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DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Unadilla River

Biological Assessment

2012 Survey

New York State
Department of Environmental Conservation

BIOLOGICAL STREAM ASSESSMENT

Unadilla River
Chenango, Madison, and Otsego Counties, New York
Susquehanna River Basin

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Stream: Unadilla River

River Basin: Susquehanna

Reach: Leonardsville to Holmesville, NY

Background

The Stream Biomonitoring Unit sampled six locations on the Unadilla River from Leonardsville to Holmesville New York, August 14-16, 2012. The survey was initiated at the request of Department of Environmental Conservation (NYSDEC) Region 4 and 7 offices over concerns surrounding a potential die-off of freshwater mussels. In a report on the status of mussel populations in portions of the Susquehanna River basin Lord and Harman (2011) suggested the loss of significant numbers of mussels in the Unadilla River. Speculation surrounded the possible sources of impact. Possibilities included the illegal and/or legal spreading of whey by-products on agricultural fields from Agro-farma, Inc. contracted haulers, Agro-farma, Inc.'s discharge to the Unadilla River, chemical contamination of mussel tissues, and natural mussel population dynamics such as parasites or disease. As a result of the uncertainty surrounding the issue, the survey reported on here was conducted. The objectives of the study were to characterize populations of freshwater pearly mussels (Family: Unionidae) and if evidence of a pearly mussel die-off was found, determine possible source(s), and to assess general water quality and identify any impacts to biological communities. Potential sources of impact to water quality were isolated through strategically locating sampling locations. These objectives were carried out by:

1. Surveying the population of Unionidae present in the Unadilla River.
2. Analyzing specimens of Uniondae for parasites and tissue contaminants
3. Conducting a biological assessment of water quality using benthic macroinvertebrates

The survey of mussel populations and histological analysis was conducted in accordance with the Quality Assurance Project Plan specific to this project (NYSDEC 2012b) and outlined in this document. Mussel specimens were analyzed for both parasites and tissue contaminants to help identify potential sources of impact. Processing of tissue samples for priority contaminants followed the methods in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC, 2012). Results of the survey of mussel populations were compared with previous work conducted on the Unadilla River by Maricle (2010) and Lord and Harman (2010, 2011). These studies represent the most recent and similar surveys of Unadilla River Unionidae prior to any suspected impacts to mussel populations.

To characterize water quality based on benthic macroinvertebrate communities, a traveling kick sample was collected from riffle areas at each of six sites. Methods used are described in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC, 2012) and summarized in the appendices of this document. The contents of each sample were field-inspected to determine major groups of organisms present, and then preserved in alcohol for laboratory inspection of 100-specimen subsamples from each site. Water quality results were compared with data previously collected by the NYSDEC. Previous surveys include biological assessments of water quality along the entire length of the Unadilla River in 1998 and at select locations from 1991 through 2009 as part of the NYSDEC's Rotating Integrated Basin Studies Program (RIBS).

Results and Conclusions

1. A reduction in abundance of the living freshwater mussel population in the Unadilla River has occurred since 2010 when compared with the work of Maricle (2010). A limited number of living organisms and an abundance of spent shells and shell fragments were collected in 2012. Dead:live mussel ratios were high at all sites with an average 40 dead mussels for every 1 live mussel. Similar data collected by Maricle in 2010 resulted in dead:live ratios of only 2:1.

2. The 2012 survey found evidence of all species of Greatest Conservation Need collected by Maricle (2010). However, *Alasmidonta varicosa* and *Lampsilis cariosa* were only collected as spent shells in 2012.

3. The examination of Unionidae tissue from the Unadilla River did not isolate specific parasites or contaminants as factors in the loss of mussels since 2010.

4. While changes to the population of Unionidae have been documented by this survey, the cause of the decline in live mussel abundance cannot be determined by these results.

5. Water quality assessment indicated slightly impacted conditions at most sampling locations. This represents a decline in water quality in the Unadilla River from previous surveys. Deposition of fine sediment appears to be the driving factor in present impacts to benthic macroinvertebrate communities.

Discussion

The Unadilla River is a tributary to the Susquehanna River and located in south-central New York State. It stretches approximately 70 miles from its headwaters in Millers Mill (Herkimer County) to its confluence with the Susquehanna River near Sidney (Delaware County). The Unadilla River forms the boundary between Madison, Chenango, and Otsego Counties. The Unadilla River watershed is approximately 561 mi^2 and is dominated by forest cover (64%), with most of the remaining area dedicated to agriculture (35%). Fisheries in the river consist of brown trout in the upper reaches transitioning to warm water species including walleye, smallmouth bass and carp. Despite healthy fish populations in the river, the entire Unadilla River and its tributaries are listed as impaired for fish consumption due to mercury contamination (NYSDEC 2009).

The NYSDEC previously conducted several biological assessments of water quality in the Unadilla River. A multiple site biological assessment survey was conducted in 1998 to assess general water quality conditions along the entire length of the river. Results indicated non-impacted water quality with mild nutrient enrichment (Bode et al. 1999). Various sites were also sampled from 1991 through 2009 as part of the RIBS program. These surveys resulted in non-, slight, or moderately impacted water quality assessments, depending on location in the watershed. Any impacts in the river were attributed to non-point source nutrient runoff from the watershed (Bode et al. 2004).

Freshwater pearly mussel populations in the Unadilla River have also been studied over concern for the status of NYS listed Species of Greatest Conservation Need (SGCN) (http://www.dec.ny.gov/animals/9406.html). Strayer and Fetterman (1999) conducted a detailed survey of the Unionidae in the Upper Susquehanna River watershed, including sites on the Unadilla River. This work was a resurvey of efforts conducted between 1955-1965 (Clarke and Berg 1959, Harman 1970). More focused Unadilla River surveys of Unionidae were conducted by Maricle (2010) and Lord and Harman (2010, 2011). These surveys attempted to characterize the distribution and condition of SGCN species in the Unadilla River including *Alasmidonta marginata*, *A. varicosa*, *Lasmigona subviridis*, and *Lampsilis cariosa*. Results of these surveys consistently found little change in population characteristics from historical records (Strayer and Fetterman 1999). Populations of Unionidae in the Unadilla River were determined to be stable with evidence of all four SGCN present. In some instances expansion of their distribution was even suggested (Lord and Harman 2010, Maricle 2010). In 2011 however, although still finding evidence of all four SGCN Lord and Harman (2011) observed large numbers of spent (empty) shells. As noted in their report “tens of thousands of mussels have been killed in the last year” (Lord and Harman 2011). The apparent increase in spent shells from recent surveys caused concern among natural resource managers in the region, resulting in the current study, which was planned as a follow up to Maricle (2010) and Lord and Harman (2011).

Unionidae Community and Population Analysis:

Freshwater pearly mussel populations were surveyed at each of six sampling locations from August 14-16, 2012 (Figure 1, 2a-e, Table 1). These locations were selected because they corresponded with historical NYSDEC water quality sampling locations (Stations 02, 03, and 04), were located within areas of concern (AOCs) related to potential mussel die-off (Stations 00B, 02, 02A, and 02B), and bracketed the discharge of Agro-farma, Inc., a potential source of impact.

At each sampling location the area of suitable mussel habitat meeting the requirements of the defined Prescribed Search Area (PSA) (NYSDEC 2012b) was delineated prior to data collection within one stream reach. The PSA for this study was all riffle and run habitat ≤0.5 meters in depth. Pools (especially those deeper than 0.5 meters) were not considered as part of the PSA for this study. This PSA was selected to concentrate on collection of the most sensitive, pollution intolerant mussel communities which favor habitats of faster flowing, oxygen rich water. Reach length was defined as 100 meters, the center point of which was determined by the XY coordinates of the benthic macroinvertebrate sampling point. At each sampling location the habitats representing the PSA were measured and delineated using a meter tape and flagging. This defined the specific area to be searched at each location.

The collection of mussel specimens from the PSA at each site consisted of tactile searches, moving from downstream to upstream and bank to bank. This minimized disturbance (turbidity) in the PSA. Mussels were collected by hand while using mask and snorkel as necessary. Collections included both live and spent shells. The collection of all spent shells observed within the PSA at each site allowed for the calculation of dead:live ratios with the intent of identifying areas of recent mortality. For example, areas with greater dead to live ratios might indicate where a loss of mussels may have occurred. To minimize stress, each individual live mussel collected was processed and immediately returned to its original habitat and position in the river. Dead or spent shells and shell fragments collected were placed in a mesh bag for identification and processing after search of the PSA was completed.

For each collected specimen, the following information was recorded:

1. Species identification
2. Shell length, defined as the distance between the anterior and posterior shell margins and recorded using standard metric rulers
3. Record of mussel state, either “Live” or “Spent/Dead”
4. For “Live” mussels record of whether they were A) Live – no problems, or B) Moribund
5. For “Dead” mussels record of whether they were A) Dead – rotting and open with mussel intact, or B) Empty shell – completely clean

At each sampling location a minimum of 5 specimens were collected for histological and tissue contaminant analysis. These organisms were kept alive in separate containers with aeration and native river water to prevent cross contamination between specimens and between sampling locations. These specimens were kept alive until processing at the end of the week following collection. Tissue sample collection and processing was conducted in accordance with the procedures outlined in NYSDEC SOP#208-12. A separate portion of each organism was retained for histology and analysis of tissue contaminants. For tissue contaminants the portion of each specimen was combined providing a single tissue sample from each sampling station.

From the results of the present survey it appears that a reduction in the abundance of Unionidae has occurred in the Unadilla River since 2010 when compared to the work of Maricle (2010). A small number of living organisms and an abundance of spent shells and shell fragments were collected during the survey. Dead:live ratios were high at all sites with an average 40 dead mussels for every 1 live mussel (Table 2). The survey of Unionidae completed by Maricle (2010) contains the most recent, complete, and similar dataset from the Unadilla River. Comparing the data from Maricle (2010) with the data collected and presented here a pre- and post potential die-off comparison could be made. Using his data from the 13 different sites surveyed, we calculated dead:live ratios and found his survey yielded an average of 2 dead mussels for every 1 live mussel. This suggests a 20 fold increase in the number of dead mussels collected in our 2012 survey compared with that of 2010. Similarly our 2012 survey averaged 7 live mussels per site (Table 2) compared to 30 in 2010 (Maricle 2010). This represents a potential loss of approximately 4 times the number of live mussels collected in 2010.

Although the data suggest a notable decline in the number of live Unionidae since 2010, our results do not show longitudinal trends in dead:live ratios that can be linked to land spreading of whey or a particular discharge. Some of the lowest dead:live ratios occurred downstream of both the Agro-farma, Inc. discharge and areas of permitted land spreading of whey (stations 02B, 03, and 04) (Figures 2c-e and Figure 3). Therefore, the results of this survey do not point to any single known impact source. Further investigation of the area near station 02A may yield insight into why this station exhibited such a drastic increase in the dead:live ratio (Figure 3). This station is in close proximity to some of the most intensive permitted land spreading of agricultural fertilizers and is within a reach of the Unadilla River identified by Lord and Harman (2011) as experiencing significant die-off of Unionidae (Figure 2c). However, connecting the loss of mussels at this site to land spreading of whey is not possible from the results of this survey. Other factors not connected to pollution could contribute to concentrations of empty mussel shells. For example, it is unknown how much influence the physical character of the river has on the redistribution of spent shells from their original location especially under high flow events.

Factoring in both the spent shells and live organisms collected, a total of 10 different Unionidae were found and although few in number, live mussels were found at all sites (Table 2). Similar to the findings of Maricle (2010) evidence of SGCN Unionidae were collected during the present survey including *Alasmidonta marginata* (Elktoe), *Alasmidonta varicosa* (Brook Floater), *Lampsilis cariosa* (Yellow Lampmussel), and *Lasmigona subviridis* (Green Floater) (Table 2). The evidence of *Alasmidonta varicosa* is in contrast with Maricle (2010) since his survey found no evidence of this species. However, *Alasmidonta varicosa* and *Lampsilis cariosa* were only collected as spent shells during the 2012 survey. For *Lampsilis cariosa* this is a change from 2010 in which it was approximately 5% of the live population of Unionidae collected in the Unadilla River (calculated from Maricle 2010).

Examination of Unadilla River Unionid Mussels for Parasites and Tissue Contaminants:

Histological analysis of 25 collected mussel specimens was conducted by Dr. Daniel Molloy (Molloy & Associates, LLC). Table 3 summarizes the results of this analysis. Of the 25 specimens, one (#081512-02A-03) was dead at the time of collection (i.e., shells gaping and tissues degenerated) and immediately fixed in 10% formalin. On August 17th, the internal soft tissues of all 25 specimens were dissected out of their shells, and a cross section of tissue was removed and placed in a histological tissue cassette. These 25 cassettes were held in 10% neutral buffered formalin for 3 days, followed by rinsing and storage in 70% ethyl alcohol. The tissue in each of the 25 cassettes was then dehydrated, cleared, embedded, sectioned, mounted on glass sides, stained (using hematoxylin and eosin), and examined for the presence of parasites with a light microscope (≤1000X).

During dissection of the specimens it was noted that one dead mussel (specimen #081512-02A-03) had little body tissue remaining. Its visceral mass was still attached to its gaping shells, but was reduced to a small strip of tissue that did not exhibit any signs or symptoms of parasitic disease. The one moribund specimen (#081512-02B-06) was still alive and gaping at the time of dissection. Although appearing stressed (i.e., gaping), it did not exhibit any signs or symptoms of parasitic disease. None of the 23 live specimens exhibited signs or symptoms of parasitic disease during dissection (Table 3).

Results of the examination for parasites suggested trematodes were the only parasites present. Trematodes in the family Aspidogastridae (likely *Aspidogaster conchicola*) were present in specimens from stations 00B, 02, and 02A, and trematodes in the family Bucephalidae (likely a *Rhipidocotyle* sp.) were present in specimens at stations 02B, 03, 04. These two trematode taxa are common in North American Unionidae (Grizzle and Brunner, 2007). Aspidogastridae trematodes can cause internal host damage, but clear documentation is lacking in the literature that they kill their hosts. Bucephalidae trematodes are not normally considered lethal parasites. Under normal conditions, their most serious effect is host sterility since they block gonad development. There is some evidence (Jokela et al., 2005) however, suggesting that Unionidae may be less tolerant of environmental stress when infected with these trematodes and thus have higher risk of mortality than uninfected individuals. If stressful environmental conditions such as elevated water temperatures, or anoxia were present at stations 02B, 03, 04 higher mortality rates might occur in Bucephalidae-infected individuals. However, loss of mussels from Bucephalidae seems unlikely, since there were larger numbers of dead mussels at sampling stations with Aspidogastridae tematodes (Table 3).

The 25 specimens used in the histological analysis were also used for the analysis of tissue contamination, since contaminants can bioconcentrate in mussel tissues to many times the concentrations found in water. The presence of contaminants could indicate a possible cause for the recent apparent decline in live mussels in the river. Samples were freeze-dried and analyzed by a contract laboratory. Analyses were conducted for polycyhlorinated biphenyls (as total PCBs), polynuclear aromatic hydrocarbons (PAHs), and metals..

Two metals, mercury and arsenic, were present in concentrations above the NYSDEC levels of concern for mussels (Table 4), although it is unlikely these concentrations are high enough to result in significant mortality of Unionidae. These results are in keeping with the continued listing of the Unadilla River as impaired for fish consumption due to mercury contamination (NYSDEC 2009). Concentrations for all other parameters were either below levels of concern or below detection limits (Table 4).

Biological Assessment of Water Quality:

Water quality in the Unadilla River was determined based on analysis of benthic macroinvertebrate communities. Results of the water quality assessment survey indicated slightly impacted conditions at most sampling locations (Figure 4). An assessment of slight impact indicates the benthic macroinvertebrate community is altered from natural conditions but still reflects good water quality. Aquatic life is considered to be fully supported in the stream at these locations. One sampling location, station 02B (Figure 2c, Table 1) which was located immediately downstream of the Agro-farma, Inc. discharge, was assessed as non-impacted (Figure 4). Sampling results reflect very good water quality. Aquatic life is considered to be fully supported at this location as well. However, it should be noted that the water quality score for this location fell just above the threshold between non- and slightly impacted. Based on the expected variability in biological assessment results (Smith and Bode 2004), water quality at this location likely varies between non- and slightly impacted depending upon the physical conditions of the stream in a given year.

Although macroinvertebrate communities were diverse and had high richness of Ephemeroptera, Plecoptera, and Trichoptera (EPT, Figure 4), the communities were indicative of fine sediment deposition and suspended fine particulate organic as indicated by impact source determination (ISD) (Table 5). These are typical results from stressors common in watersheds dominated by agricultural practices, including siltation and eutrophication. Silt tolerant mayflies in the genus *Caenis* and water column filtering caddisflies (*Cheumatopsyche* and *Hydropsyche*) were present and abundant. Nutrient tolerant riffle beetles (*Stenelmis crenata*) and non-biting midges (*Polypedilum flavum*) were also present in abundance at all sites (Table 6).

Physical habitat attributes important for the survival of aquatic life were assessed as either natural or severely altered (Figure 5). At stations 00B, 02B, 03, and 04, habitat alteration is likely not a factor limiting the development of benthic macroinvertebrate communities. At these locations assessment of both in-stream and riparian habitat reflects conditions minimally influenced by human disturbance. However, at stations 02 and 02A habitat has been degraded. Therefore, the composition of the benthic macroinvertebrate community may be limited regardless of water quality. The habitat variables most altered at these two locations included general channel alteration including channel straightening, the deposition of fine sediments, and a lack of bank stability (Table 7). Results of pebble count substrate analysis indicate the dominant substrate is a mix of gravel and coarse gravel with finer sediments such as sand and silt present at most sites (Figure 6 and Table 8). When coupled with the habitat assessment information these data suggest the Unadilla River is subject to fine sediment deposition from eroding, unstable stream banks, the long term effects of which may be reduction of habitat available for colonization by macroinvertebrates.

Impact source determination also supports the conclusion that deposition of fine sediment is a potential source of impact to benthic macroinvertebrate communities in the Unadilla River. At both stations 02 and 02A, where habitat is severely altered, ISD indicates siltation as the probable source of impact (Table 5). However, ISD also scores the communities at these sites as natural. Therefore siltation and habitat modification at these locations is beginning to contribute to changes in macroinvertebrate community structure but not yet enough to cause significant alteration. ISD scored most stations high for siltation (Table 5) as well as a mix of other sources such as organic wastes or urban runoff.

Results of the present water quality assessment represent a decline in water quality in the Unadilla River since the most recent and complete biological assessment survey (Bode et al. 1999). The NYSDEC's 1998 survey resulted in non-impacted assessment at all sampling locations and indicated mild nutrient enrichment (Bode et al. 1999). In the present survey all sampling locations except one were assessed as slightly impacted suggesting a worsening in conditions. Additionally, the results of this investigation suggest impact from the deposition of fine sediments in the Unadilla River in addition to nutrient enrichment. However, without pebble count data from past surveys we can't be sure that sediment deposition was not previously a problem as well.

Conclusions

An overall reduction in abundance of the living population of Unionidae in the Unadilla River has occurred since 2010. During the 2012 survey, a limited number of living organisms and an abundance of spent shells and shell fragments were collected, with very high dead:live ratios at all sites. Similar data collected in 2010 resulted in much lower ratios. Although the data suggest a difference in the number of live Unionidae, our results do not show longitudinal trends pointing toward any one specific source of impact. Although the number of live mussels in the Unadilla River appears to be lower than recorded in 2010, similar evidence of SGCN species to that of Maricle (2010) was observed. However, one species, *Lampsilis cariosa* that was collected only as spent shells was approximately 5% of the live population of Unionidae in 2010.

The examination of Unionidae tissue from the Unadilla River did not yield results that could isolate specific parasites or contaminants as factors in the loss of mussels since 2010. The presence of parasites (trematodes) was not surprising as they are common and widespread in Unionidae. If coupled with high nutrient concentrations certain parasites may cause stress and limit survival (Jokela et al., 2005). However, nutrient concentrations high enough to cause such an occurrence would also likely limit the benthic macroinvertebrate community. The results of the biological assessment survey do not indicate severe nutrient impact. Similarly, except for mercury and arsenic, the tissue analysis data do not suggest any significant build up of contaminant concentrations in mussel tissues. Although the concentration of mercury exceeded the levels of concern set by the NYSDEC this is a long standing known problem documented before 2010. Therefore, it is unlikely these concentrations were high enough or suddenly became high enough to result in any significant loss of Unionidae. Documentation of the mercury contamination however should support the continuation of listing the Unadilla River as impaired for fish consumption.

The NYSDEC's previous biological assessments for water quality in the Unadilla River in the late 1990's suggested non-impacted conditions with indications of non-point source nutrient runoff affecting communities (Bode et al. 2004). The results of the present water quality survey indicate slightly impacted conditions at most sampling locations (Figure 3). This represents a decline in water quality in the Unadilla River. Currently nutrients do not appear to be the dominant source of impact to biological condition, instead impact from the deposition of fine sediment is indicated.

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Figure 1. Overview map, Unadilla River watershed.

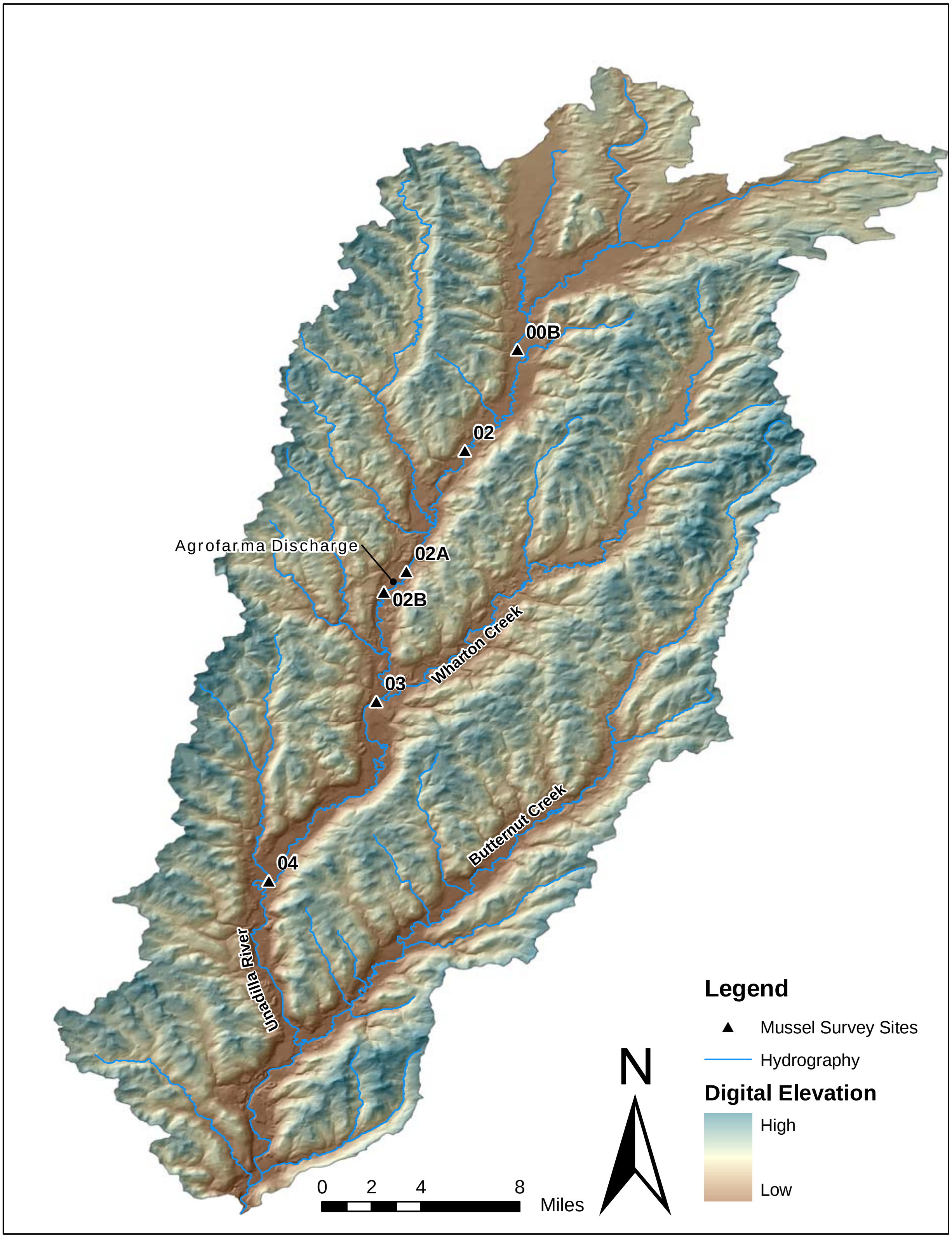


Figure 2a. Site location map, Unadilla River, Station 00B. Mussel AOC boundary source Lord and Harman (2011). Application field boundary source NYSDEC regional offices 4 and 7.

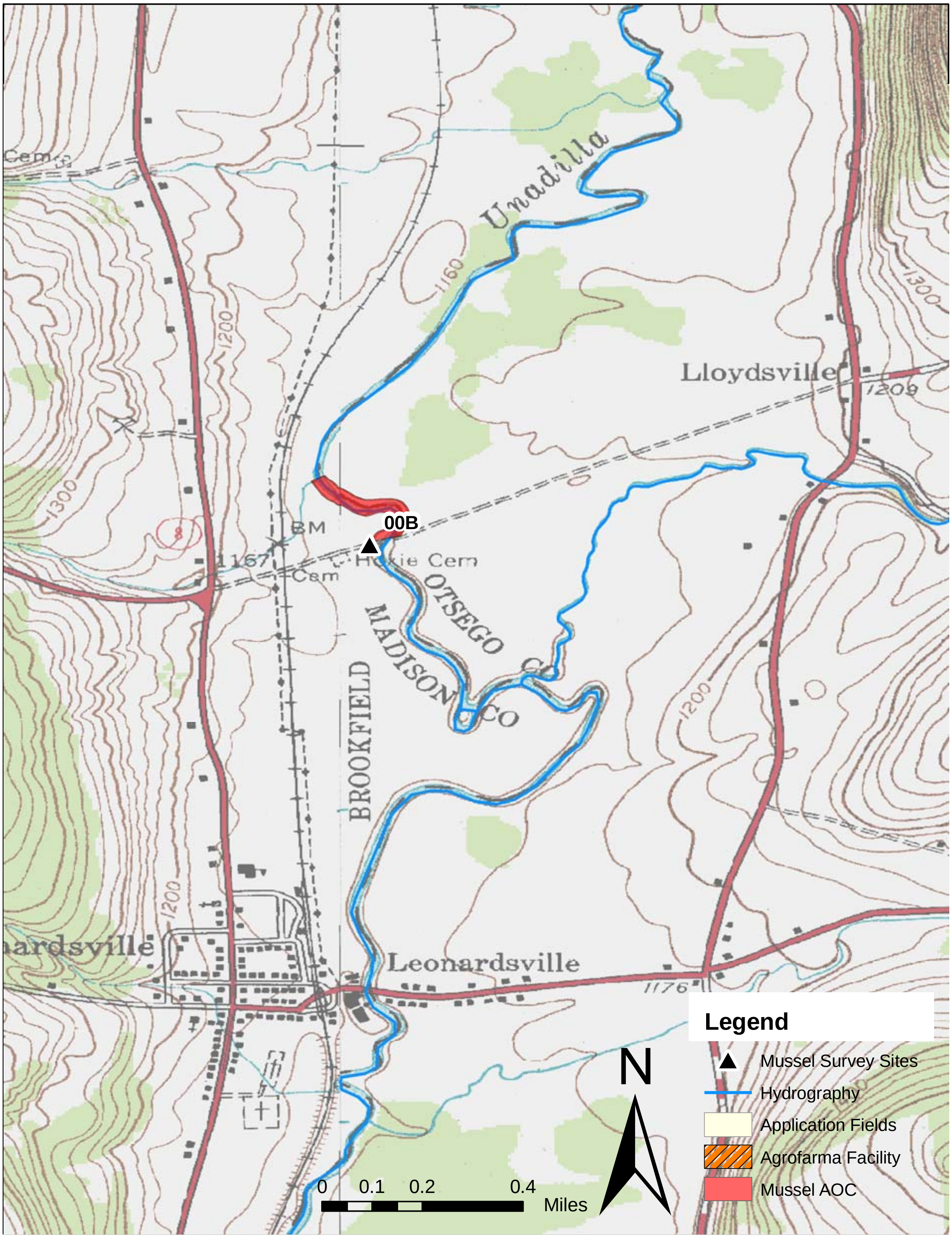


Figure 2b. Site location map, Unadilla River, Station 02. Mussel AOC boundary source Lord and Harman (2011). Application field boundary source NYSDEC regional offices 4 and 7.

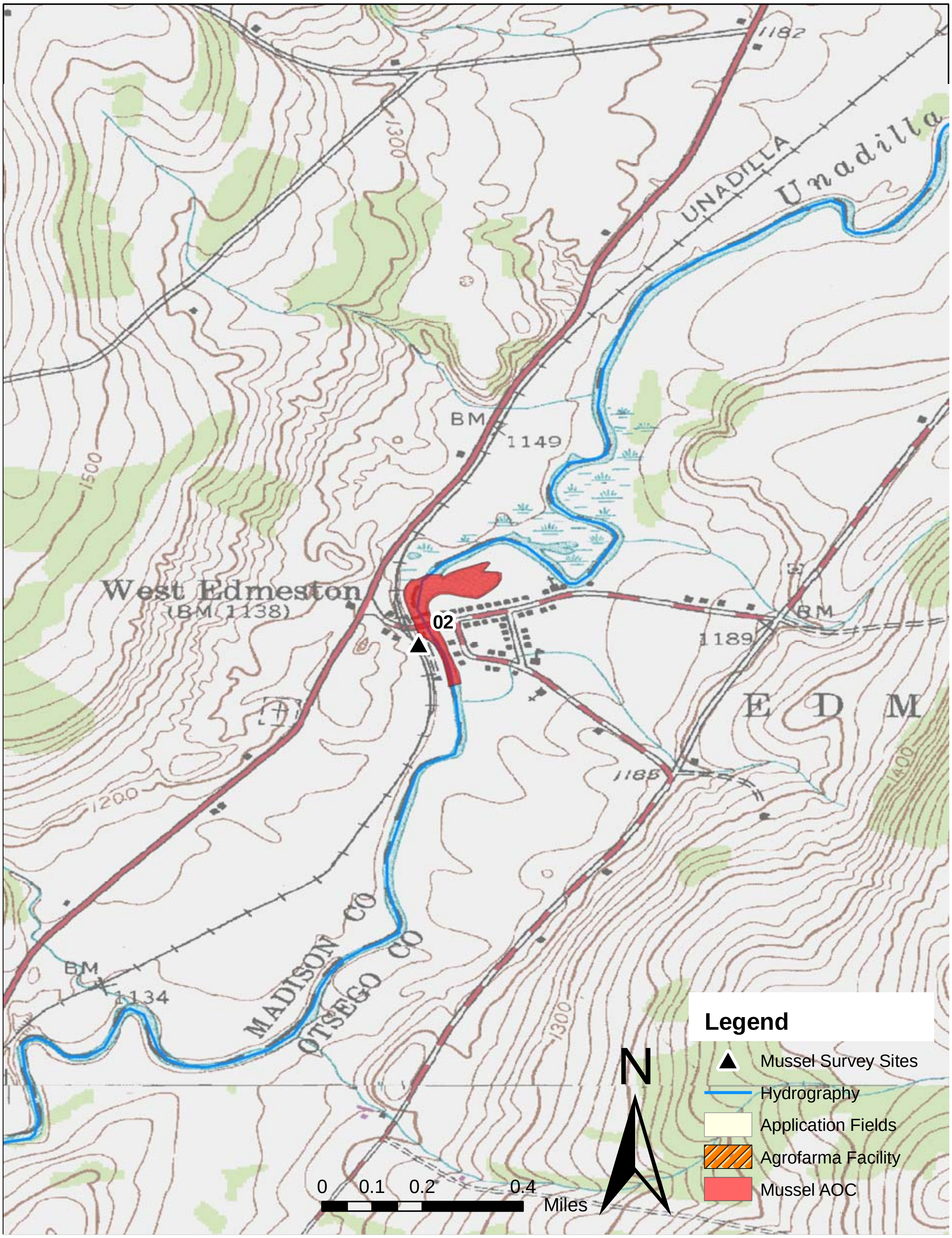


Figure 2c. Site location map, Unadilla River, Stations 02A and 02B. Mussel AOC boundary source Lord and Harman (2011). Application field boundary source NYSDEC regional offices 4 and 7.

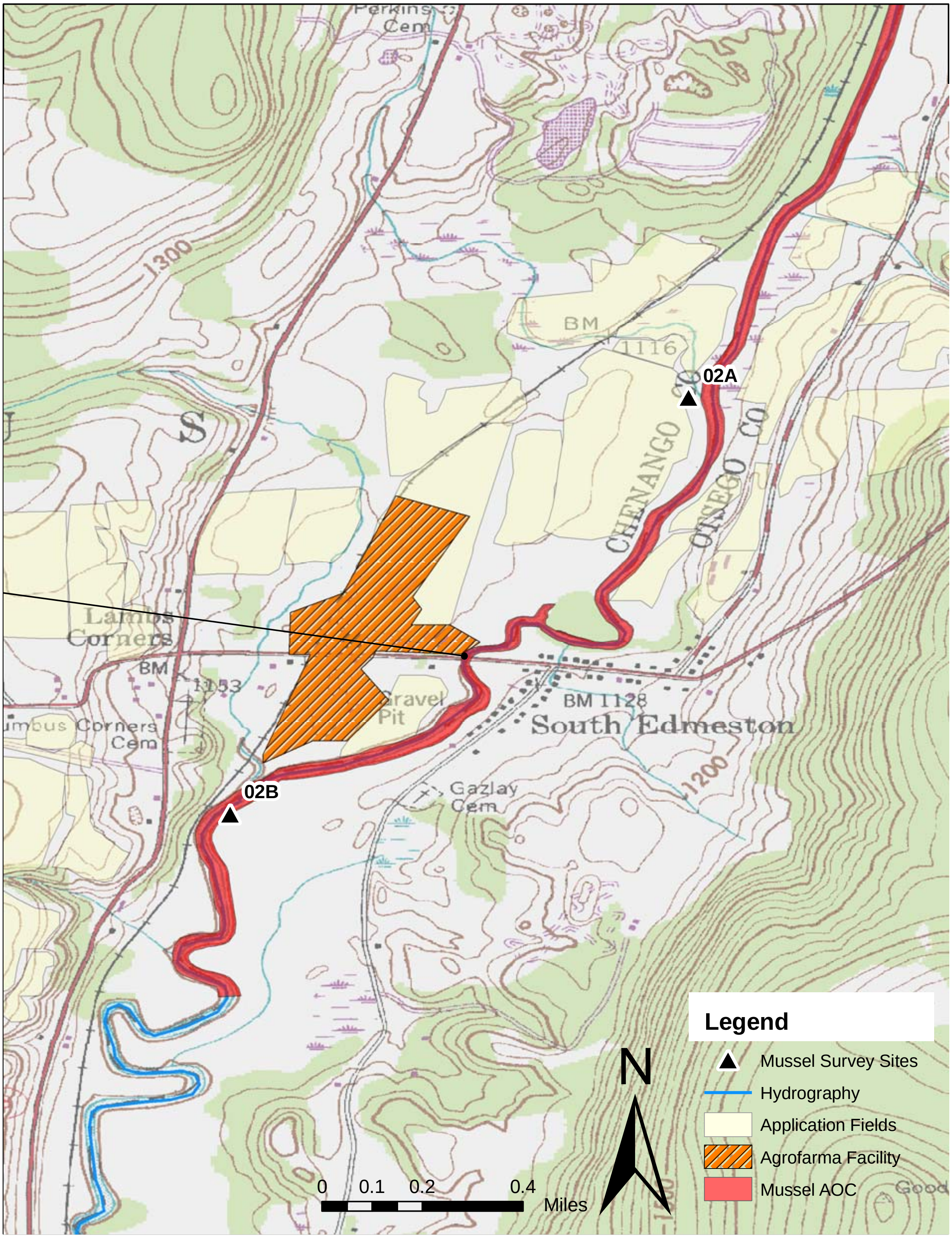


Figure 2d. Site location map, Unadilla River, Station 03. Mussel AOC boundary source Lord and Harman (2011). Application field boundary source NYSDEC regional offices 4 and 7.

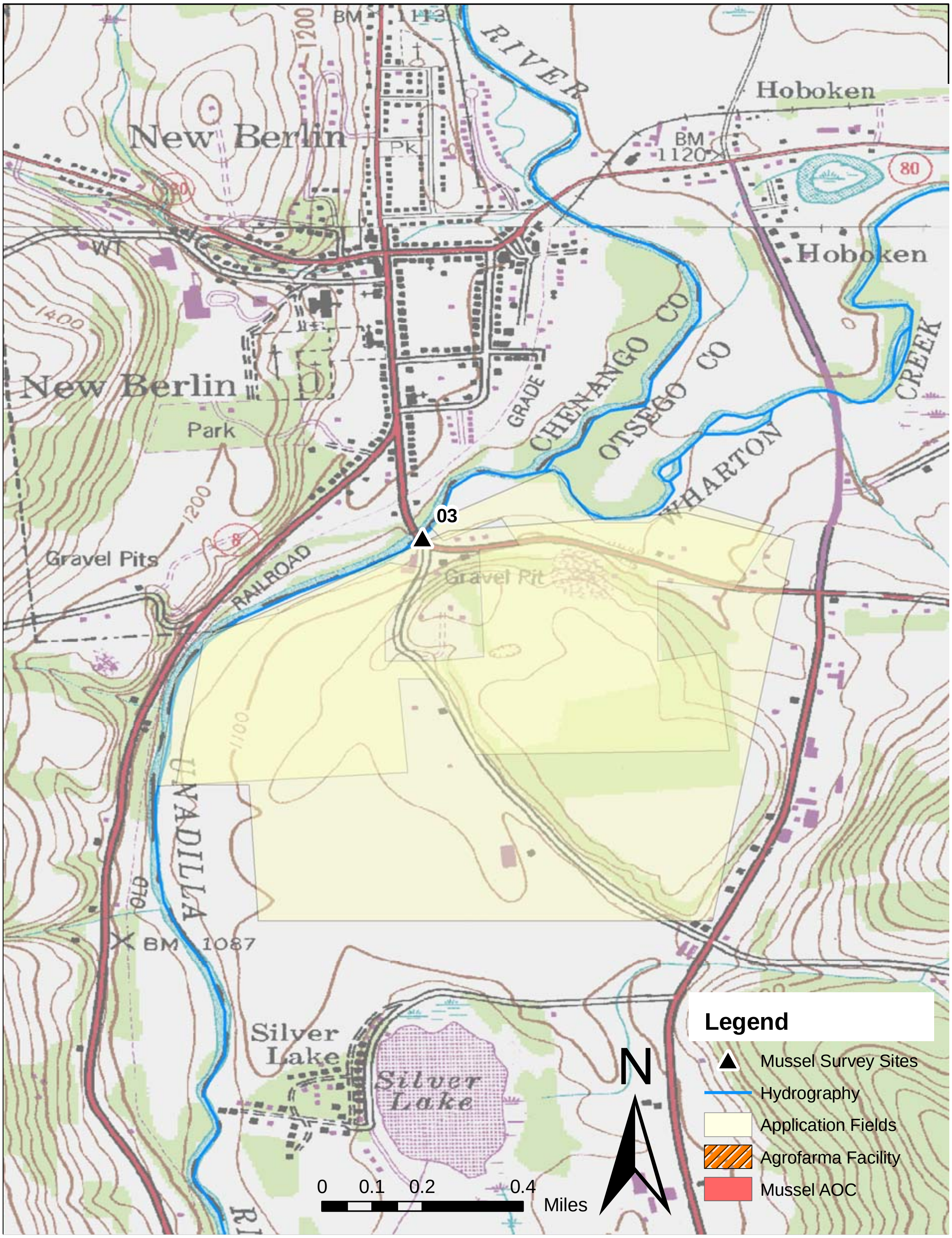


Figure 2e. Site location map, Unadilla River, Station 04. Mussel AOC boundary source Lord and Harman (2011). Application field boundary source NYSDEC regional offices 4 and 7.

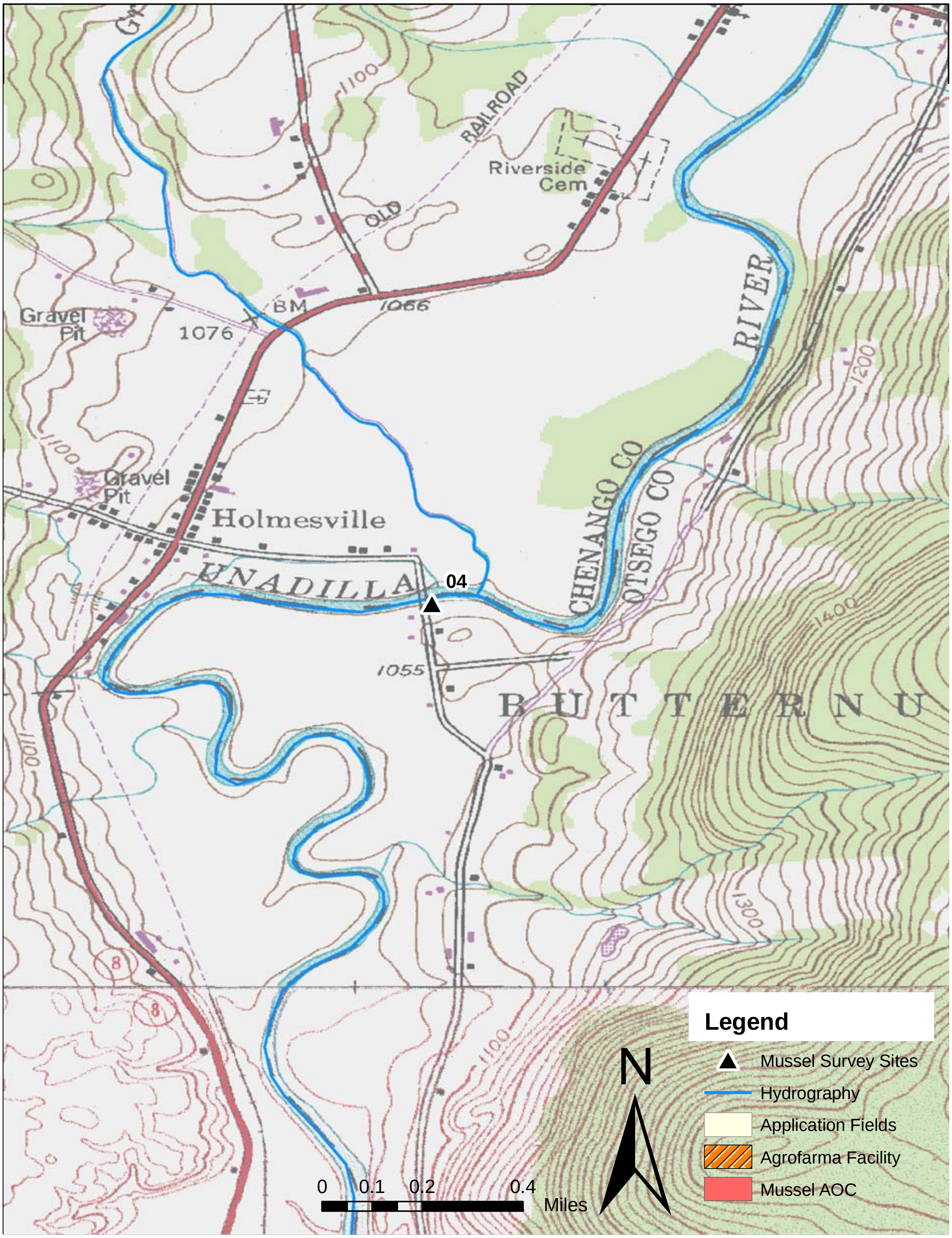


Table 1. Survey locations on the Unadilla River, August, 2012.

Station	Location
DILA-00B	North of Leonardsville, Skaneatles Turnpike Latitude: 42.8219 Longitude: -75.24873
DILA-02	West Edmeston, Welsh Rd. bridge Latitude: 42.76278 Longitude: -75.27944
DILA-02A	New Berlin, Upstream of Agro-farma, Inc. Latitude: 42.691985 Longitude: -75.313639
DILA-02B	New Berlin, Downstream of Agro-farma, Inc. Latitude: 42.679982 Longitude: -75.326842

Table 1 Cont'd. Survey locations on the Unadilla River, August, 2012.

Station	Location
DILA-03	New Berlin, Co. Rte 13 bridge Latitude: 42.61611 Longitude: -75.33111
DILA-04	Holmesville, Ditch Road bridge Latitude: 42.51111 Longitude: -75.39417

Table 2. Summary of Unionidae population information collected in the Unadilla River, 2012. Explanation of table attributes is provided below.

Row Labels	S - Rank	NE Concern	Status	DILA-00B		DILA-02		DILA-02A		DILA-02B		DILA-03		DILA-04	
				Shell	Live	Shell	Live	Shell	Live	Shell	Live	Shell	Live	Shell	Live
Alasmidonta marginata	S4	X	-					3		4	2				
Alasmidonta undulata	-	-	-	11	1	3		5		3	1	1		7	
Alasmidonta varicosa	S1	X	T	1				1							
Anondontoides ferussacianus	-	-	-			1									
Elliptio complanata	-	-	-	482	10	191	4	306	2	127	2			92	3
Lampsilis cariosa	S3	X		9		32		140		43		3		23	
Lampsilis radiata	-	-	-	5		1		4		1	2			24	2
Lasmigona subviridis	S1 S2	X	T					19	1			2			
Pyganodon cataracta	-	-	-	5		2		1		1					
Strophitus undulatus	-	-	-	23	3	11	1	14	2	19	2	2	1		
Total				536	14	243	5	493	5	198	9	8	1	146	5
Species Richness				7		7		9		7		4		4	
SGCN Richness				2		1		4		2		2		1	
Dead:Live				99:4		122:3		105:1		132:5		8:2		74:3	

Explanation of table values:
S-Rank (as related to the occurrence of SGCN species) – S1 Typically 5 or fewer occurrences, S2 Typically 6 – 20 occurrences, S3 Typically 21 – 100 occurrences, S4 Apparently secure in NY
NE Concern – An “X” indicates the species was listed as a “wildlife species of regional conservation concern in the Northeastern United States”
Status – A “T” indicates the species is listed as New York State “Threatened”
Shell – Number of empty shells/dead mussels collected from each sampling location for each species
Live – Number of live, fully intact mussels collected from each sampling location for each species
Total – The total number of either shell or live collected from each sampling location
Species Richness – The total number of different species identified at each sampling location
SGCN Richness – The total number of difference species listed as greatest conservation need in New York State identified at each sampling location
Dead :Live– Ratio of dead to live mussels calculated for each sampling location

Additional information on species of greatest conservation need in New York State can be found on the website of the Department of Environmental Conservation (http://www.dec.ny.gov/animals/9406.html)

Figure 3. Number of spent Unionidae shells for every one live organism collected in the Unadilla River.

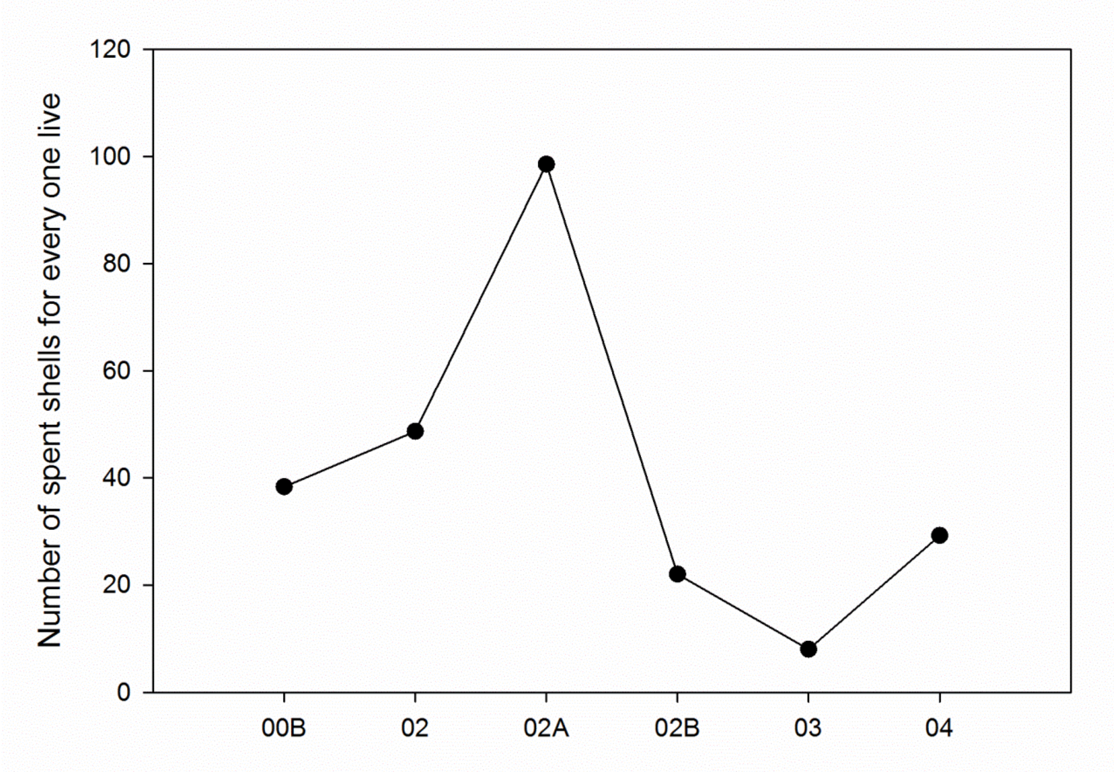


Table 3. Summary of histological results performed on specimens from sampling locations on the Unadilla River, 2012.

Station (No. Unionids Examined)	Specimen #	Aspidogastrid Trematode Infection	Bucephalid Trematode Infection	Unionid Condition
DILA-00B	081412-00B-01			Live
	081412-00B-02			Live
	081412-00B-03	Observed		Live
	081412-00B-04			Live
	081412-00B-05			Live
DILA-02	081412-02-01			Live
	081412-02-02			Live
	081412-02-03			Live
	081412-02-04	Observed		Live
	081412-02-05			Live
DILA-02A	081512-02A-01	Observed		Live
	081512-02A-02			Live
	081512-02A-03	Observed		Dead
DILA-02B	081512-02B-01			Live
	081512-02B-02			Live
	081512-02B-03			Live
	081512-02B-04		Observed	Live
	081512-02B-05			Live
	081512-02B-06		Observed	Moribund
DILA-03	081612-03-01		Observed	Live
DILA-04	081612-04-01		Observed	Live
	081612-04-02			Live
	081612-04-03			Live
	081612-04-04			Live
	081612-04-05			Live

Table 4. Tissue contaminant concentrations from Unadilla River sampling locations, 2012. ND = concentration below detection limits, n/a = not analyzed due to low specimen weight.

Compound	Units	DILA-00B	DILA-02	DILA-02A	DILA-02B	DILA-03	DILA-04
Polychlorinated Biphenyls (PCBs)							
Aroclor 1016	ug/Kg	ND	ND	ND	ND	n/a	ND
Aroclor 1221		ND	ND	ND	ND	n/a	ND
Aroclor 1232		ND	ND	ND	ND	n/a	ND
Aroclor 1242		ND	ND	ND	ND	n/a	ND
Aroclor 1248		ND	ND	ND	ND	n/a	ND
Aroclor 1254		ND	ND	ND	ND	n/a	ND
Aroclor 1260		ND	ND	ND	ND	n/a	ND
Aroclor 1262		ND	ND	ND	ND	n/a	ND
Aroclor 1268		ND	ND	ND	ND	n/a	ND
Polynuclear Aromatic Hydrocarbons (PAHs)							
Phenanthrene	ug/Kg	14.00	19.00	7.80	19.00	n/a	16.00
Fluoranthene		13.00	12.00	9.20	14.00	n/a	18.00
Pyrene		73.00	110.00	28.00	120.00	n/a	72.00
Benz(a)anthracene		2.90	3.20	2.50	2.90	n/a	2.60
Chrysene		20.00	29.00	12.00	34.00	n/a	29.00
Metals							
Mercury, Total	mg/Kg	0.12	0.92	0.19	0.20	n/a	0.62
Arsenic, Total		6.33	8.23	8.25	8.39	n/a	8.79
Cadmium, Total		0.34	0.87	0.71	0.72	n/a	0.41
Chromium, Total		1.55	6.21	1.11	2.31	n/a	3.54
Copper, Total		3.42	4.26	4.25	5.56	n/a	8.15
Lead, Total		0.36	0.83	0.27	0.38	n/a	0.71
Nickel, Total		0.43	0.79	0.26	0.58	n/a	0.37
Selenium, Total		2.50	3.30	2.80	2.20	n/a	3.20
Titanium, Total		1.30	1.53	0.56	0.48	n/a	0.50
Zinc, Total		119.00	132.00	106.00	111.00	n/a	114.00

Figure 4. Biological Assessment Profile (BAP) of index values, Unadilla River, 2012. Values are plotted on a normalized scale of water quality. The BAP represents the mean of the five values for each site, representing species richness (Spp), EPT richness, Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA), and the Nutrient Biotic Index for phosphorus (NBI-P). See Appendix IV for a more complete explanation.

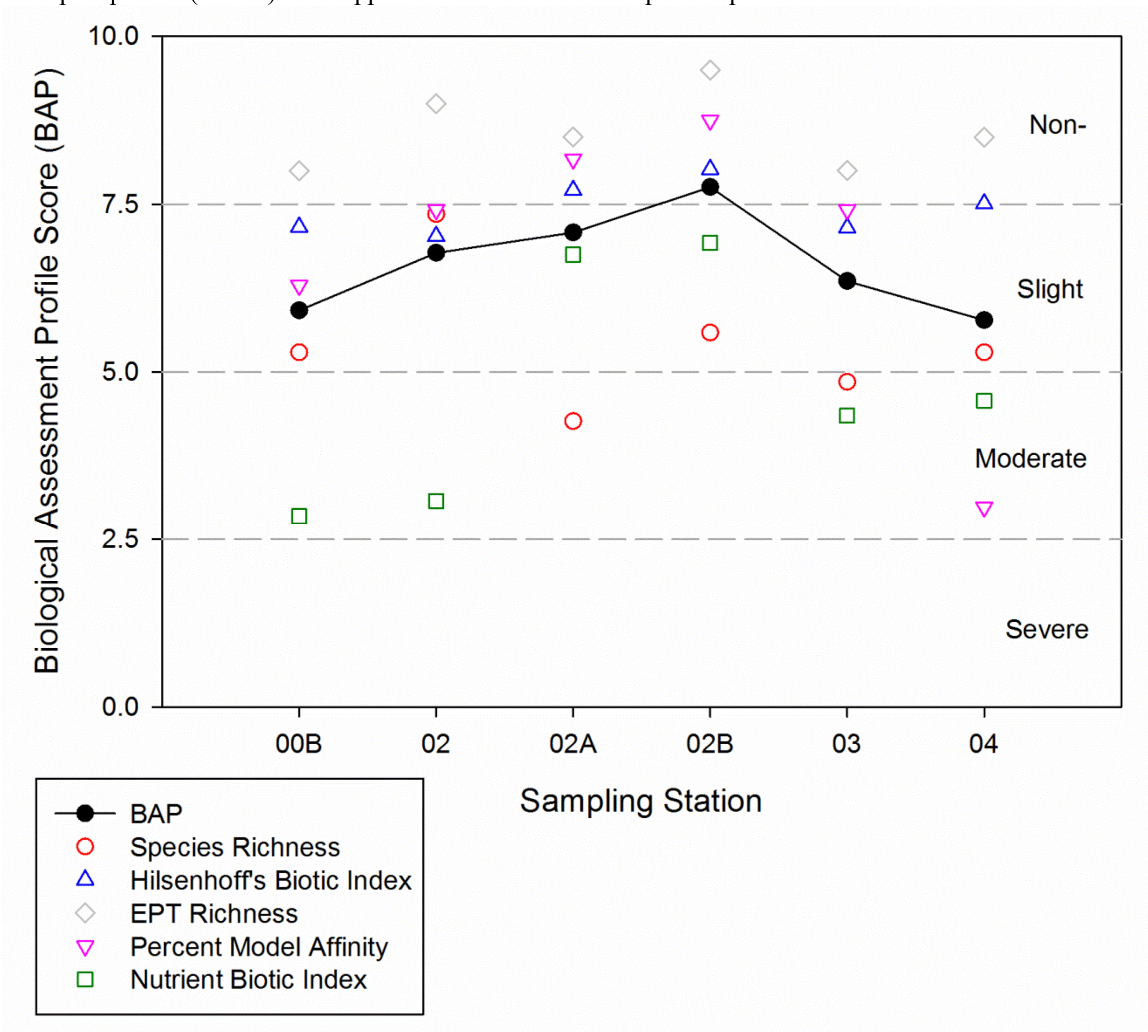


Table 5. Impact Source Determination (ISD), Unadilla River, 2012. Numbers represent percent similarity to community type models for each impact category. Highest similarities at each station are shaded. Similarities less than 50% are less conclusive. Highest numbers represent probable stressor(s) to the community. See Appendix XI for further explanation.

Community Type	Station					
	00B	02	02A	02B	03	04
Natural: minimal human disturbance	52	64	54	46	51	50
Nutrient Enrichment: mostly nonpoint, agricultural	46	51	35	41	36	52
Toxic: industrial, municipal, or urban run-off	51	55	31	41	26	63
Organic: sewage effluent, animal wastes	54	48	36	38	26	62
Complex: municipal/industrial	43	60	47	43	55	51
Siltation	47	64	54	56	51	60

Note: Impact Source Determinations (ISD) are intended as supplemental data to the macroinvertebrate community assessments.

Table 6. Macroinvertebrate species collected in the Unadilla River, 2012.

Taxon	DILA- 00B	DILA- 02	DILA- 02A	DILA- 02B	DILA- 03	DILA- 04
Acentrella sp.	1					
Acroneuria abnormis			1			
Agnetina capitata				1		
Antocha sp.	1			1		
Atherix sp.	2	1				
Baetis flavistriga				3	1	
Baetis intercalaris	3		1	1	2	
Baetisca sp.						1
Caenis sp.		4	16	14	3	
Cardiocladius obscurus						1
Cheumatopsyche sp.	8	8	4	2	8	21
Chimarra aterrima?						2
Chimarra obscura	17	5	3	8	23	21
Chimarra socia			1			
Corydalus cornutus					4	
Dicrotendipes neomodestus	1					
Dubiraphia vittata		2				
Eukiefferiella similis gr.			1		1	
Hemerodromia sp.	1	1				
Hydropsyche betteni	1					
Hydropsyche bronta				1	2	1
Hydropsyche morosa	2				4	2
Hydropsyche slossonae	4			1		4
Hydropsyche sparna	5	1	3		5	
Hydroptila sp.		1				
Isonychia sp.	2	3	7	4	5	1
Leucrocuta sp.			8	18	1	1
Microtendipes pedellus gr.	3	3		1	4	1
Optioservus trivittatus	13	13	18	10	5	8
Paragnetina media	1	1		1		
Polypedilum flavum	19	26	9	13	19	3
Promoresia elegans		1				
Psephenus herricki		2		1		
Psychomyia sp.		1				2
Rheotanytarsus exiguus gr.		1				
Serratella deficiens		1	1			
Stenelmis crenata	10	11	18	11	5	15
Stenelmis sp.						7
Stenonema ithaca				3		
Stenonema mediopunctatum		1	6	1	4	
Stenonema sp.	6	2		5		4
Stenonema terminatum		8	3			1
Thienemannimyia gr. spp.		1				
Undetermined Cambaridae		1				
Undetermined Lumbriculidae					4	4
Undetermined Turbellaria		1				

Figure 5. Habitat assessment scores for each sampling location on the Unadilla River.

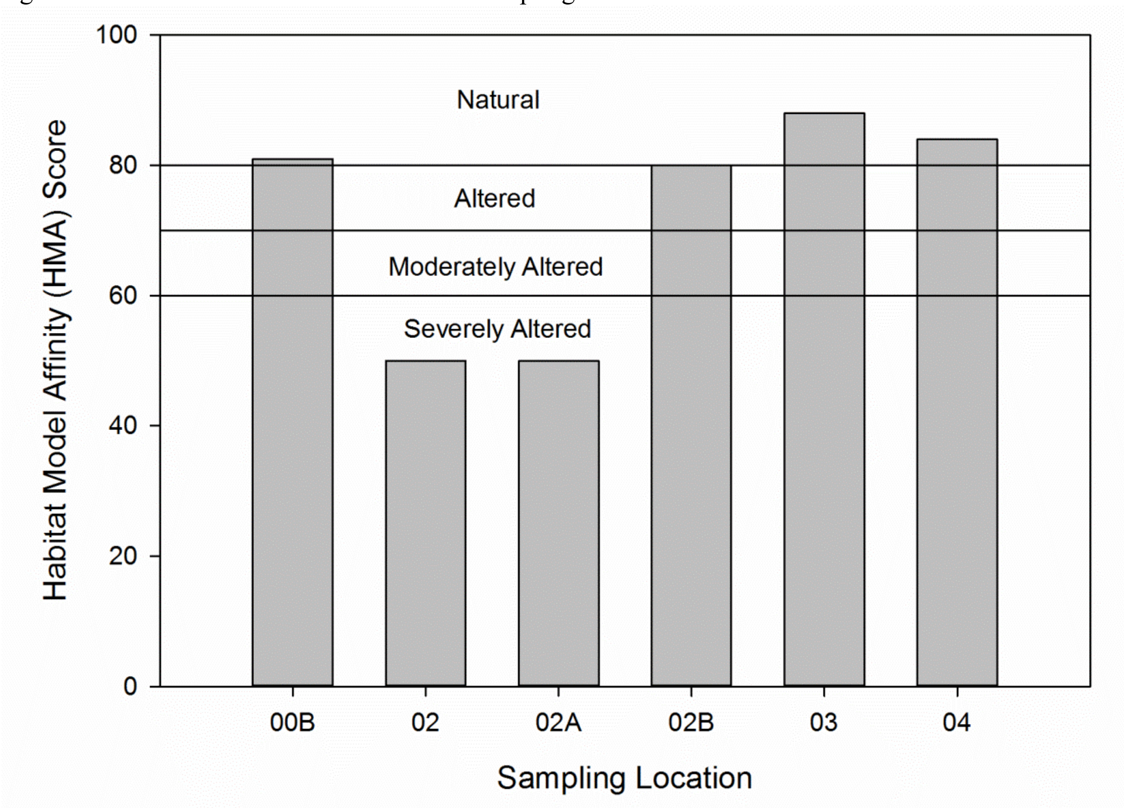


Table 7. Summary of physical habitat attribute scores used in calculating the Habitat Model Affinity (Figure 4) in the Unadilla River. The following attributes are ranked on a scale from 0 (poor) -20 (optimal). Epi. Cover = Epifaunal substrate cover, Embed. = Embeddedness, Vel/Dep Reg. = Velocity Depth Regime, Sed. Dep. = Sediment Deposition, Flow Status = Channel Flow Status, Chan. Alt. = Channel Alteration, Rif. Freq. = Riffle Frequency, Bank Stab. = Bank Stability, Bank Veg. = Bank Vegetative Cover, Rip. Width = Riparian Corridor Width. Values of 10 or below are highlighted to identify those parameters ranked as marginal or poor.

Station	Epi. Cover	Embed.	Vel/Dep Reg.	Sed. Dep.	Flow Status	Chan. Alt.	Rif. Freq.	Bank Stab.	Bank Veg.	Rip. Width
00B	15	12	19	16	18	17	15	9	13	13
02	8	6	9	6	15	5	12	7	11	12
02A	7	8	13	10	15	2	9	6	7	13
02B	19	18	19	11	15	20	19	11	12	6
03	18	14	18	16	18	16	19	15	17	9
04	18	16	18	15	15	16	19	13	13	10

Figure 6. Pebble count analysis from the Unadilla River. The dominant substrates in the river were gravel and coarse gravel with finer sediments such as sand and silt present at most sites

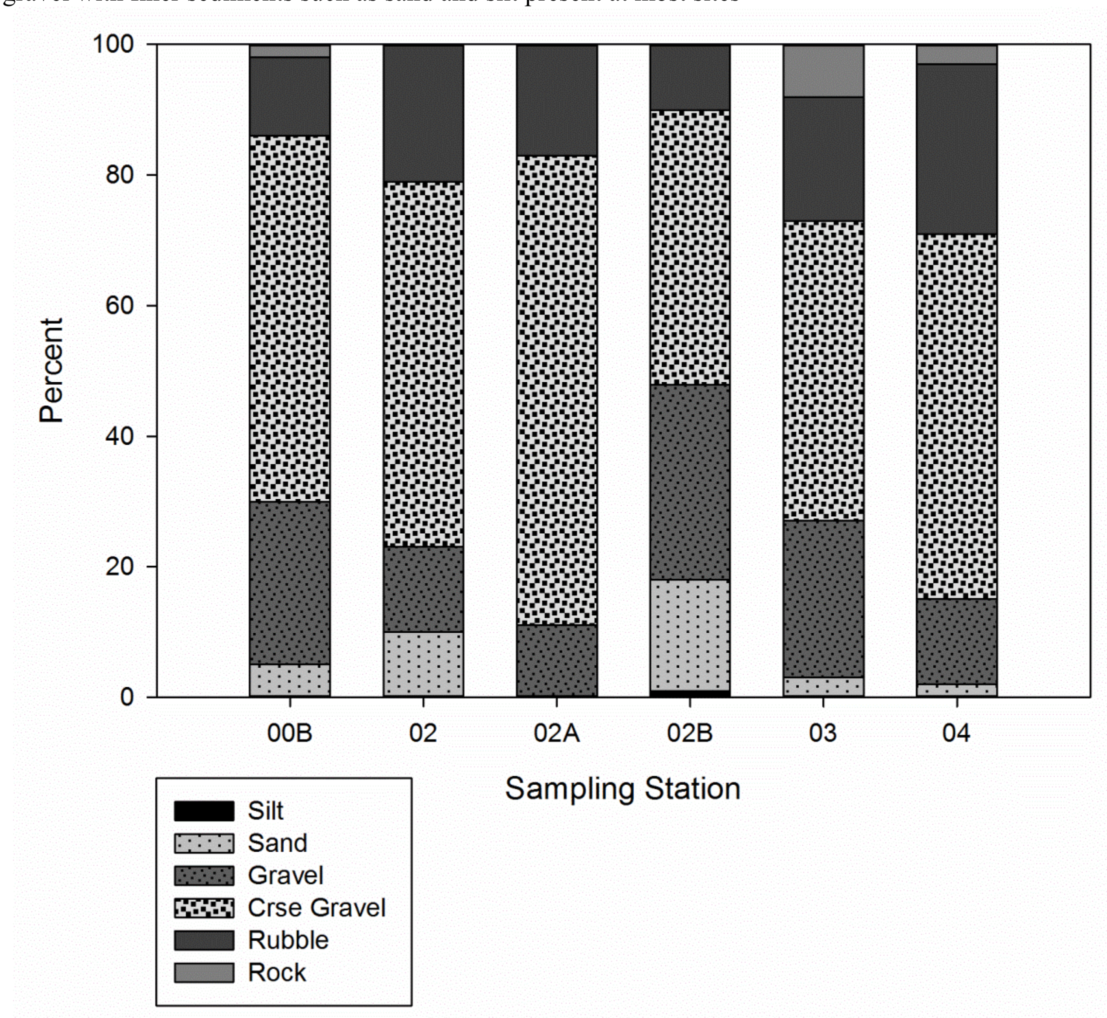


Table 8. Summary of substrate particle sizes recorded from pebble counts in the Unadilla River. Values are calculated as a proportion of the total from a random count of 100 pebbles in the stream reach.

Station	Silt	Sand	Gravel	Crse. Gravel	Rubble	Rock	Phi Score
00B	0.00	0.05	0.25	0.56	0.12	0.02	-4.73
02	0.00	0.10	0.13	0.56	0.21	0.00	-4.68
02A	0.00	0.00	0.11	0.72	0.17	0.00	-5.06
02B	0.01	0.17	0.30	0.42	0.10	0.00	-4.03
03	0.00	0.03	0.24	0.46	0.19	0.08	-5.07
04	0.00	0.02	0.13	0.56	0.26	0.03	-5.14

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 meter 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 organisms are dislodged and carried into the net. Sampling is continued for a specified time and distance in the stream. Rapid assessment sampling specifies sampling for five minutes over a distance of five meters. The contents of the net 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 stereomicroscope 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 are 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.

Appendix II. Macroinvertebrate Community Parameters

1. Species Richness: the total number of species or taxa found in a 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, and less than 11, severely impacted.

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

3. Hilsenhoff Biotic Index: a measure of the tolerance of organisms in a 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 the purpose of characterizing species' tolerance, intolerant = 0-4, facultative = 5-7, and tolerant = 8-10. Tolerance 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 Quality Assurance document, Bode et al. (2002). Impact ranges 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: a measure of similarity to a model, non-impacted community based on percent abundance in seven major macroinvertebrate groups (Novak and Bode, 1992). Percentage 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.

5. Nutrient Biotic Index: a measure of stream nutrient enrichment identified by macroinvertebrate taxa. 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 with assigned tolerance values. Tolerance values ranging from intolerant (0) to tolerant (10) are based on nutrient optima for Total Phosphorus (listed in Smith, 2005). Impact ranges are: 0-5.00, non-impacted; 5.01-6.00, slightly impacted; 6.01-7.00, moderately impacted, and 7.01-10.00, severely impacted.

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 richness, biotic index, and percent model affinity (see Appendix II). 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-organisms 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. Nutrient Biotic Index is 5.00 or less. 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.

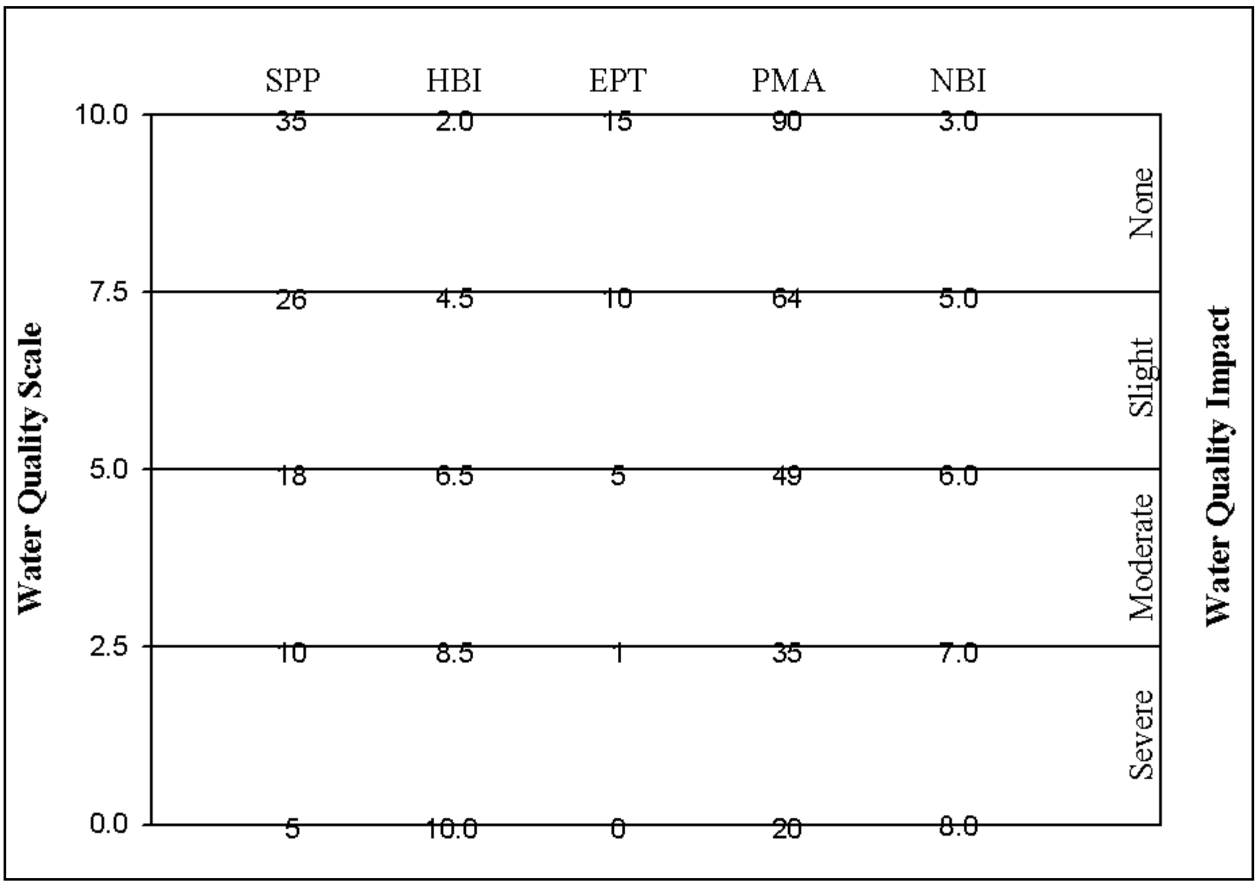
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50. Percent model affinity is 50-64. Nutrient Biotic Index is 5.01-6.00. 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 is usually 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. Percent model affinity is 35-49. Nutrient Biotic Index is 6.01-7.00. 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 fewer. 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. Nutrient Biotic Index is greater than 7.00. 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-A. Biological Assessment Profile: Conversion of Index Values to a 10-Scale

The Biological Assessment Profile (BAP) 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 five indices -- species richness (SPP), EPT richness (EPT), Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA), and Nutrient Biotic Index (NBI)-- defined in Appendix II 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.



Appendix IV-B. 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
Nutrient Biotic Index	6.0	5.0	6.0	5.0
Average		6.152 (slight)		7.8 (non-)

Appendix V. Water Quality Assessment Criteria

Non-Navigable Flowing Waters

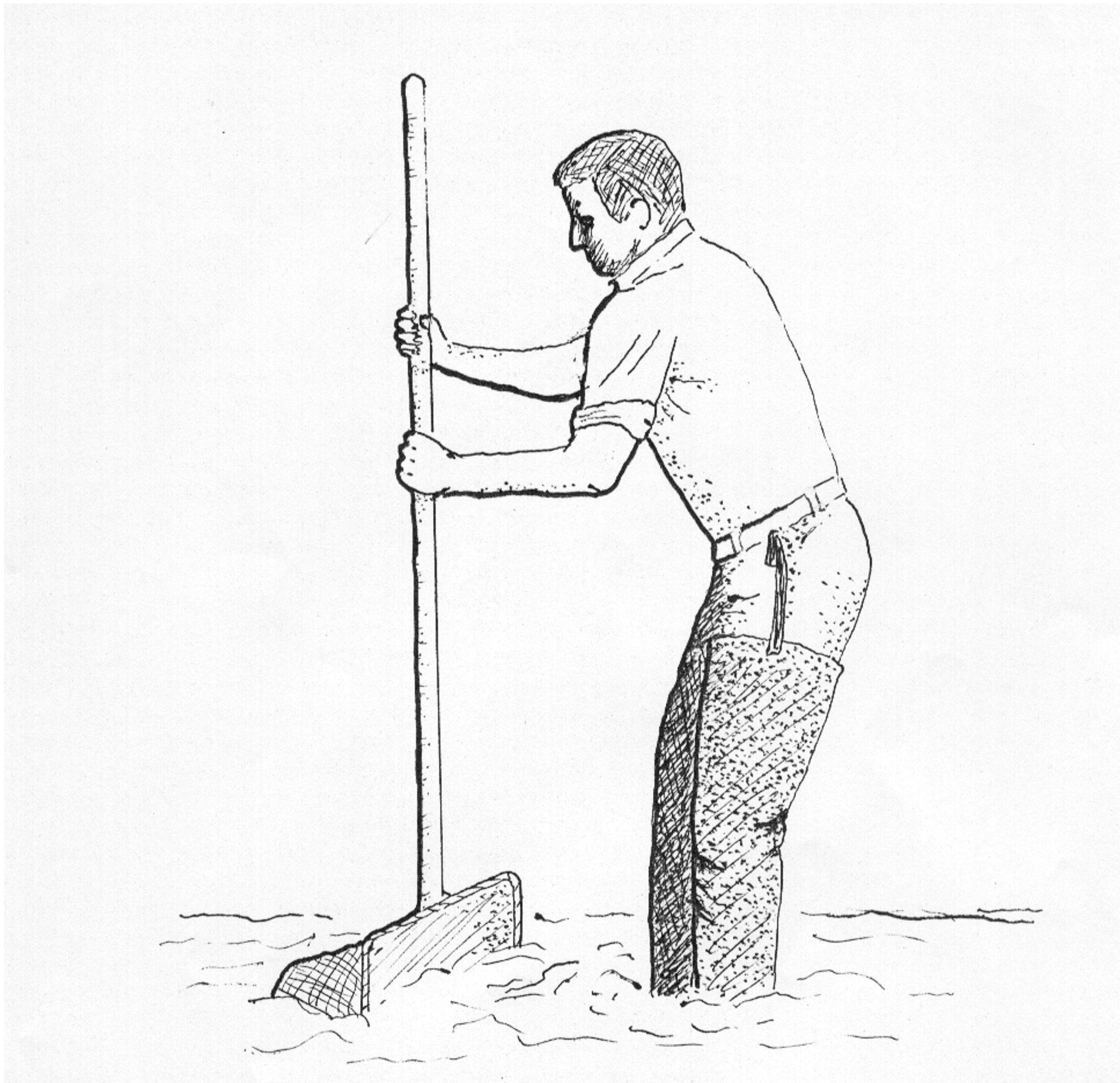
	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Diversity **
Non-Impacted	>26	0.00-4.50	>10	>64	>4
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	3.01-4.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	2.01-3.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	0.00-2.00

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

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

Appendix VI. The Traveling Kick Sample



Rocks and sediment in a riffle are dislodged by foot upstream of a net. Dislodged organisms are

⟵current

carried by the current into the net. Sampling continues for five minutes, as the sampler gradually moves downstream to cover a distance of five meters

Appendix VII-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 VII-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 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.

more common, though

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.

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

SOWBUGS

Appendix VIII. 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.

Appendix IX. Glossary

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

Electrofishing: sampling fish by using electric currents to temporarily immobilize them, allowing capture

EPT richness: the number of taxa of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) in a sample or subsample

Eutrophic: high nutrient levels normally leading to excessive biological productivity

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

Mesotrophic: intermediate nutrient levels (between oligotrophic and eutrophic) normally leading to moderate biological productivity

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

Non Chironomidae/Oligochaeta (NCO) richness: the number of taxa neither belonging to the family Chironomidae nor the subclass Oligochaeta in a sample or subsample

Oligotrophic: low nutrient levels normally leading to unproductive biological conditions

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 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 taxa 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

Trophic: referring to productivity

Appendix X. Methods for Calculation of the Nutrient Biotic Index

Definition: The Nutrient Biotic Index (Smith et al., 2007) is a diagnostic measure of stream nutrient enrichment identified by macroinvertebrate taxa. The frequency of occurrences of taxa at varying nutrient concentrations allowed the identification of taxon-specific nutrient optima using a method of weighted averaging. The establishment of nutrient optima is possible based on the observation that most species exhibit unimodal response curves in relation to environmental variables (Jongman et al., 1987). The assignment of tolerance values to taxa based on their nutrient optimum provided the ability to reduce macroinvertebrate community data to a linear scale of eutrophication from oligotrophic to eutrophic. Two tolerance values were assigned to each taxon, one for total phosphorus, and one for nitrate (listed in Smith, 2005). This provides the ability to calculate two different nutrient biotic indices, one for total phosphorus (NBI-P), and one for nitrate (NBI-N). Study of the indices indicates better performance by the NBI-P, with strong correlations to stream nutrient status assessment based on diatom information.

Calculation of the NBI-P and NBI-N: Calculation of the indices [2] follows the approach of Hilsenhoff (1987).

$$\text{NBI Score}_{(\text{TP or NO3}^-)} = \sum (a \times b) / c$$

Where ***a*** is equal to the number of individuals for each taxon, ***b*** is the taxon's tolerance value, and ***c*** is the total number of individuals in the sample for which tolerance values have been assigned.

Classification of NBI Scores: NBI scores have been placed on a scale of eutrophication with provisional boundaries between stream trophic status.

Index	Oligotrophic	Mesotrophic	Eutrophic
NBI-P	< 5.0	> 5.0 - 6.0	> 6.0
NBI-N	< 4.5	> 4.5 - 6.0	> 6.0

Jongman, R. H. G., C. J. F. ter Braak and O. F. R. van Tongeren. 1987. Data analysis in community and landscape ecology. Pudoc Wageningen, Netherlands, 299 pages.

Smith, A.J., R. W. Bode, and G. S. Kleppel. 2007. A nutrient biotic index for use with benthic macroinvertebrate communities. Ecological Indicators 7(200):371-386.

Tolerance values assigned to taxa for calculation of the Nutrient Biotic Indices

TAXON	TP T-Value	NO3 T-Value
Acentrella sp.	5	5
Acerpenna pygmaea	0	4
Acroneuria abnormis	0	0
Acroneuria sp.	0	0
Agnetina capitata	3	6
Anthopotamus sp.	4	5
Antocha sp.	8	6
Apatania sp.	3	4
Atherix sp.	8	5
Baetis brunneicolor	1	5
Baetis flavistriga	7	7
Baetis intercalaris	6	5
Baetis sp.	6	3
Baetis tricaudatus	8	9
Brachycentrus appalachia	3	4
Caecidotea racovitzai	6	2
Caecidotea sp.	7	9
Caenis sp.	3	3
Cardiocladius obscurus	8	6
Cheumatopsyche sp.	6	6
Chimarra aterrima?	2	3
Chimarra obscura	6	4
Chimarra socia	4	1
Chimarra sp.	2	0
Chironomus sp.	9	6
Cladotanytarsus sp.	6	4
Corydalus cornutus	2	2
Cricotopus bicinctus	7	6
Cricotopus tremulus gr.	8	9
Cricotopus trifascia gr.	9	9
Cricotopus vierriensis	6	5
Cryptochironomus fulvus gr.	5	6
Diamesa sp.	10	10
Dicranota sp.	5	10
Dicrotendipes neomodestus	10	4
Dolophilodes sp.	4	3
Drunella cornutella	4	4
Ectopria nervosa	10	9
Epeorus (Iron) sp.	0	0
Ephemerella sp.	4	4
Ephemerella subvaria	4	1
Ephoron leukon?	1	1
Eukiefferiella devonica gr.	9	9
Ferrissia sp.	9	5
Gammarus sp.	8	9
Glossosoma sp.	6	0
Goniobasis livescens	10	10
Helicopsyche borealis	1	2
Hemerodromia sp.	5	6
Heptagenia sp.	0	0
Hexatoma sp.	0	1
Hydropsyche betteni	7	9
Hydropsyche bronta	7	6
Hydropsyche morosa	5	1
Hydropsyche scalaris	3	3

TAXON	TP T-Value	NO3 T-Value
Hydropsyche slossonae	6	10
Hydropsyche sp.	5	4
Hydropsyche sparna	6	7
Hydroptila consimilis	9	10
Hydroptila sp.	6	6
Hydroptila spatulata	9	8
Isonychia bicolor	5	2
Lepidostoma sp.	2	0
Leucotrichia sp.	6	2
Leucrocuta sp.	1	3
Macrostemum carolina	7	2
Macrostemum sp.	4	2
Micrasema sp. 1	1	0
Micropsectra dives gr.	6	9
Micropsectra polita	0	7
Micropsectra sp.	3	1
Microtendipes pedellus gr.	7	7
Microtendipes rydalensis gr.	2	1
Nais variabilis	5	0
Neoperla sp.	5	5
Neureclipsis sp.	3	1
Nigronia serricornis	10	8
Nixe (Nixe) sp.	1	5
Ophiogomphus sp.	1	3
Optioservus fastiditus	6	7
Optioservus ovalis	9	4
Optioservus sp.	7	8
Optioservus trivittatus	7	6
Orthocladius nr. dentifer	3	7
Pagastia orthogonia	4	8
Paragnetina immarginata	1	2
Paragnetina media	6	3
Paragnetina sp.	1	6
Paraleptophlebia mollis	2	1
Paraleptophlebia sp.	2	3
Parametriocnemus lundbecki	8	10
Paratanytarsus confusus	5	8
Pentaneura sp.	0	1
Petrophila sp.	5	3
Phaenopsectra dyari?	4	5
Physella sp.	8	7
Pisidium sp.	8	10
Plauditus sp.	2	6
Polycentropus sp.	4	2
Polypedilum aviceps	5	7
Polypedilum flavum	9	7
Polypedilum illinoense	10	7
Polypedilum laetum	7	6
Polypedilum scalaenum gr.	10	6
Potthastia gaedii gr.	9	10
Promoresia elegans	10	10
Prostoma graecense	2	7
Psephenus herricki	10	9
Psephenus sp.	3	4

NBI tolerance values (cont'd)

TAXON	TP T-Value	NO3 T-Value
Psychomyia flavida	1	0
Rheocricotopus robacki	4	4
Rheotanytarsus exiguus gr.	6	5
Rheotanytarsus pellucidus	3	2
Rhithrogena sp.	0	1
Rhyacophila fuscula	2	5
Rhyacophila sp.	0	1
Serratella deficiens	5	2
Serratella serrata	1	0
Serratella serratoides	0	1
Serratella sp.	1	1
Sialis sp.	5	6
Simulium jenningsi	6	2
Simulium sp.	7	6
Simulium tuberosum	1	0
Simulium vittatum	7	10
Sphaerium sp.	9	4
Stenacron interpunctatum	7	7
Stenelmis concinna	5	0
Stenelmis crenata	7	7
Stenelmis sp.	7	7
Stenochironomus sp.	4	3
Stenonema mediopunctatum	3	3
Stenonema modestum	2	5
Stenonema sp.	5	5
Stenonema terminatum	2	3
Stenonema vicarium	6	7
Stylaria lacustris	5	2
Sublettea coffmani	3	5

TAXON	TP T-Value	NO3 T-Value
Synorthocladius nr. semivirens	6	9
Tanytarsus glabrescens gr.	5	6
Tanytarsus guerlus gr.	5	5
Thienemannimyia gr. spp.	8	8
Tipula sp.	10	10
Tricorythodes sp.	4	9
Tvetenia bavarica gr.	9	10
Tvetenia vitracies	7	6
Undet. Tubificidae w/ cap. setae	10	8
Undet. Tubificidae w/o cap. setae	7	7
Undetermined Cambaridae	6	5
Undet. Ceratopogonidae	8	9
Undet. Enchytraeidae	7	8
Undet. Ephemerellidae	3	6
Undetermined Gomphidae	2	0
Undet. Heptageniidae	5	2
Undetermined Hirudinea	9	10
Undetermined Hydrobiidae	6	7
Undetermined Hydroptilidae	5	2
Undet. Limnephilidae	3	4
Undet. Lumbricina	8	8
Undet. Lumbriculidae	5	6
Undetermined Perlidae	5	7
Undetermined Sphaeriidae	10	8
Undetermined Turbellaria	8	6
Zavrelia sp.	9	9

Appendix XI. 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.

ISD 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

ISD Models (cont'd)

	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

ISD Models (cont'd)

	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

	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

ISD Models (cont'd)

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