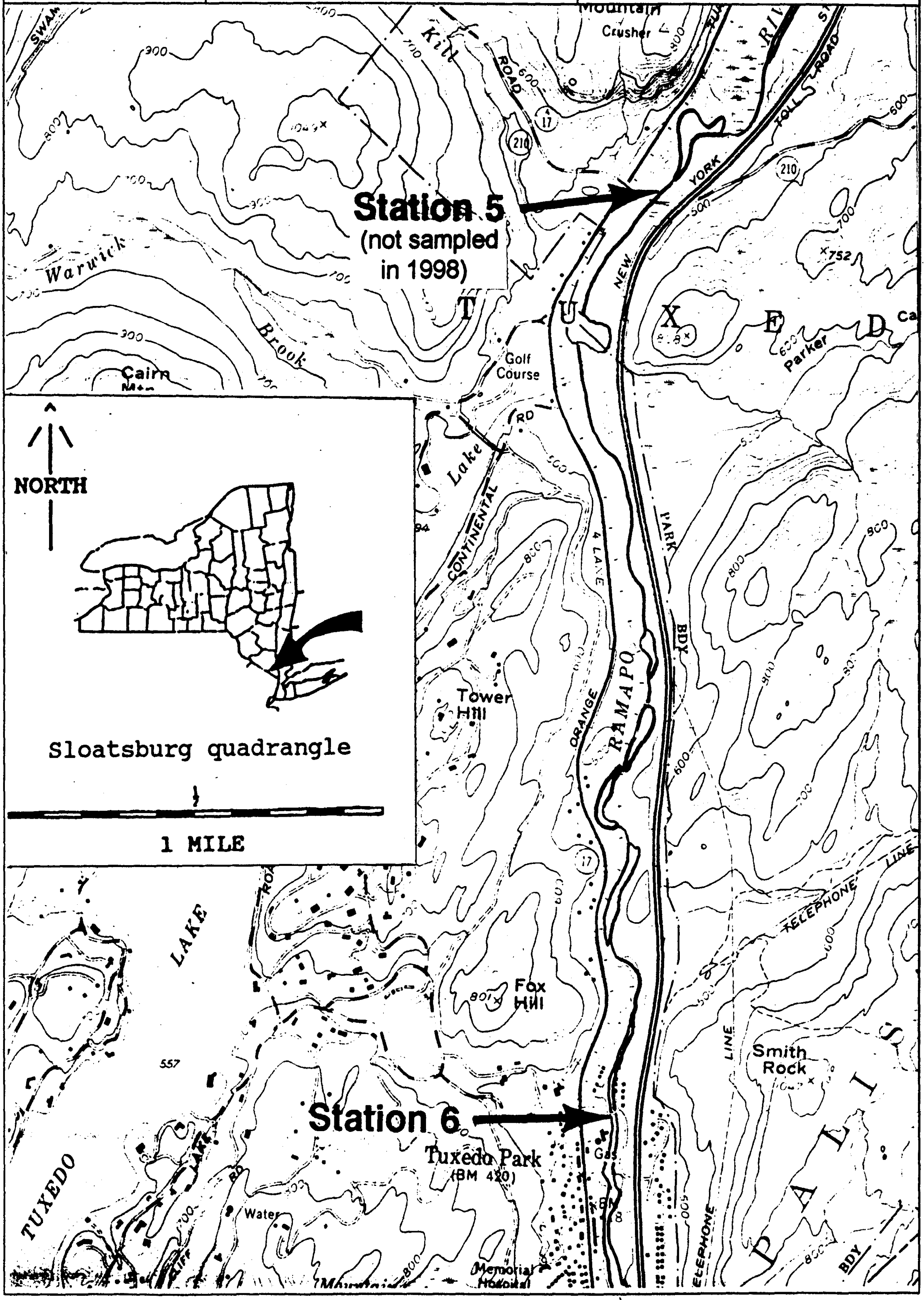


Figure 3c	Site location map	Ramapo River

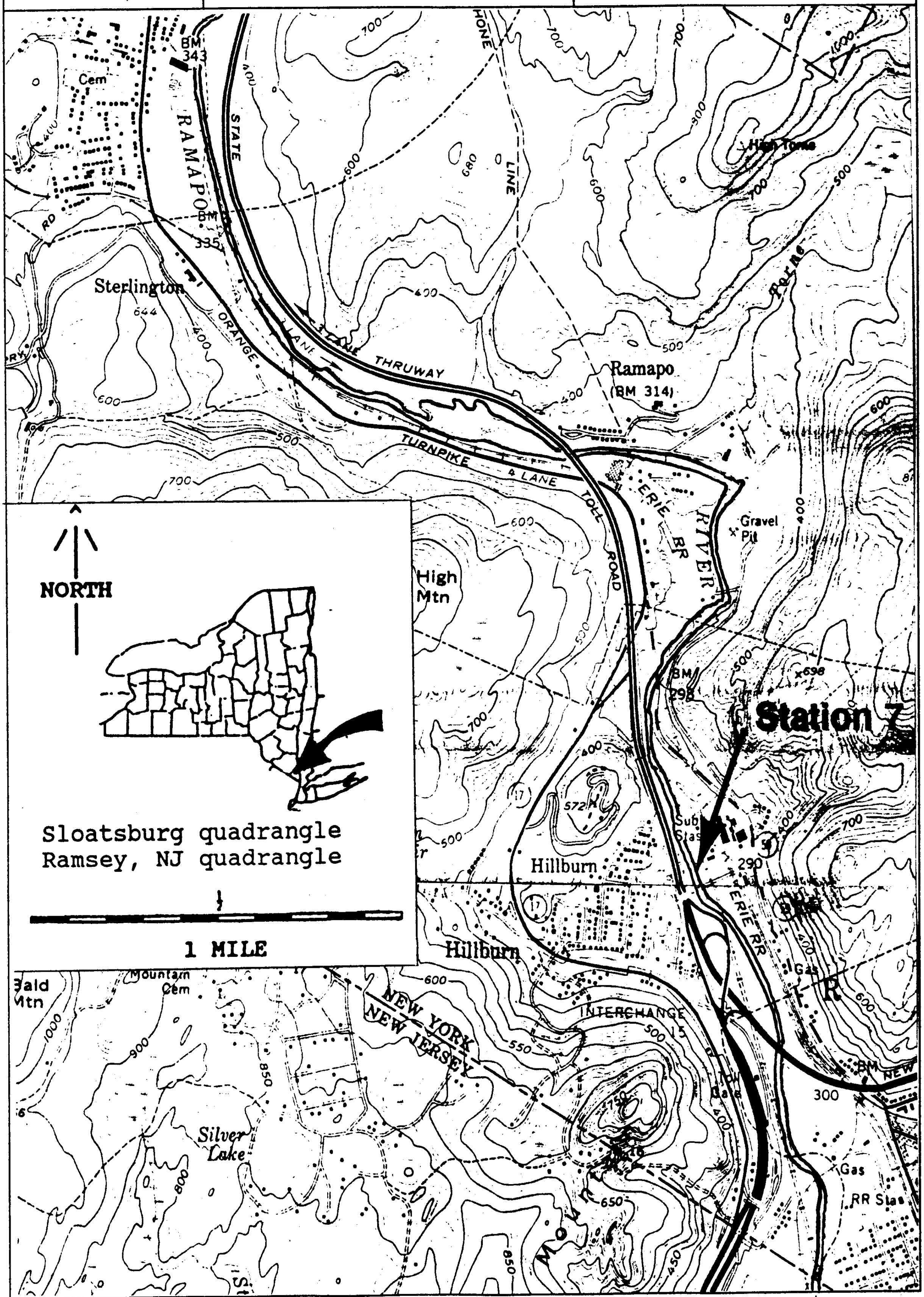


TABLE 3. MACROINVERTEBRATE SPECIES COLLECTED IN THE RAMAPO RIVER, ORANGE AND ROCKLAND COUNTIES, NEW YORK, AUGUST 25, 1998.

PLATYHELMINTHES
- TURBELLARIA
  - Undetermined Turbellaria

ANNELIDA
- OLIGOCHAETA
  - Tubificidae
    - Undet. Tubificidae w/o cap. setae

MOLLUSCA
- PELECYPODA
  - Sphaeriidae
    - Undetermined Sphaeriidae

ARTHROPODA
- CRUSTACEA
  - ISOPODA
    - Asellidae
      - Caecidotea communis
  - AMPHIPODA
    - Gammaridae
      - Gammarus sp.
  - DECAPODA
    - Cambaridae
      - Orconectes rusticus
- INSECTA
  - EPHEMEROPTERA
    - Isonychiidae
      - Isonychia bicolor
    - Baetidae
      - Baetis flavistriga
      - Baetis sp.
    - Heptageniidae
      - Leucrocuta sp.
      - Undetermined Heptageniidae
    - Caenidae
      - Caenis anceps
  - COLEOPTERA
    - Elmidae
      - Microcylloepus pusillus
      - Optioservus trivittatus
      - Stenelmis crenata
      - Stenelmis sp.
  - MEGALOPTERA
    - Corydalidae
      - Corydalus cornutus
  - NEUROPTERA
    - Sisyridae
      - Climacia sp.
  - TRICHOPTERA
    - Philopotamidae
      - Chimarra sp.
    - Hydropsychidae
      - Cheumatopsyche sp.
      - Hydropsyche betteni
      - Hydropsyche bronta
      - Hydropsyche sp.
    - Hydroptilidae
      - Leucotrichia sp.
  - DIPTERA
    - Tipulidae
      - Antocha sp.
    - Simuliidae
      - Simulium venustum
      - Simulium vittatum
      - Simulium sp.
    - Empididae
      - Hemerodromia sp.
    - Muscidae
      - Undetermined Muscidae
    - Chironomidae
      - Tanypodinae
        - Thienemannimyia gr. spp.
      - Orthocladiinae
        - Cardiocladius obscurus
        - Cricotopus bicinctus
        - Eukiefferiella claripennis gr.
        - Nanocladius distinctus
        - Parametriocnemus lundbecki
        - Rheocricotopus robacki
        - Tvetenia bavarica gr.
      - Chironominae
        - Chironomini
          - Polypedilum convictum
          - Polypedilum illinoense
        - Tanytarsini
          - Rheotanytarsus exiguus gr.
          - Tanytarsus guerlus gr.

STREAM SITE:	Ramapo River, Station 0
LOCATION:	Harriman, New York, below River Road bridge
DATE:	August 25, 1998
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ANNELIDA			
OLIGOCHAETA	Tubificidae	Undet. Tubificidae w/o cap. setae	2
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	Caecidotea communis	22
AMPHIPODA	Gammaridae	Gammarus sp.	16
DECAPODA	Cambaridae	Orconectes rusticus	11
INSECTA			
EPHEMEROPTERA	Baetidae	Baetis flavistriga	3
COLEOPTERA	Elmidae	Stenelmis crenata	8
TRICHOPTERA	Philopotamidae	Chimarra sp.	4
	Hydropsychidae	Cheumatopsyche sp.	14
		Hydropsyche betteni	2
DIPTERA	Empididae	Hemerodromia sp.	2
	Chironomidae	Thienemannimyia gr. spp.	1
		Polypedilum convictum	15

SPECIES RICHNESS	12 (fair)
BIOTIC INDEX	6.16 (good)
EPT RICHNESS	4 (fair)
MODEL AFFINITY	49 (fair)
ASSESSMENT	moderately impacted

DESCRIPTION The kick sample was taken 20 meters downstream of the River Road bridge in Harriman, at the Mary Harriman Park. The sample had low invertebrate biomass, and appeared dominated by crayfish, riffle beetles, scuds, sowbugs, caddisflies, and midges. Water quality was clearly moderately impacted, based on both the field assessment and the indices.

STREAM SITE:	Ramapo River, Station 3
LOCATION:	Harriman, New York, at Nepera plant bridge
DATE:	August 25, 1998
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

MOLLUSCA			
PELECYPODA	Sphaeriidae	Undetermined Sphaeriidae	7
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	Caecidotea communis	7
INSECTA			
COLEOPTERA	Elmidae	Stenelmis crenata	12
TRICHOPTERA	Hydropsychidae	Cheumatopsyche sp.	54
		Hydropsyche betteni	1
DIPTERA	Simuliidae	Simulium vittatum	3
	Empididae	Hemerodromia sp.	1
	Muscidae	Undetermined Muscidae	1
	Chironomidae	Cardiocladius obscurus	1
		Nanocladius distinctus	1
		Polypedilum convictum	6
		Rheotanytarsus exiguus gr.	4
		Tanytarsus guerlus gr.	2

SPECIES RICHNESS	13 (fair)
BIOTIC INDEX	5.51 (good)
EPT RICHNESS	2 (fair)
MODEL AFFINITY	44 (fair)
ASSESSMENT	moderately impacted

DESCRIPTION The only suitable riffle was under and downstream of the Nepera Road bridge. Compared to Station 0, the dissolved oxygen level had dropped and specific conductance had increased. The invertebrate fauna appeared dominated by caddisflies and crayfish. Water quality was assessed as moderately impacted, as at Station 0.

STREAM SITE:	Ramapo River, Station 4
LOCATION:	Arden, New York, 0.2 miles south of Arden bridge, end of Water St.
DATE:	August 25, 1998
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

MOLLUSCA			
PELECYPODA	Sphaeriidae	Undetermined Sphaeriidae	2
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	1
	Baetidae	Baetis flavistriga	4
		Baetis sp.	2
COLEOPTERA	Elmidae	Microcylloepus pusillus	1
		Stenelmis crenata	14
MEGALOPTERA	Corydalidae	Corydalus cornutus	2
TRICHOPTERA	Hydropsychidae	Cheumatopsyche sp.	22
		Hydropsyche betteni	1
DIPTERA	Simuliidae	Simulium venustum	1
		Simulium vittatum	1
	Empididae	Hemerodromia sp.	1
	Chironomidae	Cricotopus bicinctus	6
		Parametriocnemus lundbecki	1
		Tvetenia bavarica gr.	2
		Polypedilum convictum	36
		Rheotanytarsus exiguus gr.	2
		Tanytarsus guerlus gr.	1

SPECIES RICHNESS	18 (fair)
BIOTIC INDEX	5.46 (good)
EPT RICHNESS	5 (fair)
MODEL AFFINITY	54 (good)
ASSESSMENT	slightly impacted

DESCRIPTION The sampling site was moved approximately 200 meters downstream of the site used in previous years, because a better riffle was located, at the end of Water Street in Arden, opposite a cemetery. Caddisflies, midges, and crayfish were numerous, as at upstream sites, but mayflies and hellgrammites were present in the sample. Based on the field assessment and the indices, overall water quality was assessed as slightly impacted.

STREAM SITE:	Ramapo River, Station 6
LOCATION:	Tuxedo Park, New York, downstream of East Village Road
DATE:	August 25, 1998
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

MOLLUSCA			
PELECYPODA	Sphaeriidae	Undetermined Sphaeriidae	3
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	8
	Baetidae	Baetis flavistriga	12
	Heptageniidae	Undetermined Heptageniidae	1
	Caenidae	Caenis anceps	26
COLEOPTERA	Elmidae	Stenelmis crenata	7
MEGALOPTERA	Corydalidae	Corydalus cornutus	4
NEUROPTERA	Sisyridae	Climacia sp.	1
TRICHOPTERA	Hydropsychidae	Cheumatopsyche sp.	13
		Hydropsyche sp.	2
	Hydroptilidae	Leucotrichia sp.	3
DIPTERA	Simuliidae	Simulium vittatum	2
	Chironomidae	Thienemannimyia gr. spp.	1
		Polypedilum convictum	11
		Rheotanytarsus exiguus gr.	6

SPECIES RICHNESS	15 (fair)
BIOTIC INDEX	5.10 (good)
EPT RICHNESS	7 (good)
MODEL AFFINITY	85 (excellent)
ASSESSMENT	slightly impacted

DESCRIPTION The riffle sampled at this site had the appearance of a "swimmers' dam", located 100 meters downstream of the East Village Road bridge in Tuxedo Park. The dissolved oxygen level had increased compared to the upstream site. The invertebrate fauna was similar to that found at Station 4, with many mayflies, caddisflies, and hellgrammites. Water quality was clearly in the slightly impacted range.

STREAM SITE:	Ramapo River, Station 7
LOCATION:	Hillburn, New York, above 4th Street bridge
DATE:	August 25, 1998
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

PLATYHELMINTHES			
TURBELLARIA		Undetermined Turbellaria	4
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	8
	Baetidae	Baetis flavistriga	17
		Baetis sp.	5
	Heptageniidae	Leucrocuta sp.	4
	Caenidae	Caenis anceps	7
COLEOPTERA	Elmidae	Optioservus trivittatus	1
		Stenelmis sp.	1
MEGALOPTERA	Corydalidae	Corydalus cornutus	2
TRICHOPTERA	Philopotamidae	Chimarra sp.	2
	Hydropsychidae	Cheumatopsyche sp.	2
		Hydropsyche bronta	21
	Hydroptilidae	Leucotrichia sp.	1
DIPTERA	Tipulidae	Antocha sp.	1
	Simuliidae	Simulium sp.	9
	Chironomidae	Cardiocladius obscurus	2
		Eukiefferiella claripennis gr.	1
		Rheocricotopus robacki	1
		Polypedilum convictum	8
		Polypedilum illinoense	1
		Rheotanytarsus exiguus gr.	2

SPECIES RICHNESS	21 (good)
BIOTIC INDEX	4.88 (good)
EPT RICHNESS	9 (good)
MODEL AFFINITY	77 (excellent)
ASSESSMENT	slightly impacted

DESCRIPTION The sampling location was 50 meters upstream of the 4th Street bridge in Hillburn. This reach was an area of extended riffles, and there was a dam 200 meters above the site. The specific conductance had decreased substantially from upstream levels. The invertebrate fauna appeared improved from Station 6, with the addition of stoneflies and more mayfly species. Water quality however remained within the slightly impacted category.

LABORATORY DATA SUMMARY

STREAM NAME Ramapo River — DRAINAGE 15
DATE SAMPLED 08/25/98 — COUNTY Orange, Rockland
SAMPLING METHOD Traveling kick

STATION		00	03	04	06
LOCATION		Harriman - River Rd.	Harriman - Nepera road	Arden - Water St.	Tuxedo Park E.Vill. Rd.
DOMINANT SPECIES\% CONTRIBUTION\TOLERANCE\COMMON NAME					
Genus and species names are abbreviated here to accommodate format. Complete names are reported elsewhere in this report.	1.	Caecidotea communis 22 tolerant sowbug	Cheumatopsy sp. 54 facultative caddisfly	Polypedilum convict 36 facultative midge	Caenis anceps 26 facultative mayfly
	2.	Gammarus sp. 16 facultative scud	Stenelmis crenata 12 facultative beetle	Cheumatopsy sp. 22 facultative caddisfly	Cheumatopsy sp. 13 facultative caddisfly
Intolerant = not tolerant of poor water quality; Facultative = occurring over a wide range of water quality; Tolerant = tolerant of poor water quality.	3.	Polypedilum convict 15 facultative midge	Undeterm. Sphaeri 7 facultative clam	Stenelmis crenata 14 facultative beetle	Baetis flavistr 12 intolerant mayfly
	4.	Cheumatopsy sp. 14 facultative caddisfly	Caecidotea communis 7 tolerant sowbug	Cricotopus bicinct 6 tolerant midge	Polypedilum convict 11 facultative midge
	5.	Orconectes rusticus 11 facultative crayfish	Polypedilum convict 6 facultative midge	Baetis flavistr 4 intolerant mayfly	Isonychia bicolor 8 intolerant mayfly
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESES)					
Chironomidae (midges)		16 (2)	14 (5)	48 (6)	18 (3)
Trichoptera (caddisflies)		20 (3)	55 (2)	23 (2)	18 (3)
Ephemeroptera (mayflies)		3 (1)	0 (0)	7 (3)	47 (4)
Plecoptera (stoneflies)		0 (0)	0 (0)	0 (0)	0 (0)
Coleoptera (beetles)		8 (1)	12 (1)	15 (2)	7 (1)
Oligochaeta (worms)		2 (1)	0 (0)	0 (0)	0 (0)
Others (**)		51 (4)	19 (5)	7 (5)	10 (4)
TOTAL		100 (12)	100 (13)	100 (18)	100 (15)
SPECIES RICHNESS		12	13	18	15
HBI INDEX		6.16	5.51	5.46	5.10
EPT VALUE		4	2	5	7
PMA VALUE		49	44	54	85
FIELD ASSESSMENT		mod impact	mod impact	slt impact	slt impact
OVERALL ASSESSMENT		moderately impacted	moderately impacted	slightly impacted	slightly impacted

** sowbugs (Sta.0,3); scuds (Sta.0); crayfish (Sta.0); fingernail clams (Sta.3,4,6)

LABORATORY DATA SUMMARY

STREAM NAME Ramapo River | DRAINAGE 15
DATE SAMPLED 08/25/98 | COUNTY Orange
SAMPLING METHOD Traveling kick | Rockland

STATION	07			
LOCATION	Hillburn - 4th St.			
DOMINANT SPECIES\% CONTRIBUTION\TOLERANCE\COMMON NAME				
Genus and species names are abbreviated here to accommodate format. Complete names are reported elsewhere in this report. 1.	Hydropsyche bronta 21 facultative caddisfly			
2.	Baetis flavistr 17 intolerant mayfly			
Intolerant = not tolerant of poor water quality; Facultative = occurring over a wide range of water quality; Tolerant = tolerant of poor water quality. 3.	Simulium sp. 9 facultative black fly			
4.	Polypedilum convict 8 facultative midge			
5.	Isonychia bicolor 8 intolerant mayfly			
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESES)				
Chironomidae (midges)	15 (6)			
Trichoptera (caddisflies)	26 (4)			
Ephemeroptera (mayflies)	41 (5)			
Plecoptera (stoneflies)	0 (0)			
Coleoptera (beetles)	2 (2)			
Oligochaeta (worms)	0 (0)			
Others (**)	16 (4)			
TOTAL	100 (21)			
SPECIES RICHNESS	21			
HBI INDEX	4.88			
EPT VALUE	9			
PMA VALUE	77			
FIELD ASSESSMENT	slt impact			
OVERALL ASSESSMENT	slightly impacted			

** black flies; hellgrammites; flatworms; crane flies

FIELD DATA SUMMARY SHEET				
STREAM NAME: Ramapo River REACH: Harriman to Hillburn DATE SAMPLED: 08-25-98 FIELD PERSONNEL INVOLVED: Abele, Bode				
STATION	00	03	04	06
ARRIVAL TIME AT STATION	10:00	11:05	11:35	12:25
LOCATION	Harriman River Rd.	Harriman Nepera	Arden Water St.	Tuxedo Park
PHYSICAL CHARACTERISTICS				
Width (meters)	4	5	4	20
Depth (meters)	0.1	0.2	0.2	0.2
Current speed (cm per sec)	65	120	100	85
Substrate (%)				
rock (> 10 in. or bedrock)	10	10		10
rubble (2.5-10 in.)	30	40	30	30
gravel (0.08-2.5 in.)	30	20	30	20
sand (0.06-2.0 mm)	10	10	20	20
silt (0.004-0.06 mm)	20	20	20	20
clay (less than 0.004 mm)				
Embeddedness (%)	40	30	40	20
CHEMICAL MEASUREMENTS				
Temperature (oC)	23.4	23.4	22.4	24.1
Specific conductance (umhos)	847	1003	964	692
Dissolved Oxygen (mg per l)	7.7	6.0	6.5	10.1
pH	7.8	7.4	7.4	8.4
BIOLOGICAL ATTRIBUTES				
Canopy (%)	50	90	80	10
Aquatic Vegetation				
algae - water column				
algae - filamentous				
algae - diatoms		present	present	
macrophytes; moss		moss		
Occurrence of Macroinvertebrates				
Chironomidae (midges)	X		X	X
Trichoptera (caddisflies)	X	X	X	X
Ephemeroptera (mayflies)			X	X
Plecoptera (stoneflies)				
Coleoptera (beetles)	X	X	X	X
Oligochaeta (worms)	X			X
Other (**)	X	X	X	X
ESTIMATED BIOMASS	-	-	-	-
FIELD ESTIMATE OF WATER QUALITY	mod	mod	slt	slt
FIELD COMMENTS				

** crayfish (Sta. 0,3,4); scuds (Sta. 0,3,4); hellgrammites (Sta. 4,6); leeches (Sta. 3,4,6); fingernail clams (Sta. 3)

FIELD DATA SUMMARY SHEET				
STREAM NAME: Ramapo River REACH: Harriman to Hillburn DATE SAMPLED: 08-25-98 FIELD PERSONNEL INVOLVED: Abele, Bode				
STATION ARRIVAL TIME AT STATION LOCATION	07 12:55 Hillburn 4th St.			
PHYSICAL CHARACTERISTICS				
Width (meters)	20			
Depth (meters)	0.2			
Current speed (cm per sec)	120			
Substrate (%)				
rock (> 10 in. or bedrock)				
rubble (2.5-10 in.)	30			
gravel (0.08-2.5 in.)	30			
sand (0.06-2.0 mm)	30			
silt (0.004-0.06 mm)	10			
clay (less than 0.004 mm)				
Embeddedness (%)	20			
CHEMICAL MEASUREMENTS				
Temperature (oC)	23.1			
Specific conductance (umhos)	395			
Dissolved Oxygen (mg per l)	8.8			
pH	8.0			
BIOLOGICAL ATTRIBUTES				
Canopy (%)	10			
Aquatic Vegetation				
algae - water column				
algae - filamentous				
algae - diatoms	present			
macrophytes; moss				
Occurrence of Macroinvertebrates				
Chironomidae (midges)	X			
Trichoptera (caddisflies)	X			
Ephemeroptera (mayflies)	X			
Plecoptera (stoneflies)	X			
Coleoptera (beetles)				
Oligochaeta (worms)				
Other (**)	X			
ESTIMATED BIOMASS	-			
FIELD ESTIMATE OF WATER QUALITY	slt			
FIELD COMMENTS				

** flatworms; crayfish; black flies; hellgrammites

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 to which rose bengal stain has been added.

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 and placed in a petri dish with alcohol. This portion is examined under a dissecting stereomicroscope and 100 organisms are removed from the debris. As they are removed, they are sorted into major groups, placed in vials containing 70 percent alcohol, and counted. 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.

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 sample is recorded on a data sheet. All organisms from the subsample are archived, either slide-mounted or preserved in alcohol.

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 excellent 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

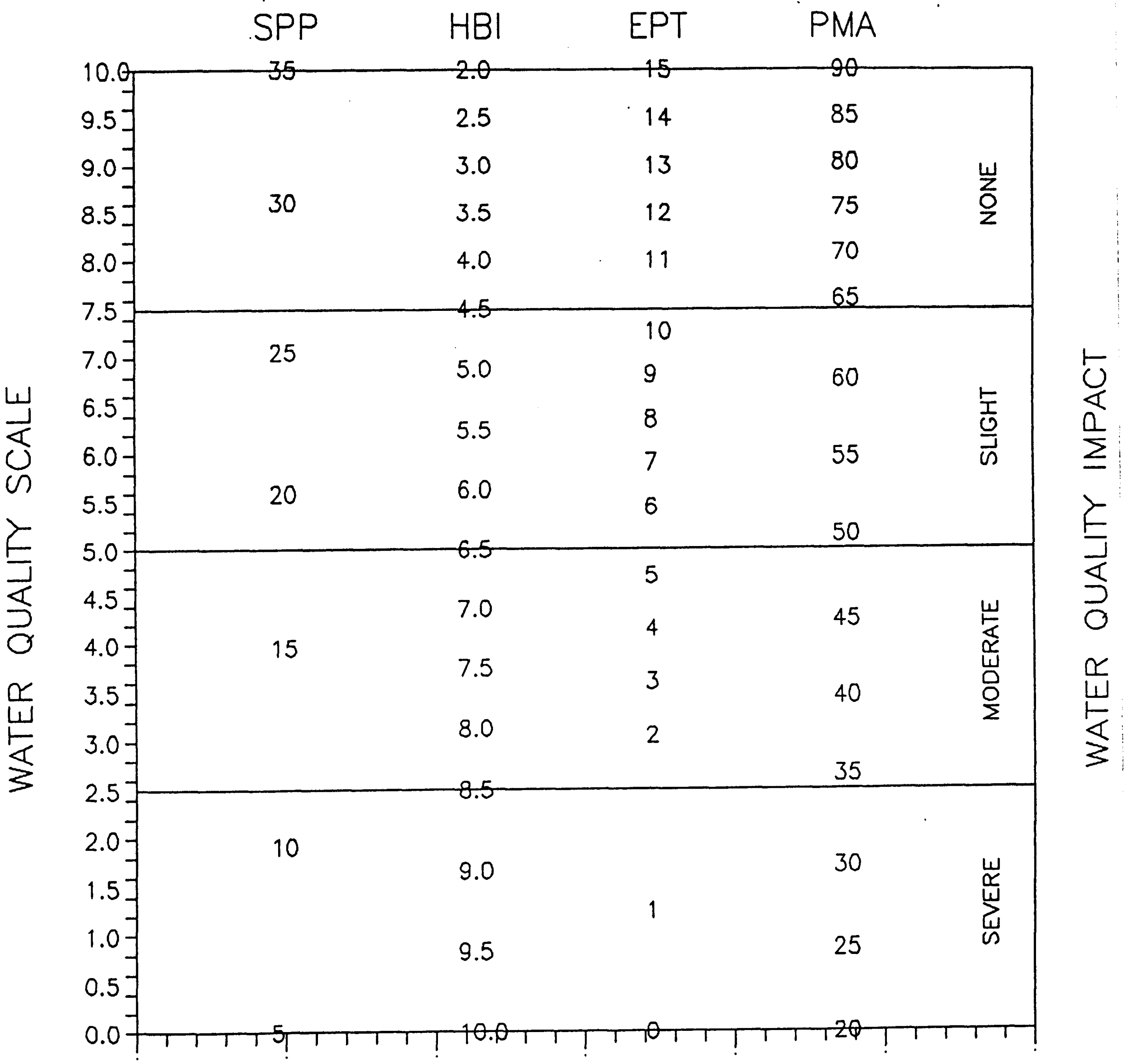
Indices reflect fair water quality. The macroinvertebrate community is altered to a large degree from the pristine state. Species richness usually is 11-18 species. Mayflies and stoneflies are rare or absent, and caddisflies are often restricted; the EPT value is 2-5. The biotic index value is 6.51-8.50. 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 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.

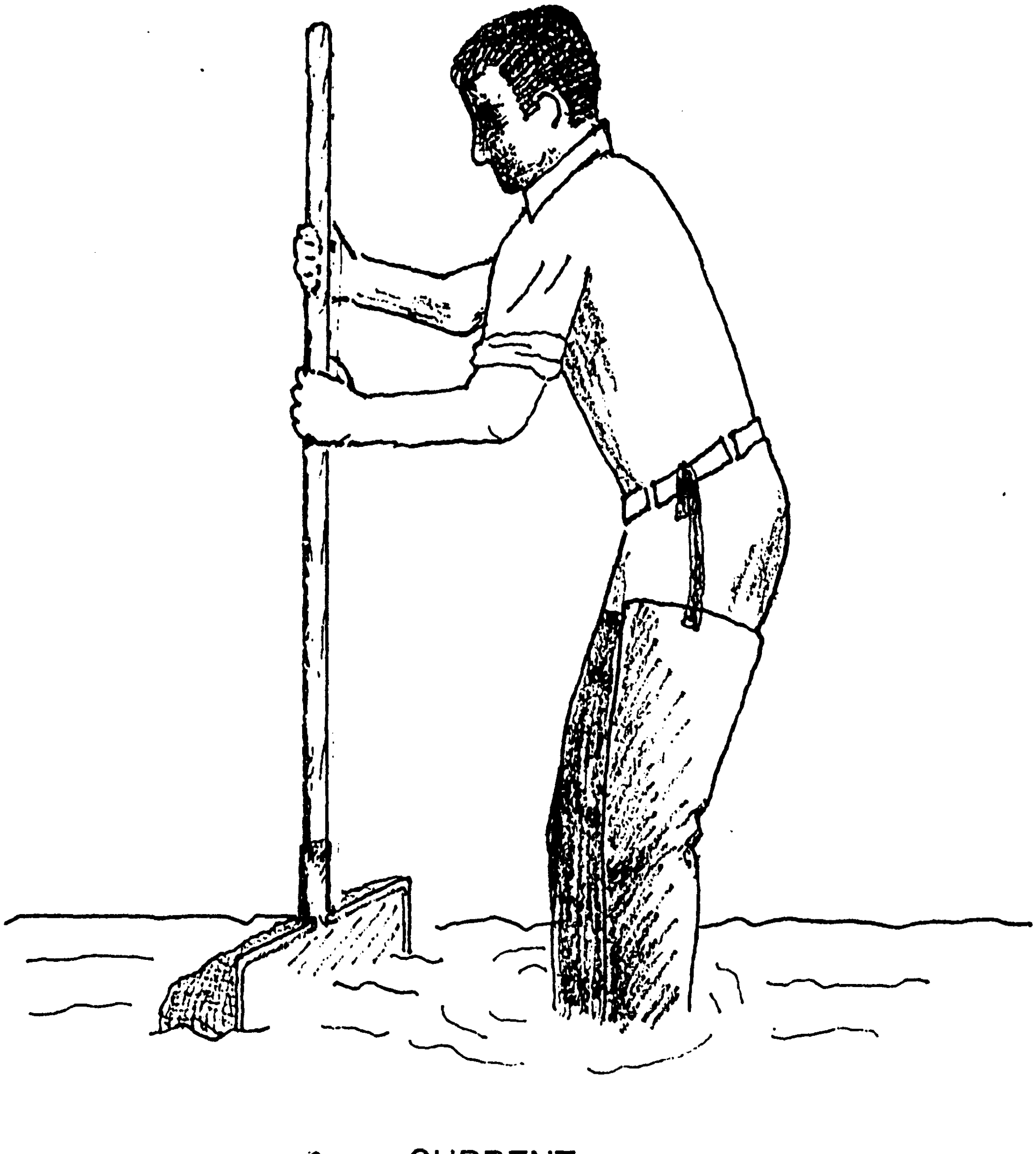
WATER QUALITY ASSESSMENT CRITERIA

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.

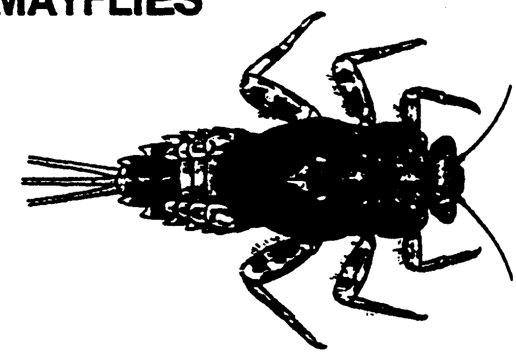
THE TRAVELING KICK SAMPLE



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.

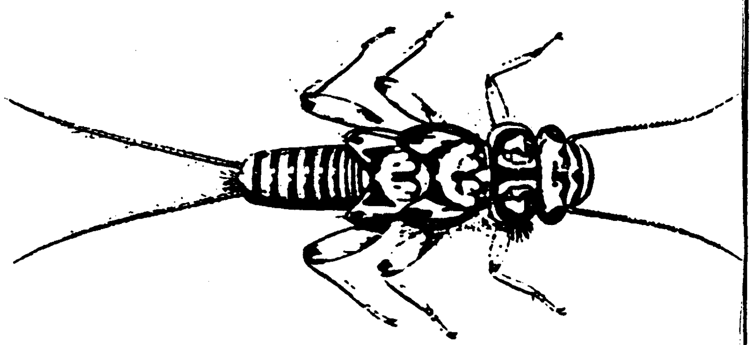
AQUATIC MACROINVERTEBRATES THAT USUALLY INDICATE GOOD WATER QUALITY

MAYFLIES



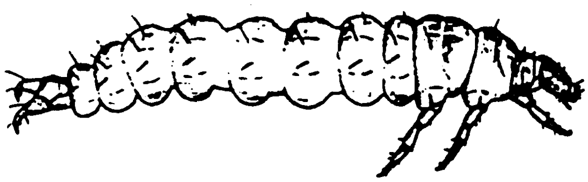
Mayfly nymphs are often the most numerous organisms found in clean streams. They are sensitive to most types of pollution, including low dissolved oxygen (less than 5 ppm), chlorine, ammonia, metals, pesticides, and acidity. Most mayflies are found clinging to the undersides of rocks.

STONEFLIES



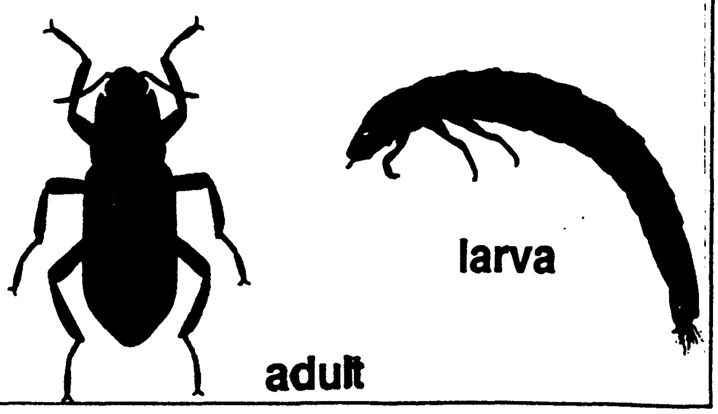
Stonefly nymphs are mostly limited to cool, well-oxygenated streams. They are sensitive to most of the same pollutants as mayflies except acidity. They are usually much less numerous than mayflies. The presence of even a few stoneflies in a stream suggests that good water quality has been maintained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



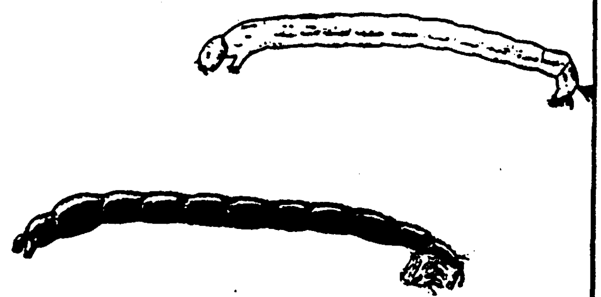
The most common beetles in streams are riffle beetles and water pennies. Most of these require a swift current and an adequate supply of oxygen, and are generally considered clean-water indicators.

Illustrations by Arwin Provonsha
In McCafferty: Aquatic Entomology

AQUATIC MACROINVERTEBRATES THAT USUALLY INDICATE POOR WATER QUALITY

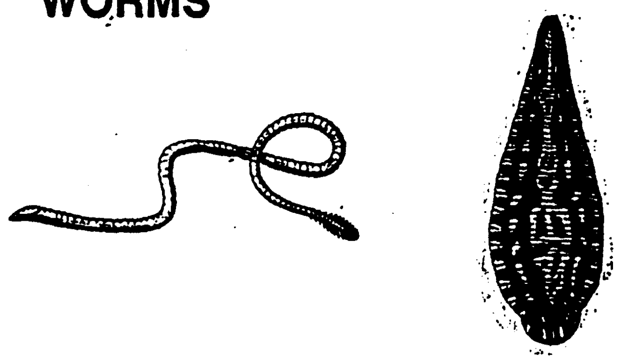
MIDGES

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.



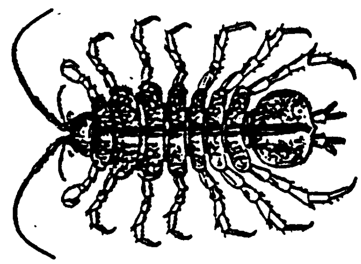
WORMS

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

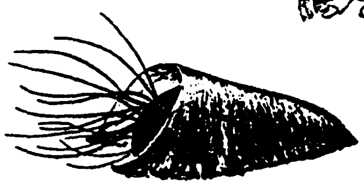
Aquatic sowbugs are crustaceans that are often numerous in situations of high organic content and low oxygen levels. When numerous they can indicate a stream segment in the recovery stage of sewage pollution.



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

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, such as 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 mostly 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: nonpoint nutrient additions, toxics, sewage effluent or animal wastes, municipal/industrial, siltation, impoundment, and natural. Cluster analysis was then performed within each group, using percent similarity, mostly at the family or genus level. Within each group different 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. Similarities less than 50% are less conclusive. 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									TOXIC				
	A	B	C	D	E	F	G	H	I	A	B	C	D	E
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-	-	-	-	5
OLIGOCHAETA	-	-	-	5	-	-	-	-	-	-	10	20	5	5
HIRUDINEA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-	5	-	-	-
SPHAERIIDAE	-	-	-	5	-	-	-	-	-	-	-	-	-	-
ASELLIDAE	-	-	-	-	-	-	-	-	-	10	10	-	20	10
GAMMARIDAE	-	-	-	5	-	-	-	-	-	5	-	-	-	5
Isonychia	-	-	-	-	-	-	-	5	-	-	-	-	-	-
BAETIDAE	5	15	20	5	20	10	10	5	10	15	10	20	-	-
HEPTAGENIIDAE	-	-	-	-	5	5	5	5	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	5	-	-	-	-	-	-
Caenis/Tricorythodes	-	-	-	-	5	-	-	5	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus	5	-	-	5	-	5	5	-	-	-	-	-	-	-
Optioservus	10	-	10	5	-	-	15	5	-	-	-	-	-	-
Promoresia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenelmis	15	15	-	10	15	5	25	5	10	10	15	-	40	35
PHILOPOTAMIDAE	15	5	-	5	-	25	5	-	-	10	-	-	-	-
HYDROPSYCHIDAE	15	15	15	25	10	35	20	45	20	20	10	15	10	35
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	5	-	15	5	5	-	-	-	40	-	-	-	-	-
Simulium vittatum	-	-	-	-	-	-	-	-	5	-	20	-	-	-
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE														
Tanypodinae	-	-	-	-	-	-	5	-	-	5	10	-	-	-
Cardiocladius	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	10	15	10	5	-	-	-	-	5	15	10	25	10	5
Eukiefferiella/ Tvetenia	-	15	10	5	-	-	-	-	5	-	-	20	10	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-	-	-	5	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	10	20	10	5	10	5	10	-	-	-	-
Tanytarsini	10	10	10	5	20	5	5	10	-	-	-	-	-	-
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100

	SEWAGE EFFLUENT, ANIMAL WASTES									MUNICIPAL/INDUSTRIAL					
	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-	40	-	-	-	5
OLIGOCHAETA	5	35	15	10	10	35	40	10	20	20	20	70	10	-	20
HIRUDINEA	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
SPHAERIIDAE	-	-	-	10	-	-	-	-	-	-	5	-	-	-	-
ASELLIDAE	5	10	-	10	10	10	10	50	-	10	5	10	10	15	5
GAMMARIDAE	-	-	-	-	-	10	-	10	-	40	-	-	-	15	-
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	10	5	-	-	-	-	10	5	-	-	-	5	-
HEPTAGENIIDAE	10	10	10	-	-	-	-	-	-	5	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
Promoresia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Stenelmis	15	-	10	10	-	-	-	-	-	5	-	-	10	5	-
PHILOPOTAMIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HYDROPSYCHIDAE	45	-	10	10	10	-	-	10	10	10	-	-	50	20	-
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simulium vittatum	-	-	-	25	10	35	-	-	5	-	-	-	-	-	-
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-
CHIRONOMIDAE															
Tanypodinae	-	5	-	-	-	-	-	-	-	-	10	-	-	5	15
Cardiocladius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	-	10	15	-	-	10	10	-	5	5	10	20	-	5	10
Eukiefferiella/ Tvetenia	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	10	60	-	30	10	10	-	-	-	10	20	40
Tanytarsini	10	10	10	10	-	-	-	10	20	-	-	-	10	10	-
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

	SILTATION					IMPOUNDMENT									
	A	B	C	D	E	A	B	C	D	E	F	G	H	I	
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	-
<u>Isonychia</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	20	5	-	-	5	-	5	-	-	5	-	-	5
HEPTAGENIIDAE	5	10	-	20	5	5	5	-	5	5	5	5	-	5	5
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Caenis/Tricorythodes</u>	5	20	10	5	15	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Psephenus</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
<u>Optioservus</u>	5	10	-	-	-	-	-	-	-	-	-	-	-	5	-
<u>Promoresia</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Stenelmis</u>	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	-	-	-	-	-	-	-	-
<u>Cardiocladius</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Cricotopus/ Orthocladius</u>	25	-	10	5	5	5	25	5	-	10	-	5	10	-	-
<u>Eukiefferiella/ Tvetenia</u>	-	-	10	-	5	5	15	-	-	-	-	-	-	-	-
<u>Parametriocnemus</u>	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
<u>Chironomus</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Polypedilum aviceps</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Polypedilum</u> (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