New York State
Department of Environmental Conservation

Division of Water

Susquehanna River

Biological Assessment

2003 Survey

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SUSQUEHANNA RIVER

BIOLOGICAL ASSESSMENT

Susquehanna River Basin
Otsego, Chenango, Broome, and Tioga Counties, New York

Survey date: July 21 and 31, 2003
Report date: January 30, 2004

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Stream: Susquehanna River

Reach: Oneonta to Smithboro, New York

NYS Drainage Basin: Susquehanna River

Background:

The Stream Biomonitoring Unit conducted biological sampling on the Susquehanna River on July 21, 2003. The purpose of the sampling was to assess water quality, and determine any spatial or chronological water quality trends. Traveling kick samples for macroinvertebrates were taken in riffle areas at 8 sites, using methods described in the Quality Assurance document (Bode et al., 2002) 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. Macroinvertebrate community parameters used in the determination of water quality included species richness, biotic index, EPT value, and PMA (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 macroinvertebrate data reports, including individual site descriptions and raw invertebrate data from each site.

Results and Conclusions:

1. Based on macroinvertebrate sampling in 2003, water quality in the Susquehanna River ranged from slightly impacted to non-impacted. The primary stressor to water quality was nonpoint source nutrient enrichment.

2. Results of this survey may reflect better water quality than is usually found in the river, since sampling was conducted during a summer of high flows. Sampling during seasons of elevated flows tends to de-emphasize point source effects due to increased dilution and emphasize nonpoint source effects due to increased run-off. This data set thus provides a model of the types of macroinvertebrate faunas that are achievable under conditions of minimal impact from any point discharges in the basin.

Discussion

The Susquehanna River originates as the outflow of Otsego Lake in Cooperstown, New York. The upper river flows south-southwest for approximately 80 miles before entering Pennsylvania, where it flows for approximately 15 miles before bending north and re-entering New York State. The lower river in New York State flows west, passing through Binghamton, for approximately 45 miles before turning south and re-entering Pennsylvania.

Previous macroinvertebrate data gathered from the Susquehanna River by the Stream Biomonitoring Unit includes results from 4 multi-site surveys: in 1984, 1985 (2), and 1991. In the 1984 survey 6 sites sampled from Afton to Barton, finding non-impacted conditions at Afton, and slight impact at all downstream sites (Simpson and Bode, 1985). In the 1985 survey of the upper river 6 sites were sampled from Cooperstown to Hyde Park, finding slight impact at Cooperstown due to impoundment effects, moderate impact from the Cooperstown Sewage Treatment Plant discharge, and downstream recovery to slightly impacted conditions (Bode, 1986a). In a 1985 survey of the lower river 14 sites were sampled from Binghamton to Apalachin. Two zones of severe impact were documented, one below the Binghamton-Johnson City Sewage Treatment Plant discharge, and one below the Endicott (V) Sewage Treatment Plant discharge. Water quality in the remainder of the reach ranged from slightly impacted to moderately impacted (Bode, 1986b). In the 1991 survey 5 sites were sampled in the upper river from Cooperstown to Hyde Park. Water quality ranged from slightly impacted to moderately impacted, with improvement noted downstream of the Cooperstown Sewage Treatment Plant discharge compared to the 1985 survey (Bode et al., 1991). Rotating Intensive Basin Studies sampling in 1997 included 7 sites on the Susquehanna River; water quality ranged from non-impacted to slightly impacted.

The present survey was conducted to gain a more large-scale understanding of the river, and document any spatial or chronological trends in water quality. Water quality in the present survey ranged from non-impacted to slightly impacted, with most of the river displaying very good water quality. A discussion of the results of this survey should be prefaced with the understanding that sampling was conducted during a summer of high flows, and the likelihood exists that impacts normally associated with some discharges may have been diluted. Sampling during seasons of elevated flows tends to de-emphasize point source effects due to increased dilution and emphasize nonpoint source effects due to increased run-off. This data set thus provides a model of the types of macroinvertebrate faunas that are achievable under conditions of minimal impact from any point discharges in the basin.

A site at Colliersville had been sampled previously (in 1991, 1992, and 1997) and had indicated slight impact. This impact is now considered to be primarily impoundment effects from Goodyear Lake. For the present survey, a downstream site near Oneonta was chosen to better represent the water quality of the river. This site was assessed as non-impacted. The Colliersville site was also sampled, and again indicated slight impact, but this data is now excluded as being non-representative. The non-impacted conditions documented at Oneonta were maintained for all of the upper river, including sites at Unadilla, Bainbridge, and Windsor.

Water quality at Conklin, where the river re-enters New York from Pennsylvania, was assessed as slightly impacted. Habitat differences are likely minor contributors to this assessment. Due to high flows, the sample was taken in an area of slow current and sandy substrate. Caddisflies were sparse, but a diverse mayfly fauna was present. Habitat differences also account for the low values in the Impact Source Determination table (Table 1). Downstream of Binghamton, the Apalachin site was similarly assessed as slightly impacted, primarily by nutrient enrichment. Water quality recovered to non-impacted conditions at Owego and Smithboro.

Overall, water quality in the Susquehanna River appeared very good, with a short reach of slight impact in the Binghamton area. At several sites, water quality appeared better than in samplings of 1997. Sites at Bainbridge, Owego, and Smithboro that were assessed as slightly impacted in 1997 were assessed as non-impacted in the present survey. As stated, it is likely that these improved assessments are due to high flows during the summer of 2003.

Literature Cited:

Bode, R. W., M. A. Novak, L. E. Abele, D. L. Heitzman, and A. J. Smith. 2002. Quality assurance work plan for biological stream monitoring in New York State. New York State Department of Environmental Conservation, Technical Report, 115 pages.

Bode, R. W., M. A. Novak, and L. E. Abele. 1991. Biological Stream Assessment, Upper Susquehanna River. New York State Department of Environmental Conservation, Technical Report, 20 pages.

Bode, R. W. 1986a. Biological Stream Assessment, Upper Susquehanna River near Cooperstown, New York. New York State Department of Health, Technical Report, 13 pages.

Bode, R. W. 1986b. Biological Intensive Survey, Susquehanna River, Binghamton to Apalachin, New York. New York State Department of Health, Technical Report, 18 pages.

Simpson, K. W. and R. W. Bode. 1985. Rapid Biological Stream Assessment, Susquehanna River from Afton to Barton. New York State Department of Health, Technical Report, 14 pages.

Overview of field data

On the dates of sampling, July 21 and 31, 2003, the Susquehanna River at the sites sampled was 25-130 meters wide, 0.3-0.4 meters deep, and had current speeds of 20-143 cm/sec in riffles. Dissolved oxygen was 7.9- 9.7 mg/l, specific conductance was 172-315 μmhos, pH was 7.5-8.1 and the temperature was 21.0-24.2 °C. Measurements for each site are found on the field data summary sheets.

Figure 1. Biological Assessment Profile of index values, Susquehanna River, 2003. 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.

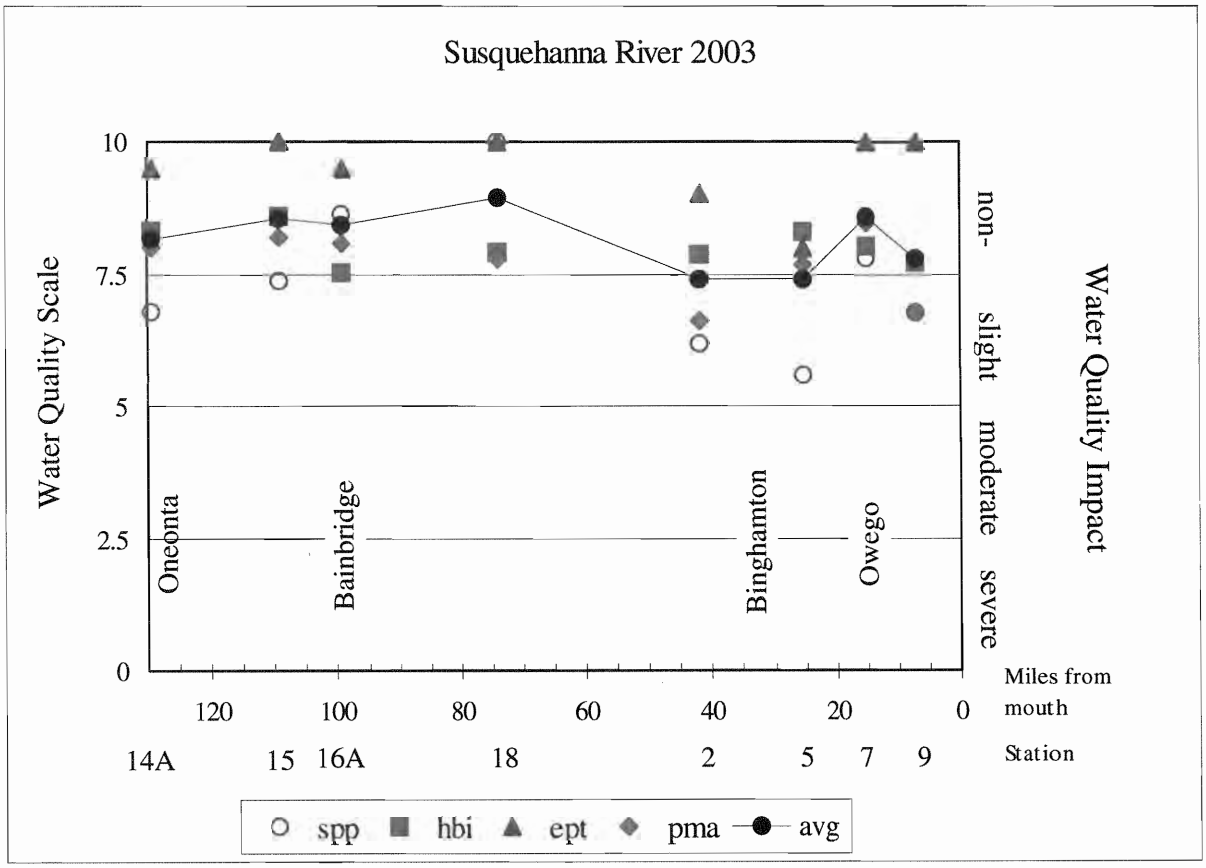


Table 1. Impact Source Determination, Susquehanna River, 2003. Numbers represent similarity to community type models for each impact category. The highest similarities at each station are highlighted. Similarities below 50% are less conclusive. Highest numbers represent probable type of impact. See Appendix X for further explanation.

Community Type	USSQ 14A	USSQ 15	USSQ 16A	USSQ 18	SUSQ 02	SUSQ 05	SUSQ 07	SUSQ 09
Natural: minimal human impacts	56	60	54	57	39	62	55	52
Nutrient additions; mostly nonpoint, agricultural	49	45	49	54	30	60	55	62
Toxic: industrial, municipal, or urban run-off	38	37	45	46	21	37	40	45
Organic: sewage, animal wastes	38	35	41	36	24	48	46	56
Complex: municipal and/or industrial	38	29	32	30	15	47	45	50
Siltation	48	42	48	40	32	43	50	50
Impoundment	39	32	43	35	17	48	47	56

TABLE SUMMARY

STATION	LOCATION	COMMUNITY TYPE
USSQ-14A	Oneonta	Natural
USSQ-15	Unadilla	Natural
USSQ-16A	Bainbridge	Natural, nutrient additions
USSQ-18	Windsor	Natural, nutrient additions
SUSQ-02	Conklin	Natural
SUSQ-05	Apalachin	Natural, nutrient additions
SUSQ-07	Owego	Natural, nutrient additions
SUSQ-09	Smithboro	Nutrient additions

TABLE 2. STATION LOCATIONS FOR SUSQUEHANNA RIVER, BROOME, CHENANGO, OTSEGO & TIOGA COUNTIES, NEW YORK (see map).

STATION	LOCATION
USSQ-14A	Oneonta 50 m below Rte. 23 bridge 129.5 miles above the mouth Latitude/longitude: 42°26'56" 75°03'06"
USSQ-15	Unadilla Rivera Rd. @ DEC Fishing Access 109.2 miles above the mouth Latitude/longitude: 42°19'14" 75°19'26"
USSQ-16A	Bainbridge Rte. 206, directly below bridge 99.3 miles above the mouth Latitude/longitude: 42°17'32" 75°28'33"
USSQ-18	Windsor 15 m below Old State Highway 17 bridge 73.9 miles above the mouth Latitude/longitude: 42°04'26" 75°38'12"
SUSQ-02	Conklin Off Rte. 7 @ Sandy Beach Park 41.8 miles above the mouth Latitude/longitude: 42°06'04" 75°52'12"
SUSQ-05	Apalachin Just above confluence with Apalachin Creek 25.2 miles above the mouth Latitude/longitude: 42°03'49" 76°08'30"
SUSQ-07	Owego Rte. 17 Rest Area, below Owego 15.0 miles above the mouth Latitude/longitude: 42°05'11" 76°16'54"
SUSQ-09	Smithboro Off Church St. 6.9 miles above the mouth Latitude/longitude: 42°01'46" 76°23'17"

Figure 2	Site Overview Map	Susquehanna River

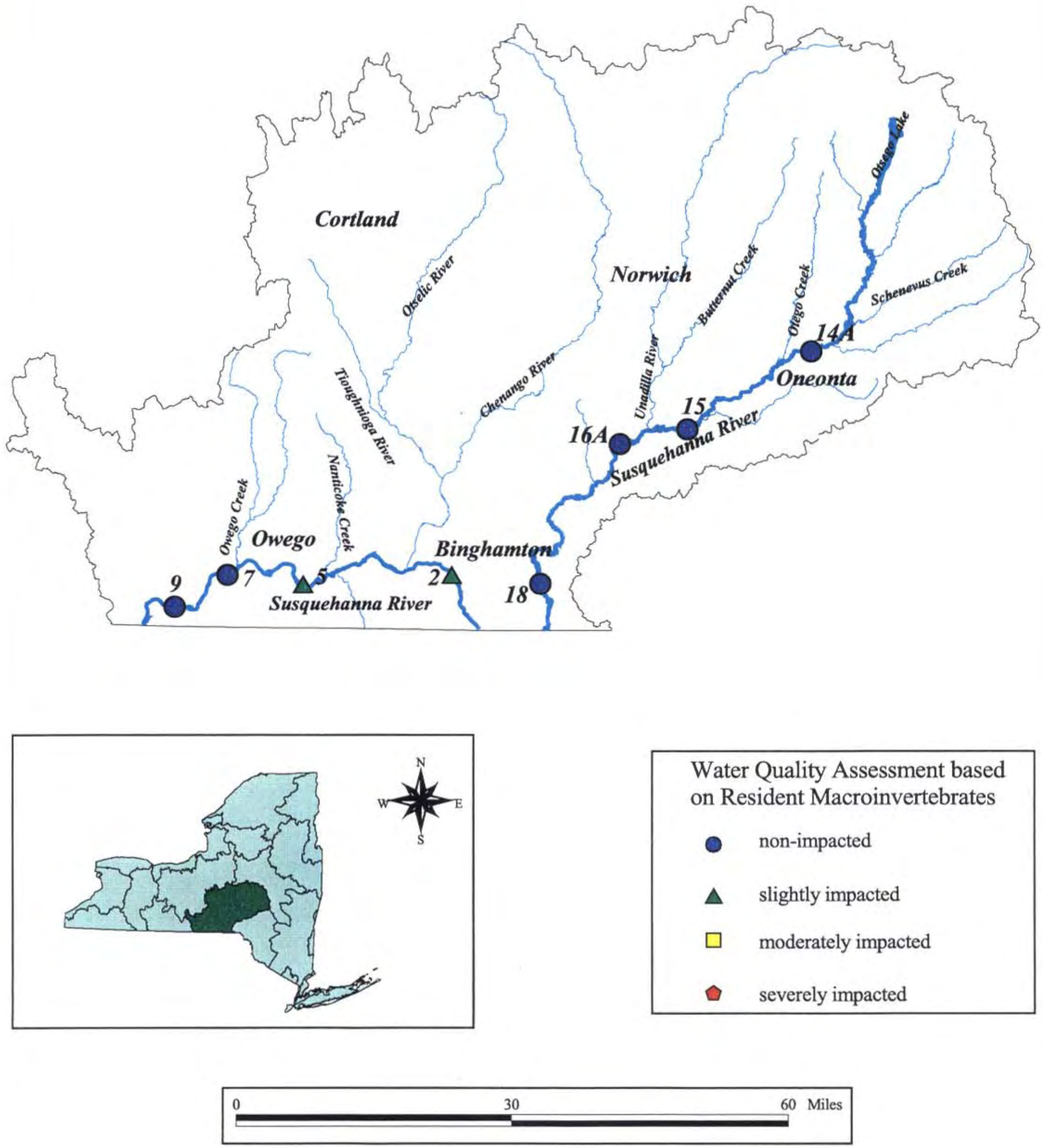


Figure 3a	Site Location Map	Susquehanna River

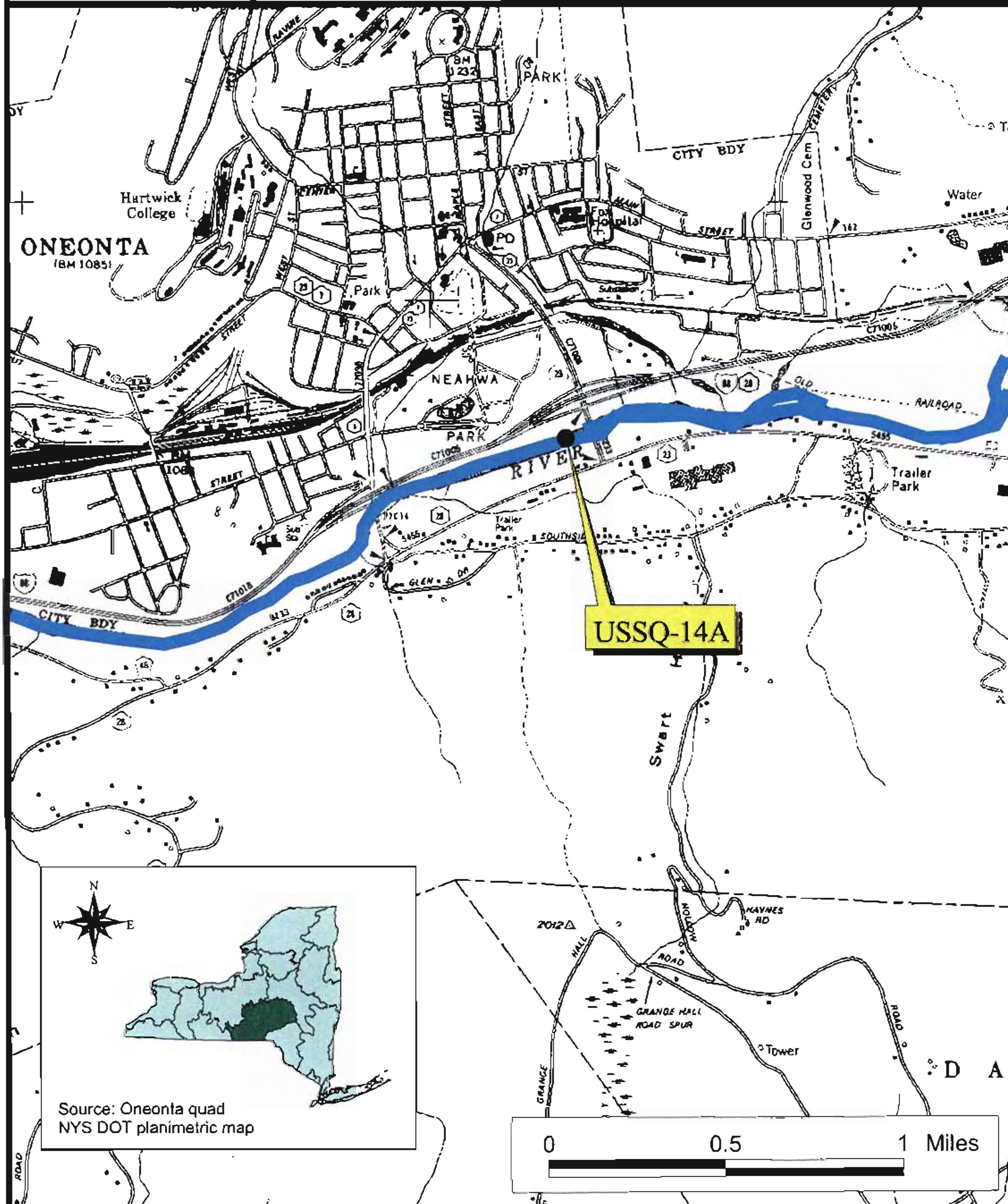


Figure 3b	Site Location Map	Susquehanna River

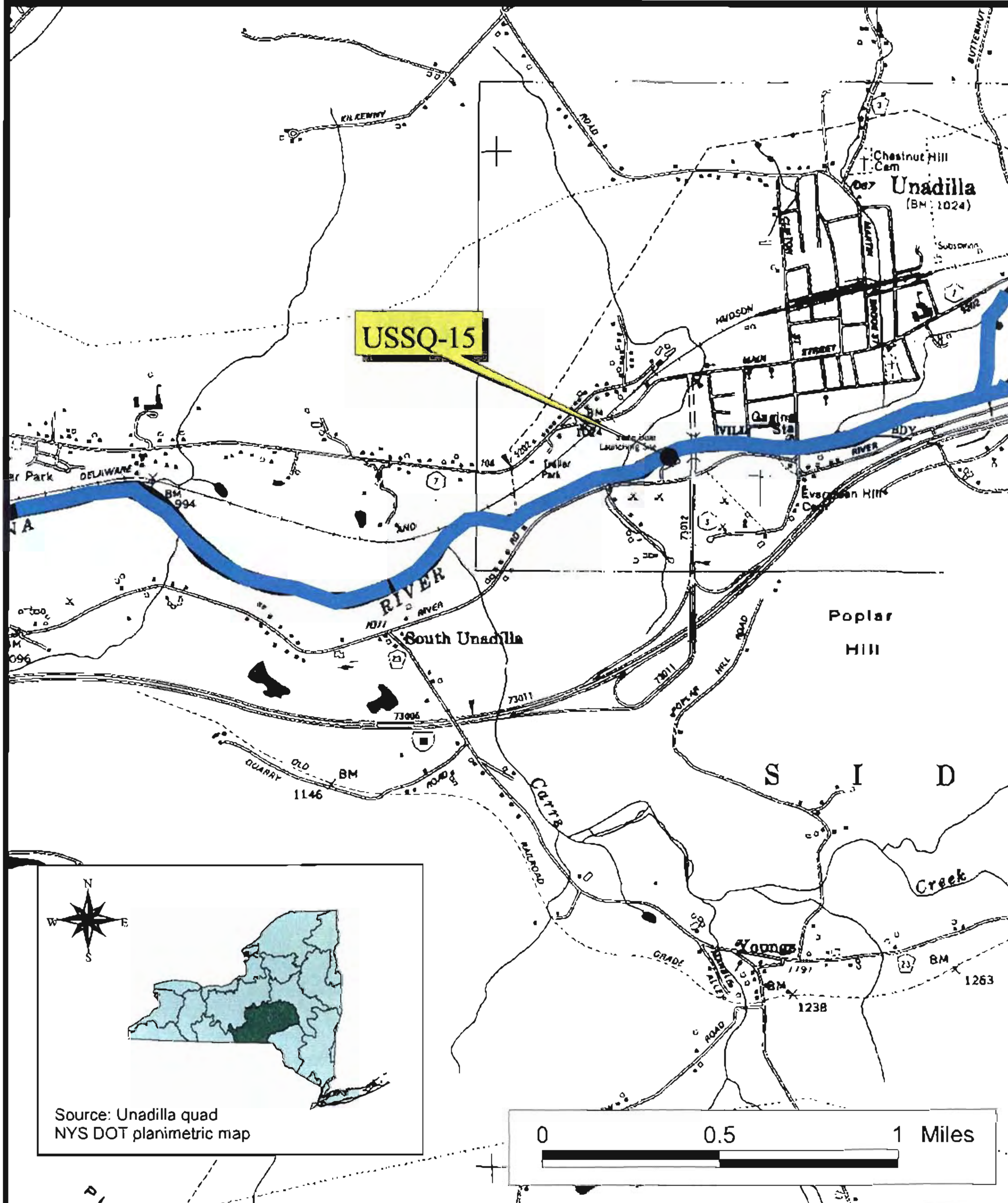


Figure 3c	Site Location Map	Susquehanna River

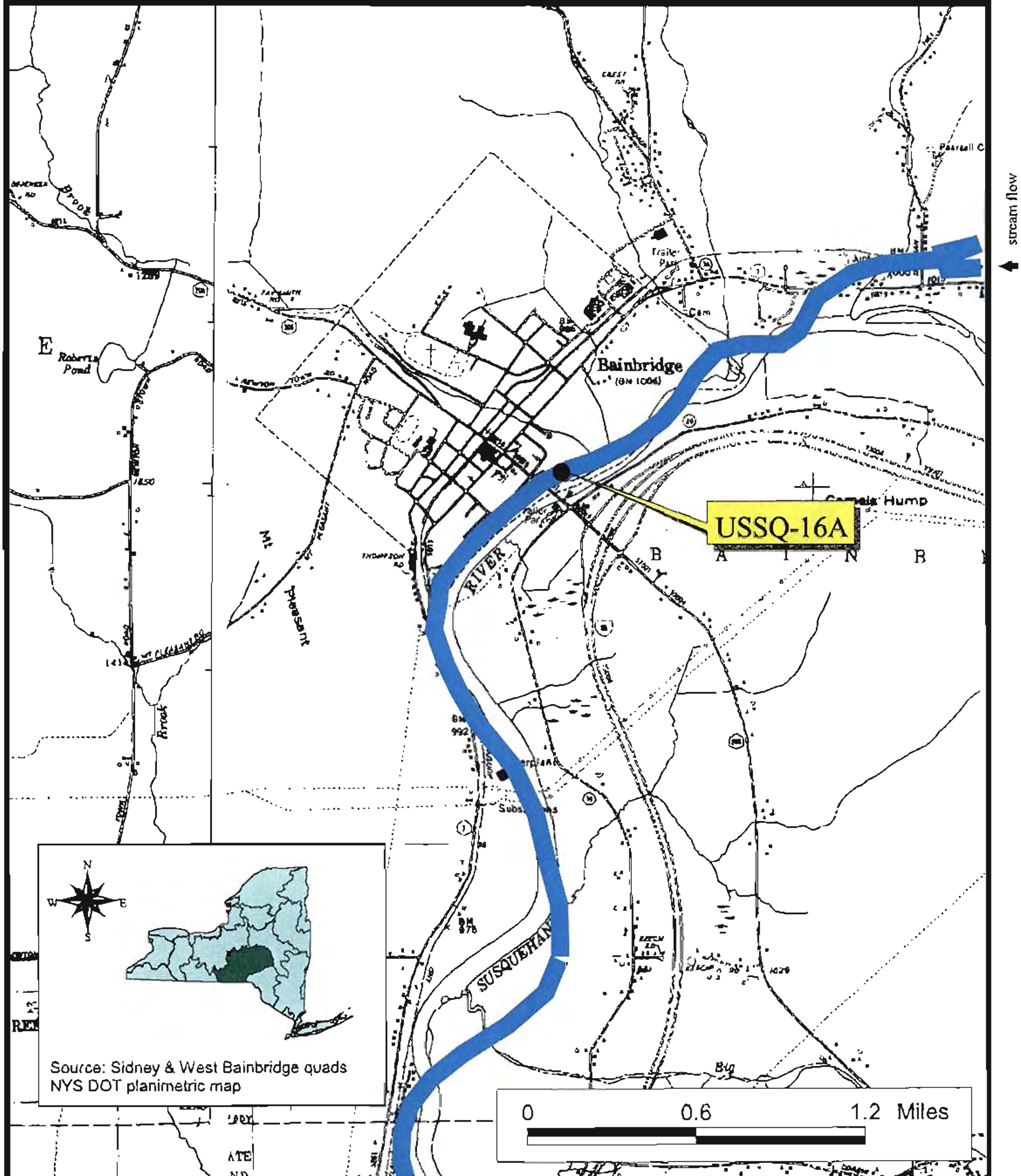


Figure 3d	Site Location Map	Susquehanna River

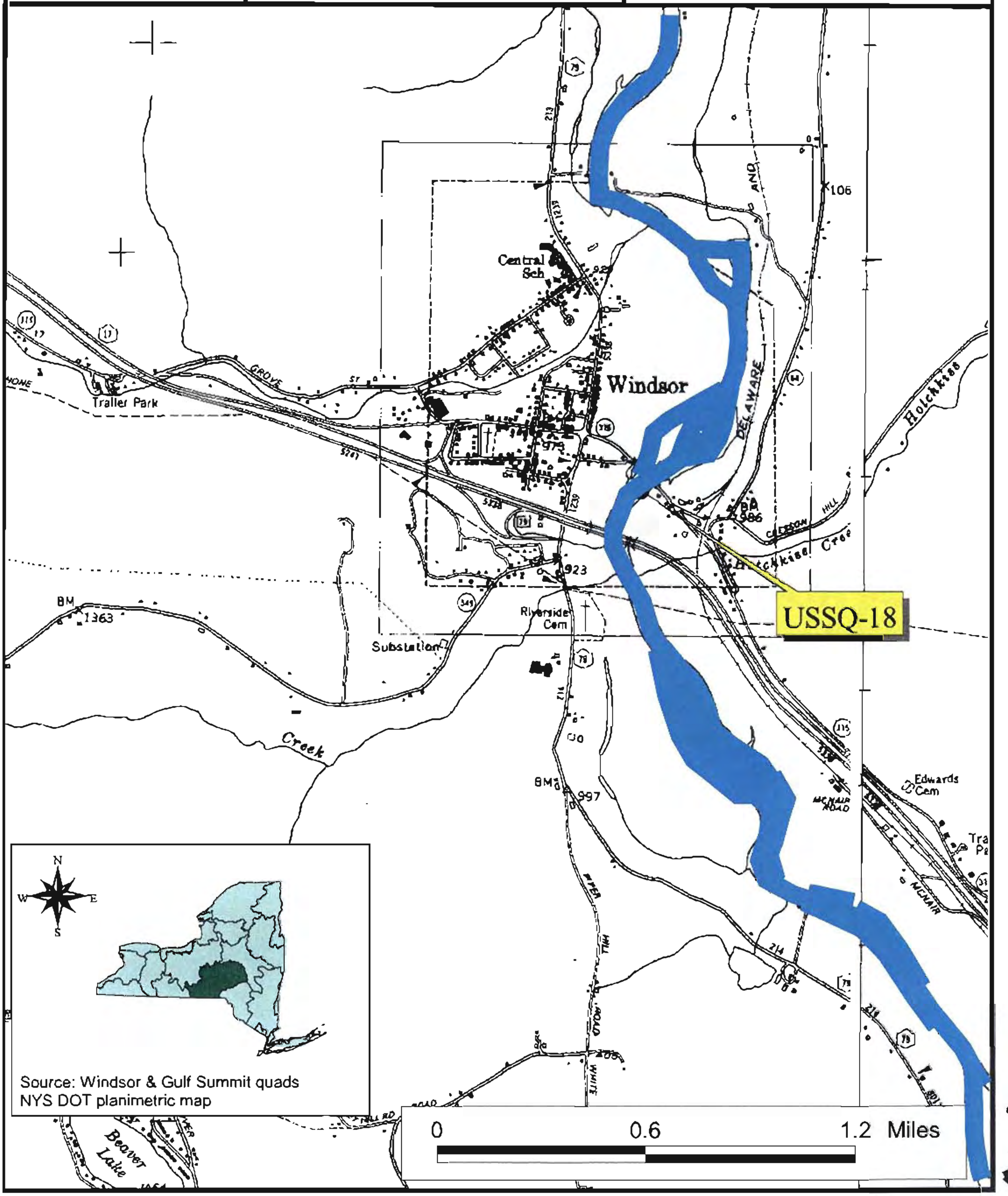


Figure 3e	Site Location Map	Susquehanna River

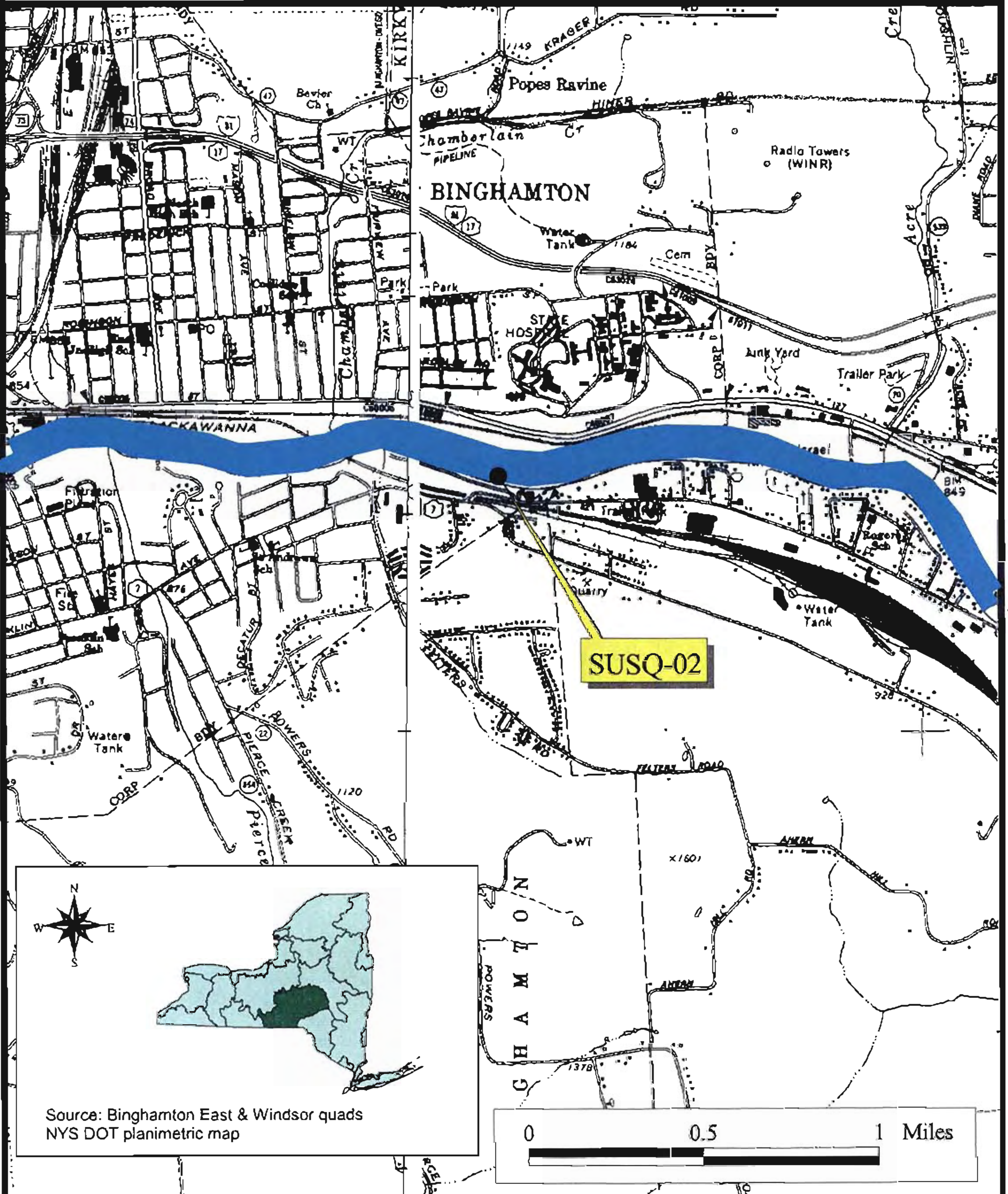


Figure 3f	Site Location Map	Susquehanna River

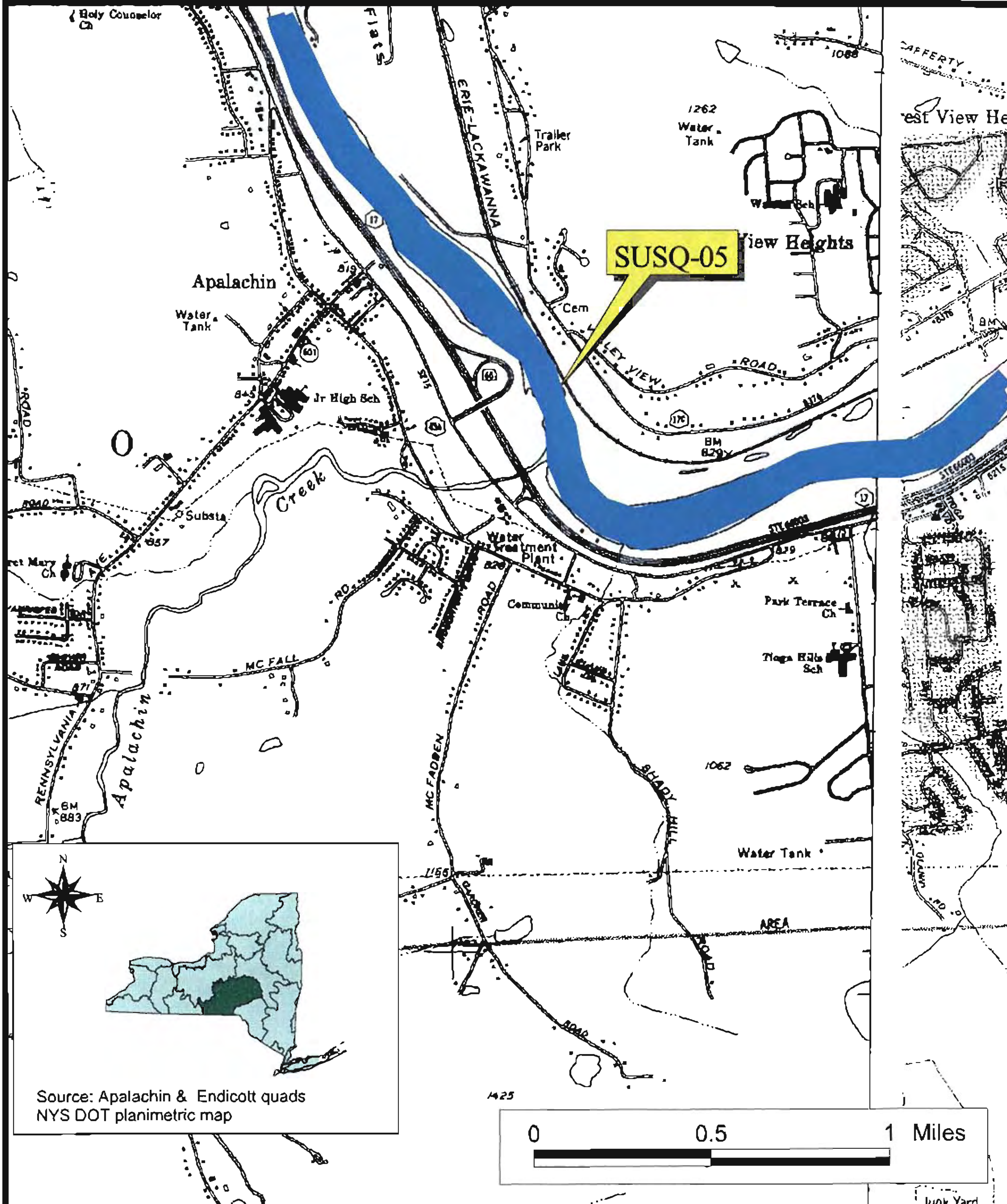


Figure 3g	Site Location Map	Susquehanna River

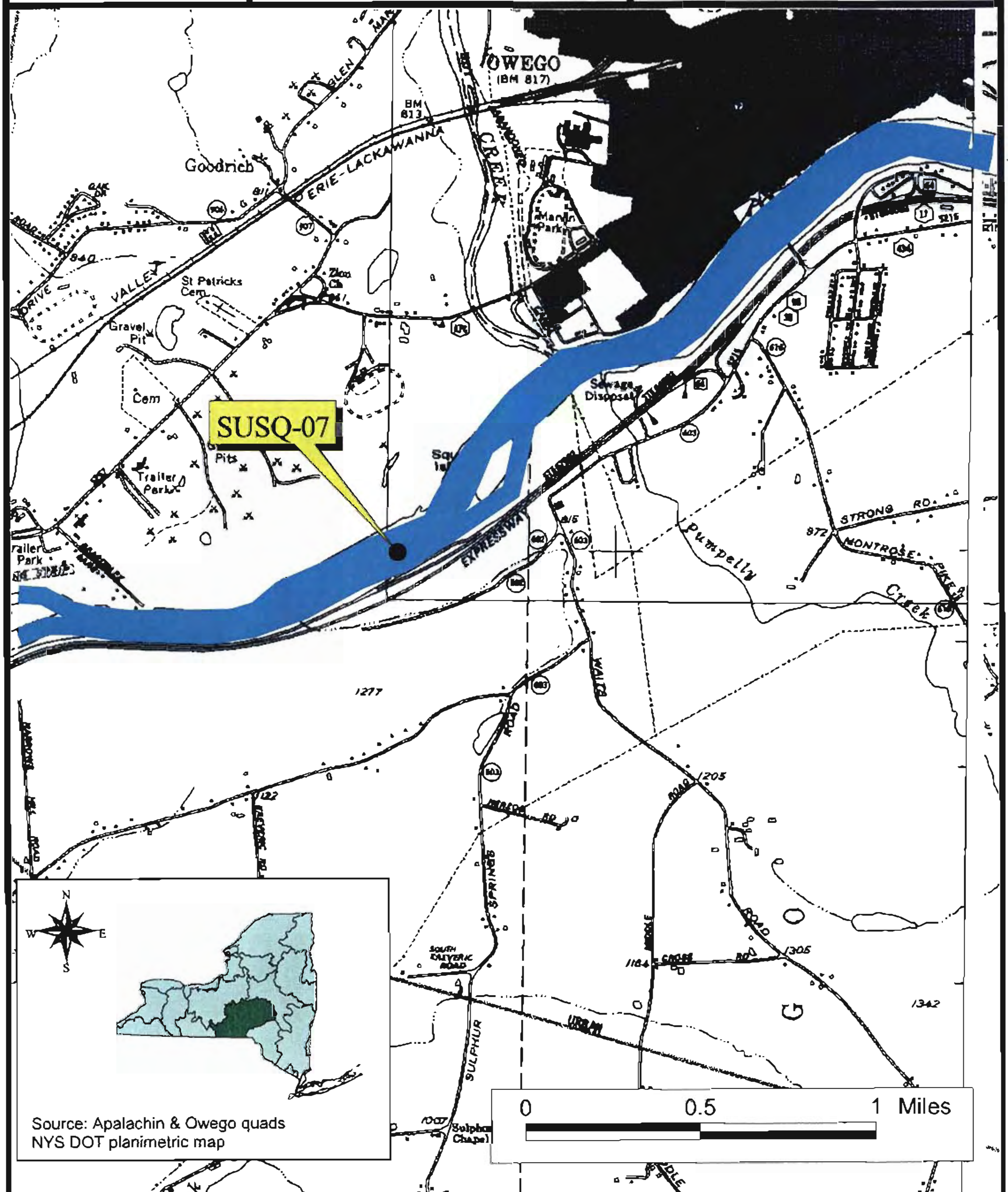


Figure 3h	Site Location Map	Susquehanna River

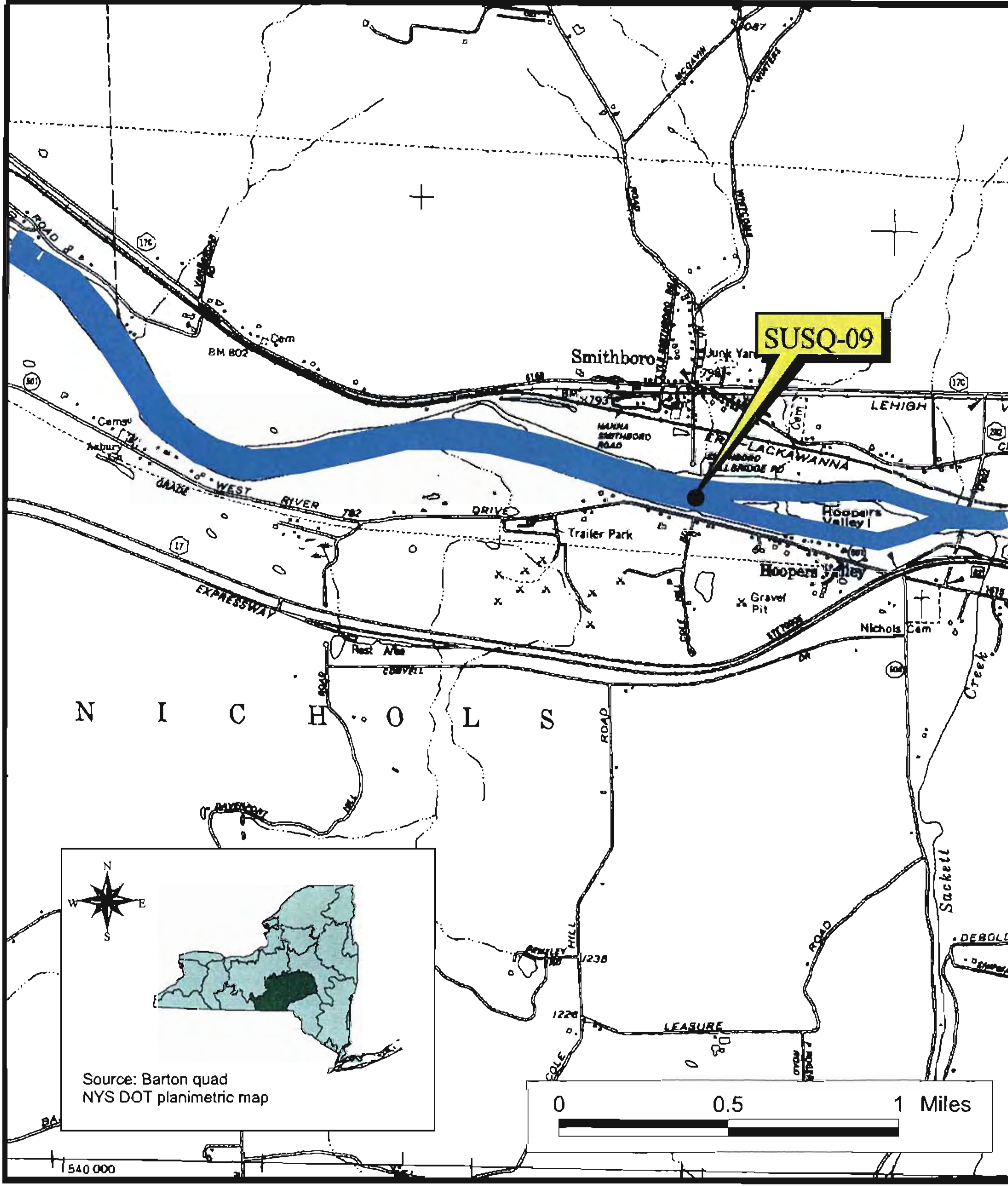


TABLE 3. MACROINVERTEBRATE SPECIES COLLECTED IN SUSQUEHANNA RIVER, BROOME, CHENANGO, OTSEGO, AND TIOGA COUNTIES, NEW YORK, 2003.

PLATYHELMINTHES
- TURBELLARIA
  - Undetermined Turbellaria

OLIGOCHAETA
- LUMBRICULIDA
  - Lumbriculidae
    - Undetermined Lumbriculidae
- TUBIFICIDA
  - Tubificidae
    - Undet. Tubificidae w/o cap. setae

MOLLUSCA
- GASTROPODA
  - Lymnaeidae
    - Undetermined Lymnaeidae
- PELECYPODA
  - Sphaeriidae
    - Pisidium sp.
    - Sphaerium sp.

ARTHROPODA
- CRUSTACEA
  - AMPHIPODA
    - Gammaridae
      - Gammarus sp.
  - DECAPODA
    - Cambaridae
      - Undetermined Cambaridae

INSECTA
- EPHEMEROPTERA
  - Isonychiidae
    - Isonychia bicolor
  - Baetidae
    - Acentrella sp.
    - Baetis brunneicolor
    - Baetis flavistriga
    - Baetis intercalaris
    - Plauditus sp.
  - Heptageniidae
    - Epeorus (Iron) sp.
    - Leucrocuta sp.
    - Nixe (Nixe) sp.
    - Rhithrogena sp.
    - Stenacron interpunctatum
    - Stenonema mediopunctatum
    - Stenonema meririvulanum
    - Stenonema pulchellum
    - Stenonema terminatum

EPHEMEROPTERA (cont'd)
- Leptophlebiidae
  - Choroterpes sp.
- Ephemerellidae
  - Ephemerella sp.
  - Serratella deficiens
  - Serratella serrata
  - Serratella serratoides
  - Serratella sp.
  - Undetermined Ephemerellidae
- Leptohyphidae
  - Tricorythodes sp.
- Caenidae
  - Caenis sp.
- Potamanthidae
  - Anthopotamus sp.
- Polymitarcyidae
  - Ephoron leukon?

ODONATA
- Coenagrionidae
  - Argia sp.

PLECOPTERA
- Perlidae
  - Agnetina capitata
  - Neoperla sp.
  - Paragnetina media
  - Perlesta sp.

COLEOPTERA
- Psephenidae
  - Psephenus herricki
- Elmidae
  - Dubiraphia bivittata
  - Dubiraphia sp.
  - Optioservus trivittatus
  - Optioservus sp.
  - Promoresia elegans
  - Stenelmis concinna
  - Stenelmis crenata
  - Stenelmis sp.

MEGALOPTERA
- Corydalidae
  - Corydalus cornutus
- Sialidae
  - Sialis sp.

TABLE 3. CONT'D. MACROINVERTEBRATE SPECIES COLLECTED IN SUSQUEHANNA RIVER, BROOME, CHENANGO, OTSEGO, AND TIOGA COUNTIES, NEW YORK, 2003.

TRICHOPTERA
- Philopotamidae
  - Chimarra aterrima?
  - Chimarra obscura
  - Chimarra socia
  - Chimarra sp.
- Psychomyiidae
  - Psychomyia flavida
- Hydropsychidae
  - Cheumatopsyche sp.
  - Hydropsyche betteni
  - Hydropsyche bronta
  - Hydropsyche dicantha
  - Hydropsyche leonardi
  - Hydropsyche morosa
  - Hydropsyche phalerata
  - Hydropsyche sp.
  - Macrostemum zebratum
  - Macrostemum sp.
  - Potamyia sp.
- Hydroptilidae
  - Hydroptila sp.
- Brachycentridae
  - Brachycentrus lateralis
- Lepidostomatidae
  - Lepidostoma sp.

DIPTERA
- Tipulidae
  - Antocha sp.
- Simuliidae
  - Simulium sp.
- Athericidae
  - Atherix sp.
- Empididae
  - Hemerodromia sp.
- Chironomidae
- Tanypodinae
  - Thienemannimyia gr. spp.
- Orthocladiinae
  - Cardiocladius obscurus
  - Cricotopus bicinctus
  - Cricotopus tremulus gr.
  - Cricotopus trifascia gr.
  - Cricotopus vierriensis
  - Nanocladius (Plecopteracoluthus) downesi
  - Nanocladius sp.
  - Tvetenia vitracies
- Chironominae
- Chironomini
  - Cryptochironomus fulvus gr.
  - Microtendipes pedellus gr.
  - Polypedilum flavum
  - Undetermined Chironomini
- Tanytarsini
  - Micropsectra polita
  - Rheotanytarsus exiguus gr.

STREAM SITE:	Upper Susquehanna River, Station 14A
LOCATION:	Oneonta, NY, 50 m below Rte 23 bridge
DATE:	July 31, 2003
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

MOLLUSCA			
PELECYPODA	Sphaeriidae	Pisidium sp.	10
ARTHROPODA			
CRUSTACEA			
DECAPODA	Cambaridae	Undetermined Cambaridae	1
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	10
	Baetidae	Acentrella sp.	6
		Baetis flavistriga	3
		Baetis intercalaris	7
	Heptageniidae	Epeorus (Iron) sp.	1
		Leucrocuta sp.	20
		Stenonema terminatum	5
	Polymitarcyidae	Ephoron leukon?	1
PLECOPTERA	Perlidae	Paragnetina media	1
COLEOPTERA	Psephenidae	Psephenus herricki	7
	Elmidae	Optioservus sp.	1
		Stenelmis crenata	2
TRICHOPTERA	Philopotamidae	Chimarra sp.	1
	Psychomyiidae	Psychomyia flavida	1
	Hydropsychidae	Cheumatopsyche sp.	13
		Hydropsyche bronta	3
		Hydropsyche morosa	10
DIPTERA	Tipulidae	Antocha sp.	1
	Simuliidae	Simulium sp.	1
	Athericidae	Atherix sp.	1
	Chironomidae	Microtendipes pedellus gr.	2
		Micropsectra polita	1

SPECIES RICHNESS	24 (good)
BIOTIC INDEX	3.71 (very good)
EPT RICHNESS	14 (very good)
MODEL AFFINITY	69 (very good)
ASSESSMENT	non-impacted
IMPACT SOURCE TYPE	Natural (56%)

DESCRIPTION The riffle sampled was considered excellent invertebrate habitat, and the fauna was dominated by clean-water mayflies. Water quality at this site was clearly non-impacted.

STREAM SITE:	Upper Susquehanna River, Station 15
LOCATION:	Unadilla, NY, Rivera Rd at DEC fishing access
DATE:	July 31, 2003
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	Gammarus sp.	9
DECAPODA	Cambaridae	Undetermined Cambaridae	1
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	3
	Baetidae	Acentrella sp.	4
		Baetis flavistriga	4
		Baetis intercalaris	8
	Heptageniidae	Leucrocuta sp.	13
		Stenonema terminatum	2
	Leptophlebiidae	Choroterpes sp.	1
	Ephemerellidae	Ephemerella sp.	14
		Serratella serrata	1
	Caenidae	Caenis sp.	3
	Polymitarcyidae	Ephoron leukon?	1
PLECOPTERA	Perlidae	Agnetina capitata	1
COLEOPTERA	Psephenidae	Psephenus herricki	2
	Elmidae	Optioservus sp.	1
		Promoresia elegans	3
		Stenelmis concinna	1
		Stenelmis crenata	12
MEGALOPTERA	Corydalidae	Corydalus cornutus	1
	Sialidae	Sialis sp.	1
TRICHOPTERA	Philopotamidae	Chimarra obscura	2
	Hydropsychidae	Hydropsyche leonardi	1
		Hydropsyche morosa	4
	Brachycentridae	Brachycentrus lateralis	4
DIPTERA	Simuliidae	Simulium sp.	3

SPECIES RICHNESS	26 (good)
BIOTIC INDEX	3.41 (very good)
EPT RICHNESS	16 (very good)
MODEL AFFINITY	71 (very good)
ASSESSMENT	non- impacted
IMPACT SOURCE TYPE	natural (60%)

DESCRIPTION The kick sample was taken near the DEC fishing access off Rivera Road at Unadilla. The invertebrate fauna was diverse and well-balanced, including many clean-water mayflies, stoneflies, beetles, and hellgrammites. Water quality was assessed as non-impacted.

STREAM SITE:	Upper Susquehanna River, Station 16A
LOCATION:	Bainbridge, NY, directly below Rte 206 bridge
DATE:	July 21, 2003
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

MOLLUSCA			
PELECYPODA	Sphaeriidae	Pisidium sp.	10
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	Gammarus sp.	1
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	5
	Baetidae	Acentrella sp.	1
		Baetis brunneicolor	1
		Baetis intercalaris	3
		Plauditus sp.	2
	Ephemerellidae	Serratella deficiens	2
		Serratella serratoides	2
	Potamanthidae	Anthopotamus sp.	1
PLECOPTERA	Perlidae	Perlesta sp.	3
COLEOPTERA	Elmidae	Optioservus trivittatus	7
		Promoresia elegans	10
		Stenelmis concinna	1
		Stenelmis crenata	4
TRICHOPTERA	Philopotamidae	Chimarra aterrima?	2
	Hydropsychidae	Cheumatopsyche sp.	4
		Hydropsyche morosa	6
		Hydropsyche phalerata	3
	Hydroptilidae	Hydroptila sp.	3
DIPTERA	Tipulidae	Antocha sp.	2
	Simuliidae	Simulium sp.	6
	Chironomidae	Cardiocladius obscurus	5
		Cricotopus bicinctus	1
		Cricotopus trifascia gr.	16
		Cricotopus vierriensis	1
		Nanocladius sp.	1
		Tvetenia vitracies	2
		Polypedilum flavum	2
		Rheotanytarsus exiguus gr.	2

SPECIES RICHNESS	30 (very good)
BIOTIC INDEX	4.47 (very good)
EPT RICHNESS	14 (very good)
MODEL AFFINITY	70 (very good)
ASSESSMENT	non-impacted
IMPACT SOURCE TYPE	natural (54%), nutrient enrichment (49%)

DESCRIPTION The sampling site was near the DOT access below the Route 206 bridge at Bainbridge. Sampling was difficult due to the swift current and high water level from recent rain. The invertebrate fauna was diverse and well-balanced, and all metrics were within the range of non-impacted water quality.

STREAM SITE:	Upper Susquehanna River, Station 18
LOCATION:	Windsor, NY, 15 m below Old State Hwy 17 bridge
DATE:	July 21, 2003
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ANNELIDA			
OLIGOCHAETA			
LUMBRICULIDA	Lumbriculidae	Undetermined Lumbriculidae	5
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	4
	Baetidae	Acentrella sp.	3
		Baetis intercalaris	11
	Heptageniidae	Leucrocuta sp.	1
		Stenacron interpunctatum	1
		Stenonema terminatum	2
	Ephemerellidae	Serratella sp.	1
	Caenidae	Caenis sp.	1
	Potamanthidae	Anthopotamus sp.	1
	Polymitarcyidae	Ephoron leukon?	4
PLECOPTERA	Perlidae	Agnetina capitata	1
		Paragnetina media	2
ODONATA	Coenagrionidae	Argia sp.	1
COLEOPTERA	Gyrinidae	Dineutus sp.	1
	Psephenidae	Psephenus herricki	4
	Elmidae	Dubiraphia bivittata	1
		Optioservus trivittatus	9
		Promoresia elegans	3
		Stenelmis concinna	2
		Stenelmis crenata	4
TRICHOPTERA	Philopotamidae	Chimarra socia	10
	Psychomyiidae	Psychomyia flavida	1
	Hydropsychidae	Cheumatopsyche sp.	3
		Hydropsyche betteni	1
		Hydropsyche morosa	6
		Hydropsyche phalerata	2
		Potamyia sp.	3
	Hydroptilidae	Hydroptila sp.	1
	Lepidostomatidae	Lepidostoma sp.	2
DIPTERA	Empididae	Hemerodromia sp.	3
	Chironomidae	Thienemannimyia gr. spp.	1
		Tvetenia vitracies	1
		Cryptochironomus fulvus gr.	1
		Microtendipes pedellus gr.	1
		Rheotanytarsus exiguus gr.	2

SPECIES RICHNESS	36 (very good)
BIOTIC INDEX	4.10 (very good)
EPT RICHNESS	21 (very good)
MODEL AFFINITY	67 (very good)
ASSESSMENT	non-impacted
IMPACT SOURCE TYPE	natural (57%), nutrient enrichment (54%)

DESCRIPTION The riffle sampled was judged to be adequate habitat. The invertebrate fauna was very diverse, with equal contribution of mayflies and caddisflies. All metrics were within the range of non-impacted water quality.

STREAM SITE:	Susquehanna River, Station 2
LOCATION:	Conklin, NY, off Rte 7 at Sandy Beach Park
DATE:	July 31, 2003
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

PLATYHELMINTHES			
TURBELLARIA	Planariidae	Undetermined Turbellaria	1
MOLLUSCA			
PELECYPODA	Sphaeriidae	Sphaerium sp.	1
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	Gammarus sp.	1
DECAPODA	Cambaridae	Undetermined Cambaridae	1
INSECTA			
EPHEMEROPTERA	Baetidae	Baetis flavistriga	19
		Baetis intercalaris	1
	Heptageniidae	Leucrocuta sp.	10
		Nixe (Nixe) sp.	2
		Stenacron interpunctatum	19
		Stenonema meririvulanum	2
		Stenonema terminatum	4
	Leptophlebiidae	Choroterpes sp.	9
	Ephemerellidae	Undetermined Ephemerellidae	1
	Caenidae	Caenis sp.	1
	Potamanthidae	Anthopotamus sp.	13
PLECOPTERA	Perlidae	Neoperla sp.	3
COLEOPTERA	Psephenidae	Psephenus herricki	3
	Elmidae	Dubiraphia sp.	1
		Optioservus sp.	1
		Stenelmis sp.	3
MEGALOPTERA	Sialidae	Sialis sp.	3
TRICHOPTERA	Hydropsychidae	Hydropsyche bronta	1

SPECIES RICHNESS	22 (good)
BIOTIC INDEX	4.14 (very good)
EPT RICHNESS	13 (very good)
MODEL AFFINITY	59 (good)
ASSESSMENT	slightly impacted
IMPACT SOURCE TYPE	natural (39%)

DESCRIPTION The sample was taken at Sandy Beach Park in Conklin. The habitat was a sandy run rather than a rubble riffle. The invertebrate fauna was diverse, and heavily dominated by mayflies, and it was determined that riffle criteria were more appropriate than sandy stream criteria. Based on the metrics water quality was assessed as slightly impacted, although it may be partially due to habitat.

STREAM SITE:	Susquehanna River, Station 5
LOCATION:	Apalachin, NY,
DATE:	July 21, 2003
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	21
	Baetidae	Acentrella sp.	5
		Baetis intercalaris	4
	Heptageniidae	Leucrocuta sp.	2
		Stenonema terminatum	11
	Caenidae	Caenis sp.	2
	Polymitarcyidae	Ephoron leukon?	1
COLEOPTERA	Gyrinidae	Dineutus sp.	1
	Psephenidae	Psephenus herricki	2
	Elmidae	Optioservus trivittatus	5
		Stenelmis concinna	2
TRICHOPTERA	Philopotamidae	Chimarra obscura	3
	Hydropsychidae	Cheumatopsyche sp.	28
		Hydropsyche leonardi	2
		Hydropsyche phalerata	5
DIPTERA	Tipulidae	Antocha sp.	1
	Simuliidae	Simulium sp.	2
	Chironomidae	Nanocladius (Plecopteracoluthus) downesi	1
		Polypedilum flavum	1
		Undetermined Chironomini	1

SPECIES RICHNESS	20 (good)
BIOTIC INDEX	3.69 (very good)
EPT RICHNESS	11 (very good)
MODEL AFFINITY	66 (very good)
ASSESSMENT	slightly impacted
IMPACT SOURCE TYPE	natural (62%), nutrient (60%)

DESCRIPTION The kick sample was taken upstream of the Apalachin Creek confluence, off Route 17 at Apalachin. The sample location was not in the plume of the Apalachin sewage treatment plant effluent discharge. The invertebrate fauna was dominated by mayflies and caddisflies, and was assessed as slightly impacted, likely by nutrient enrichment.

STREAM SITE:	Susquehanna River, Station 7
LOCATION:	Owego, NY, Rte 17 rest area below Owego
DATE:	July 21, 2003
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA	Tubificidae	Undet. Tubificidae w/o cap. setae	1
MOLLUSCA			
PELECYPODA	Sphaeriidae	Pisidium sp.	10
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	13
	Baetidae	Acentrella sp.	6
		Baetis intercalaris	6
	Heptageniidae	Leucrocuta sp.	3
		Stenacron interpunctatum	1
		Stenonema mediopunctatum	2
		Stenonema pulchellum	1
		Stenonema terminatum	3
	Leptohyphidae	Tricorythodes sp.	2
	Caenidae	Caenis sp.	2
	Polymitarcyidae	Ephoron leukon?	1
COLEOPTERA	Psephenidae	Psephenus herricki	2
	Elmidae	Optioservus sp.	1
		Stenelmis sp.	5
TRICHOPTERA	Philopotamidae	Chimarra obscura	1
	Psychomyiidae	Psychomyia flavida	1
	Hydropsychidae	Cheumatopsyche sp.	18
		Hydropsyche dicantha	1
		Hydropsyche leonardi	2
		Hydropsyche phalerata	8
		Macrostemum sp.	1
DIPTERA	Simuliidae	Simulium sp.	4
	Chironomidae	Thienemannimyia gr. spp.	2
		Cardiocladius obscurus	2
		Tvetenia vitracies	1

SPECIES RICHNESS	27 (very good)
BIOTIC INDEX	3.96 (very good)
EPT RICHNESS	18 (very good)
MODEL AFFINITY	74 (very good)
ASSESSMENT	non-impacted
IMPACT SOURCE TYPE	natural (55%), nutrient enrichment (55%), siltation (50%)

DESCRIPTION The sampling site was opposite the Route 17 rest area below Owego. The invertebrate fauna was dominated by mayflies and caddisflies, with all metrics within the range of non-impacted water quality. Impact Source Determination also indicated influences of nutrient enrichment and siltation.

STREAM SITE:	Susquehanna River, Station 9
LOCATION:	Smithboro, NY, off Church St
DATE:	July 21, 2003
SAMPLE TYPE:	Kick sample
SUBSAMPLE:	100 individuals

MOLLUSCA			
GASTROPODA	Lymnaeidae	Undetermined Lymnaeidae	2
	Sphaeriidae	Pisidium sp.	10
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Isonychiidae	Isonychia bicolor	12
	Baetidae	Acentrella sp.	2
		Baetis intercalaris	3
	Heptageniidae	Epeorus (Iron) sp.	1
		Leucrocuta sp.	3
		Rhithrogena sp.	1
		Stenonema terminatum	3
	Caenidae	Caenis sp.	1
	Potamanthidae	Anthopotamus sp.	1
ODONATA	Coenagrionidae	Argia sp.	1
COLEOPTERA	Psephenidae	Psephenus herricki	2
	Elmidae	Optioservus sp.	2
		Stenelmis sp.	9
TRICHOPTERA	Philopotamidae	Chimarra obscura	4
	Hydropsychidae	Cheumatopsyche sp.	30
		Hydropsyche bronta	1
		Hydropsyche dicantha	1
		Hydropsyche phalerata	3
		Macrostemum zebratum	2
DIPTERA	Simuliidae	Simulium sp.	2
	Chironomidae	Cricotopus tremulus gr.	1
		Polypedilum flavum	2

SPECIES RICHNESS	24 (good)
BIOTIC INDEX	4.29 (very good)
EPT RICHNESS	15 (very good)
MODEL AFFINITY	60 (good)
ASSESSMENT	non-impacted
IMPACT SOURCE TYPE	nutrient enrichment (62%)

DESCRIPTION The kick sample was taken off Church Street in Smithboro. Caddisflies dominated the invertebrate fauna, and snails were also numerous on the stream bottom. Water quality was assessed as non-impacted, but ISD indicated nutrient enrichment as a stressor.

FIELD DATA SUMMARY				
STREAM NAME: Upper Susquehanna River DATE SAMPLED: 7/21/2003 & 7/31/2003 **REACH: Oneonta to Windsor** **FIELD PERSONNEL INVOLVED: Abele, Heitzman**				
STATION	14A	15	16A	18
ARRIVAL TIME AT STATION	1:45	1:05	2:45	11:45
LOCATION	Oneonta	Unadilla	Bainbridge	Windsor
PHYSICAL CHARACTERISTICS				
Width (meters)	25	40	40	65
Depth (meters)	0.3	0.3	0.4	0.3
Current speed (cm per sec.)	125	100	143	120
Substrate (%)				
Rock (>25.4 cm, or bedrock)	0	0	40	10
Rubble (6.35 - 25.4 cm)	30	30	20	15
Gravel (0.2 – 6.35 cm)	40	30	10	25
Sand (0.06 – 2.0 mm)	20	30	30	30
Silt (0.004 – 0.06 mm)	10	10	0	20
Embeddedness (%)	20	30	75	30
CHEMICAL MEASUREMENTS				
Temperature (° C)	22.7	22.8	21.0	22.2
Specific Conductance (umhos)	271	250	172	251
Dissolved Oxygen (mg/l)	8.7	9.7	9.5	8.5
pH	7.8	8.0	7.8	7.5
BIOLOGICAL ATTRIBUTES				
Canopy (%)	15	10	0	5
Aquatic Vegetation				
algae – suspended				
algae – attached, filamentous		X	X	X
algae - diatoms	X	X	X	X
macrophytes or moss		X		X
Occurrence of Macroinvertebrates				
Ephemeroptera (mayflies)	X	X	X	X
Plecoptera (stoneflies)	X		X	X
Trichoptera (caddisflies)	X	X	X	X
Coleoptera (beetles)	X	X	X	X
Megaloptera(dobsonflies,alderflies)		X	X	X
Odonata (dragonflies, damselflies)		X		
Chironomidae (midges)	X	X	X	
Simuliidae (black flies)			X	
Decapoda (crayfish)	X	X		
Gammaridae (scuds)		X		
Mollusca (snails, clams)				X
Oligochaeta (worms)	X			X
Other				
FAUNAL CONDITION	Very good	Very good	Very good	Good

FIELD DATA SUMMARY

STREAM NAME: Susquehanna River DATE SAMPLED: 7/21/2003 & 7/31/2003
REACH: Conklin to Smithboro
FIELD PERSONNEL INVOLVED: Abele, Heitzman

STATION	05	07	09	02
ARRIVAL TIME AT STATION	10:55	10:30	12:25	4:15
LOCATION	Conklin	Apalachin	Below Owego	Smithboro
PHYSICAL CHARACTERISTICS				
Width (meters)	60	50	100	130
Depth (meters)	0.5	0.4	0.4	0.4
Current speed (cm per sec.)	20	80	100	100
Substrate (%)				
Rock (>25.4 cm, or bedrock)	0	0	0	0
Rubble (6.35 - 25.4 cm)	10	30	20	20
Gravel (0.2 – 6.35 cm)	30	30	30	30
Sand (0.06 – 2.0 mm)	30	20	20	30
Silt (0.004 – 0.06 mm)	30	20	30	20
Embeddedness (%)	30	40	40	40
CHEMICAL MEASUREMENTS				
Temperature (°C)	24.2	24.0	23.7	23.6
Specific Conductance (umhos)	246	299	311	315
Dissolved Oxygen (mg/l)	9.2	7.9	8.3	8.7
pH	7.6	7.9	8.1	8.0
BIOLOGICAL ATTRIBUTES				
Canopy (%)	0	0	0	0
Aquatic Vegetation				
algae – suspended				
algae – attached, filamentous		X		
algae - diatoms		X	X	XX
macrophytes or moss	X	X		
Occurrence of Macroinvertebrates				
Ephemeroptera (mayflies)	X	X	X	X
Plecoptera (stoneflies)	X	X	X	X
Trichoptera (caddisflies)		X	X	X
Coleoptera (beetles)	X		X	
Megaloptera(dobsonflies,alderflies)		X		X
Odonata (dragonflies, damselflies)				
Chironomidae (midges)	X	X	X	X
Simuliidae (black flies)				
Decapoda (crayfish)	X			
Gammaridae (scuds)				
Mollusca (snails, clams)	X			
Oligochaeta (worms)				X
Other		X		
FAUNAL CONDITION	Good	Very good	Good	Good

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 five minutes for a distance of five 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). If the results of the identification process are ambiguous, suspected of being spurious, or do not yield a clear water quality assessment, additional subsampling may be required.

MACROINVERTEBRATE COMMUNITY PARAMETERS

1. Species richness is the total number of species or taxa found in the sample. For subsamples of 100-organisms each that are taken from kick samples, expected ranges in most New York State streams are: greater than 26, non-impacted; 19-26, slightly impacted; 11 - 18, moderately impacted; less than 11, severely impacted.

2. EPT Richness 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. Hilsnhoff 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; 4.5 1-6.50, slightly impacted; 6.5 1-8.50, 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 seven major macroinvertebrate groups (Novak and Bode, 1992). Percent abundances in the model community are 40% Ephemeroptera, 5% Plecoptera, 10% Trichoptera, 10% Coleoptera, 20% Chironomidae, 5% Oligochaeta, and 10% Other. Impact ranges are: greater than 64, non-impacted; 50-64, slightly impacted; 35-49, moderately impacted; and less than 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. NY S 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.

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 richness, biotic index, and percent model affinity (*see Macroinvertebrate Community Parameters Appendix*). The consensus is based on the determination of the majority of the parameters. Since parameters measure different aspects of the macroinvertebrate community, they cannot be expected to always form unanimous assessments. The assessment ranges given for each parameter are based on subsamples of 100-organism each that are taken from macroinvertebrate riffle kick samples. These assessments 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; EPT richness 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.

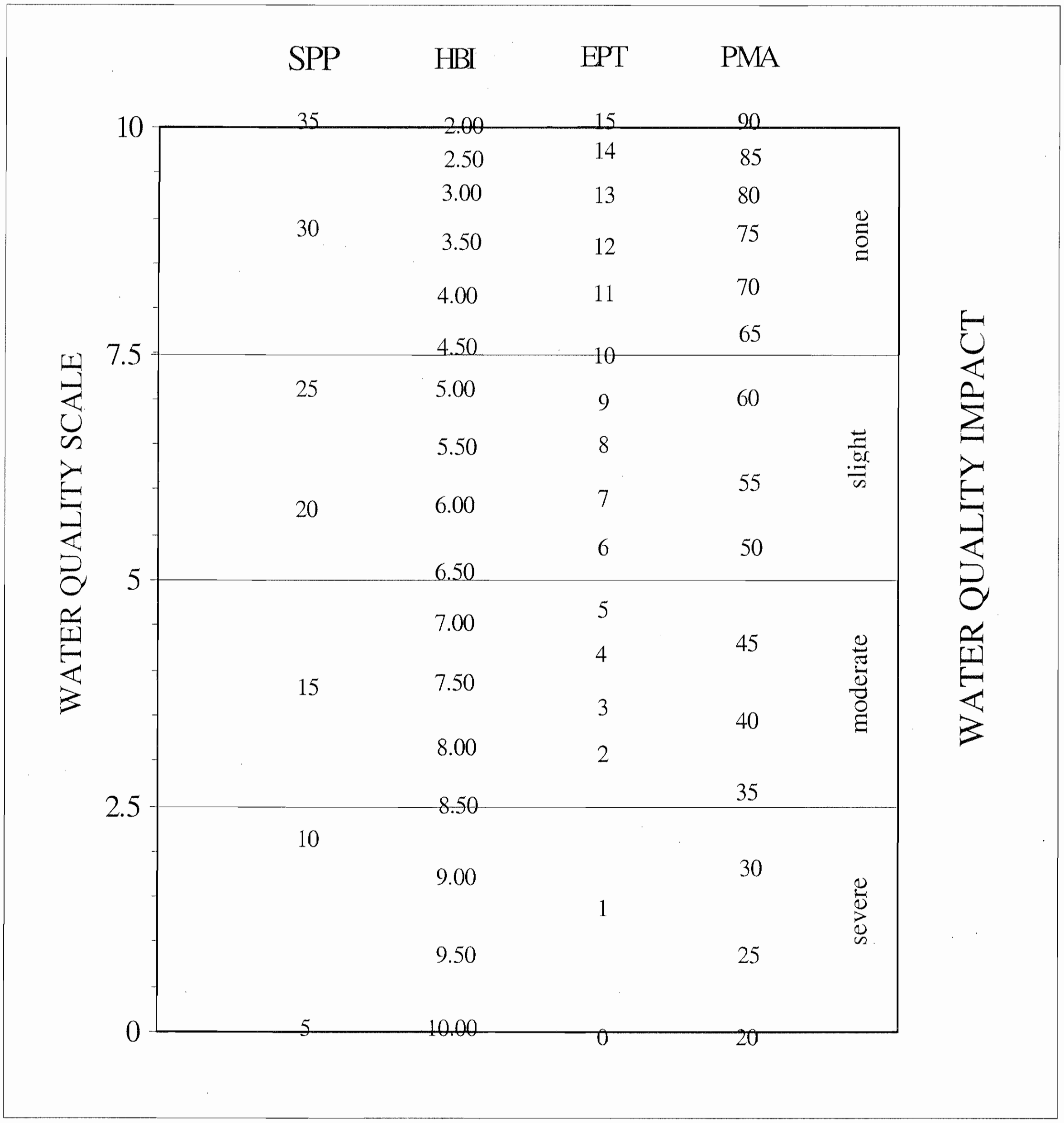
2. *Slightly impacted* Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness usually is 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50. 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 richness 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 richness 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.

Biological Assessment Profile: Conversion of Index values to Common 10-Scale

The Biological Assessment Profile of index values, developed by Phil O'Brien, Division of Water, NYSDEC, is a method of plotting biological index values on a common scale of water-quality impact. Values from the four indices, defined in the Macroinvertebrate Community Parameter Appendix, are converted to a common 0-10 scale using the formulae in the Quality Assurance document (Bode, et al., 2002) and as shown in the figure below.



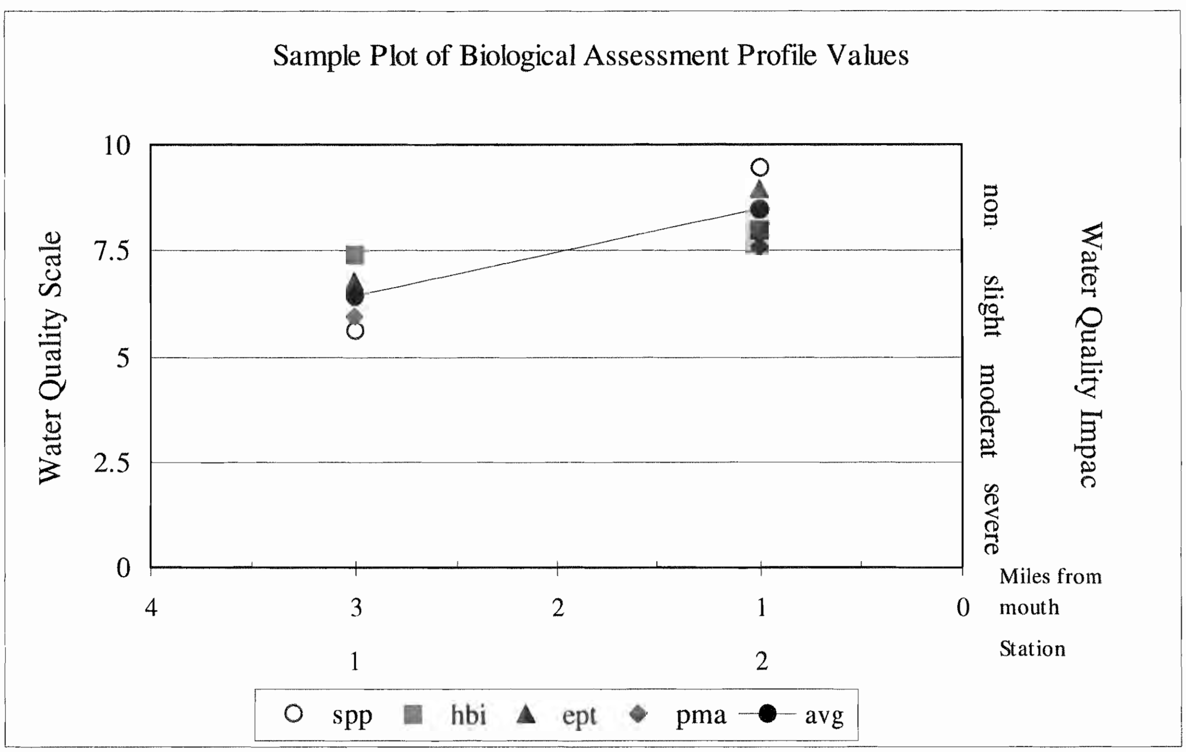
Biological Assessment Profile: Plotting Values

To plot survey data:
1. Position each site on the x-axis according to miles or tenths of a mile upstream of the mouth.
2. Plot the values of the four indices for each site as indicated by the common scale.
3. Calculate the mean of the four values and plot the result. This represents the assessed impact for each site.

Example data:

	Station 1		Station 2	
	metric value	10-scale value	metric value	10-scale value
Species richness	20	5.59	33	9.44
Hilsenhoff biotic index	5.00	7.40	4.00	8.00
EPT richness	9	6.80	13	9.00
Percent model affinity	55	5.97	65	7.60
Average		6.44 (slight)		8.51 (non-)

Table IV-B. Sample Plot of Biological Assessment Profile values



Water Quality Assessment Criteria

Water Quality Assessment Criteria for Non-Navigable Flowing Waters

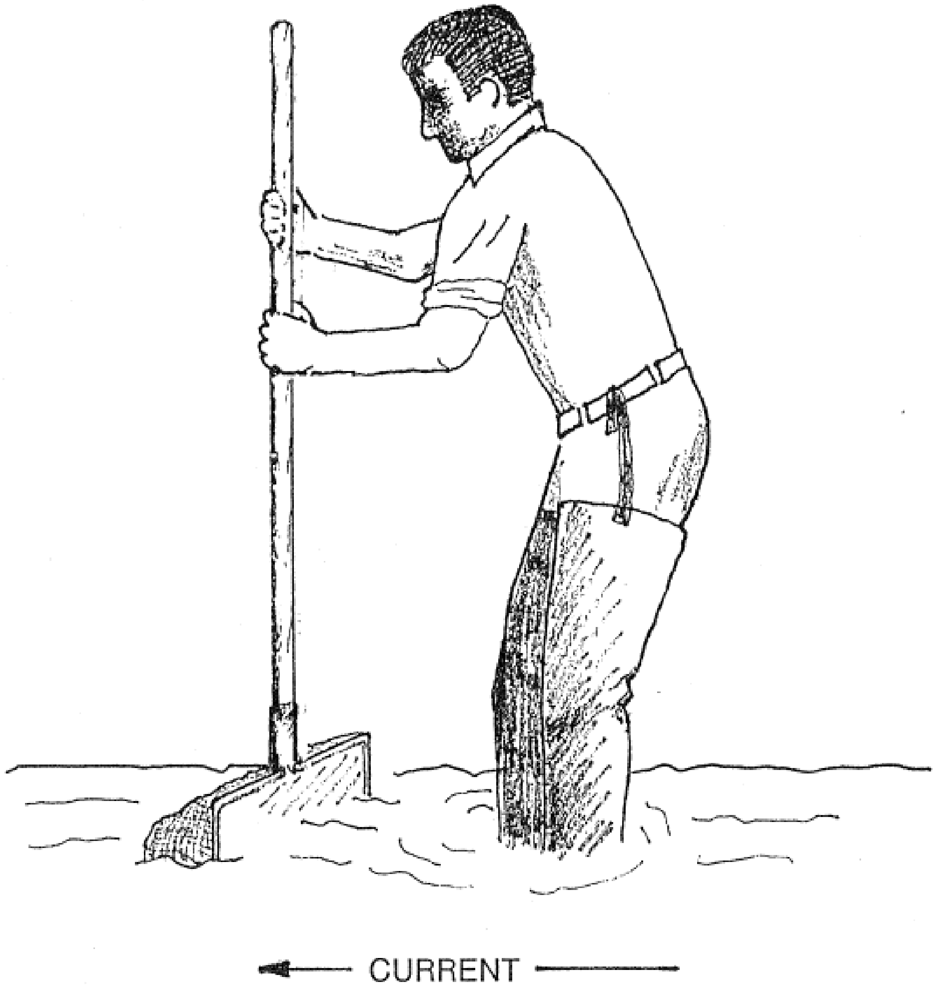
	Species Richness	Hilsenhoff Biotic Index	EPT Richness	Percent Model Affinity#	Species Diversity*
Non-Impacted	>26	0.00-4.50	>10	>64	>4
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	3.01-4.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	2.01-3.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	0.00-2.00

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 Richness	Species 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

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.

Appendix VIII-A. Aquatic Macroinvertebrates Usually Indicative of Good Water Quality

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.

MAYFLIES

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.

STONEFLIES

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 nutrient-enriched stream segments.

CADDISFLIES

The most common beetles in streams are riffle beetles (adult and larva pictured) and water pennies (not shown). Most of these require a swift current and an adequate supply of oxygen, and are generally considered clean-water indicators.

BEETLES

Appendix VIII-B. Aquatic Macroinvertebrates Usually Indicative of Poor Water Quality

Midges are the most common aquatic flies. The larvae occur in almost any aquatic situation. Many species are very tolerant to pollution. Large, red midge larvae called “bloodworms” indicate organic enrichment. Other midge larvae filter plankton, indicating nutrient enrichment when numerous.

MIDGES

Black fly larvae have specialized structures for filtering plankton and bacteria from the water, and require a strong current. Some species are tolerant of organic enrichment and toxic contaminants, while others are intolerant of pollutants.

BLACK FLIES

The segmented worms include the leeches and the small aquatic worms. 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.

WORMS

Aquatic sowbugs are crustaceans that are often numerous in situations of high organic content and low oxygen levels. They are classic indicators of sewage pollution, and can also thrive in toxic situations.

SOWBUGS

Digital images by Larry Abele, New York State Department of Environmental Conservation, Stream Biomonitoring Unit.

Appendix IX. The Rationale of Biological Monitoring

Biological monitoring 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 that they:

- are sensitive to environmental impacts
- are less mobile than fish, and thus cannot avoid discharges
- can indicate effects of spills, intermittent discharges, and lapses in treatment
- are indicators of overall, integrated water quality, including synergistic effects
- are abundant in most streams and are relatively easy and inexpensive to sample
- are able to detect non-chemical impacts to the habitat, e.g. siltation or thermal changes
- are vital components of the aquatic ecosystem and important as a food source for fish
- are more readily perceived by the public as tangible indicators of water quality
- can often provide an on-site estimate of water quality
- can often be used to identify specific stresses or sources of impairment
- can be preserved and archived for decades, allowing for direct comparison of specimens
- 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.

Anthropogenic: caused by human actions

Assessment: a diagnosis or evaluation of water quality

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

Bioaccumulate: accumulate contaminants in the tissues of an organism

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 richness: the number of species of mayflies (**E**phemeroptera), stoneflies (**P**lecoptera), and caddisflies (**T**richoptera) in a sample or subsample

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

Longitudinal trends: upstream-downstream changes in water quality in a river or stream

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

PAHs: Polycyclic Aromatic Hydrocarbons, a class of organic compounds that are often toxic or carcinogenic

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

Riffle: wadeable stretch of stream usually having a rubble bottom and sufficient current to break the water surface; 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

Synergistic effect: an effect produced by the combination of two factors that is greater than the sum of the two factors

Tolerant: able to survive poor water quality

Impact Source Determination Methods and Community Models

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. ISD 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 was 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 ISD (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 percent, 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 subsamples of 100-organisms each that are taken from traveling kick samples of New York State streams. Application of these methods for data derived from other sampling methods, habitats, or geographical areas would likely require modification of the models.

Impact Source Determination 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

Impact Source Determination Models

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

Impact Source Determination Models

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

Impact Source Determination Models

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

Impact Source Determination Models

	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