New York State Department of Environmental Conservation

Division of Water

Standard Operating Procedure:

Biological Monitoring of Surface Waters in New York State

03/29/2012

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2. Scope and Applicability

2.1 This standard operating procedure (SOP) covers the biological monitoring program for the NYSDEC, Division of Water (DOW) and applies to all Biological Monitoring Data conducted in support of the following DOW programs and reporting:

1) Rotating Intergrated Basin Studies (RIBS) water quality assessments.
2) Water Body Inventory and Priority Waterbody List (WI/PWL) documentation of water quality.
3) 40 CFR 303(d) listing of impaired waters.
4) 40 CFR 305(b) reporting of water quality assessments.
5) State Permit Discharge Elimination System (SPDES) permit writing, compliance and enforcement determinations, setting permit limitations protective of aquatic life use support.
6) Trend Monitoring Reports which are planned at 10 year intervals.
7) Department personnel working on non point source discharges
8) Tissue analysis results for contaiminant trackdown used by the Division of Fish, Wildlife, and Marine Resources or the Division of Environmental Remediation.

2.2 This SOP covers the planning, collection, assessment and reporting of biological monitoring data conducted by the DOW Stream Biomonitoring Unit.

2.3 This SOP is to be followed unless project objectives or physical conditions make it inappropriate. In such a case, the exact procedures followed, or deviations from the SOP must be documented. A log of changes will be maintained by the Stream Biomonitoring Unit for possible incorporation into future updates to this SOP.

2.4 All applicable guidelines set forth by the NYSDEC, DOW, 2011 Health and Safety Program are to be followerd by DOW staff when using this SOP.

2.5 All applicable NYSDEC, DOW SOPs are to be adhered to.

3. Biological Monitoring Overview

3.1 The biological monitoring program for the State of New York, was initiated in May, 1972 as mandated by the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). The main objective of the program is to evaluate the relative biological health of the State's surface waters through the collection and analysis of macroinvertebrate communities.

3.2 Macroinvertebrates are larger-than-microscopic invertebrate animals that inhabit stream, river, lake, and wetland bottoms; freshwater forms are primarily aquatic insects, worms, clams, snails, and crustaceans.

3.3 The activities of the DOW Stream Biomonitoring Unit include but are not limited to macroinvertebrate community assessment and macroinvertebrate tissue analysis.

3.4 Community assessments are conducted to determine water quality impairment and the attainment of aquatic life use support. Parameters such as species richness and percent model affinity are used to assess overall water quality.

3.5 Macroinvertebrate tissue assessment provides information on levels of toxic substances in the aquatic food chain. Macroinvertebrates bioconcentrate many contaminants to concentrations several times that found in the water and many serve as primary food organisms for fish.

3.6 Analysis of macroinvertebrate communities is a reliable and cost-effective approach to water quality monitoring because:

- They are sensitive to environmental impacts
- They are less mobile than fish, and thus cannot avoid discharges
- They can indicate effects of spills, intermittent discharges, and lapses in treatment
- They are indicators of overall, integrated water quality, including synergistic effects and substances lower than detectable limits
- They are abundant in most streams and are relatively easy and inexpensive to sample
- They are able to detect non-chemical impacts to the habitat, such as siltation or thermal changes
- They are readily perceived by the public as tangible indicators of water quality
- They can often provide an on-site estimate of water quality
- They bioaccumulate many contaminants, so that analysis of their tissues is a good monitor of toxic substances in the aquatic food chain, and
- They provide a suitable endpoint to water quality objectives.

3.7 The Stream Biomonitoring Unit divides its biological assessment sampling into three major categories: 1) trend monitoring, 2) site assessments and 3) waterbody assessments.

3.8 Trend monitoring and single site assessments account for the majority of the sampling and are mainly conducted as part of the Rotating Integrated Basin Studies (RIBS) program. Trend and single site assessments involve sampling targeted sites of regional reference conditions, long-term temporal trend monitoring locations, unassessed waters, and sites that are of department, regional and/or public interest.

3.9 Waterbody assessment surveys involve sampling several sites along the length of a river or reach, and are usually conducted at the request of a DEC Regional office or to collect baseline water quality information. Reasons for requesting a survey include: documentation of severity of a perceived problem, documentation of possible improvement following upgraded treatment, problem track-down, or collection of baseline data on a stream of unknown water quality.

4. Summary of Method

4.1 Identify what biotic communities require sampling based on information need

4.2 Select sampling sites based on criteria related to rationale for sampling

4.3 Determine sampling methods based on study area physical characteristics

4.4 Determine schedule of sampling based on sampling method chosen

4.5 Perform physical, habitat and recreactional use assessments

4.6 Collect organisms from identified biological study group and for required assessments.

4.7 Subsample, sort and enumerate organisms within the samples collected

4.8 Identify collected organisms

4.9 Calculate multiple community metrics to describe the sample collected

4.10 Report on a samples overall water quality through use of a multimetric index of biotic community structure. Individual multimetrics for specific community types may sometimes be combined to form an overall water quality consensus.

5. Definitions

5.1 Assessment: a diagnosis or evaluation of water quality

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

5.3 Bioaccumulate: accumulate contaminants in the tissues of an organism

5.4 Biomonitoring: the use of biological indicators to measure water quality

5.5 Community: a group of populations of organisms interacting in a habitat

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

5.7 Fauna: the animal life of a particular habitat

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

5.9 Impairment: a detrimental effect caused by an impact

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

5.11 Intolerant: unable to survive poor water quality

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

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

5.14 Ponar sampler: a quantitative grab sampler for use on soft sediments in rivers or lakes.

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

5.16 Rubble: small stones of 2 ½ -10 inch diameter; cobble.

5.17 Tolerant: able to survive poor water quality.

5.18 Xenobiotic substances: chemicals found in organisms that are not usually present or are present in concentrations higher than normally expected.

6. Health and Safety Warnings

6.1 This standard operating procedure does not address all safety concerns associated with the reality of field and laboratory work. The reader is referred to the Division of Water's Health and Safety Program and to follow the appropriate health and safety practices covered there in.

6.2 Safety is more important than the task. If for any reason conditions are considered unsafe, suspend activity and leave the site.

6.3 Be familiar with all pertinent Material Safety Data Sheets (MSDS) before using any cleaning reagents or chemicals and when working in the laboratory.

6.4 When handling chemical reagents, work in a well-ventilated area.

6.5 Do not work near an open flame or sparks.

6.6 Wear and maintain assigned/appropriate personal protective equipment.

6.7 Follow all NYSDEC Division of Water health and safety procedures. The procedures are included in the Health and Safety Program.

6.8 At least two persons should be involved in all field-collecting trips. Communication equipment should be available to field personnel for use in case of an emergency. Select sampling sites with safe access.

6.9 Rubber or latex gloves should be worn at sites with surface waters considered to be potential health hazards. Safety equipment and first aid supplies should be available in the field and laboratory at all times.

6.10 Personnel operating boats should be familiar with the Division of Water Boating Safety Program, which is based on U.S. Coast Guard rules and regulations for safe boating. Personal flotation devices are always worn in boats. Float plans must be filed for all on-water sampling events.

6.11 Personnel using the Ponar sampler should become familiar with the hazards involved. The safety-locking pin should always be in place except when the sampler is being deployed.

6.12 Always wash hands after handling sampling equipment and before eating or drinking.

7. Personnel Qualifications

7.1 Research Scientist II - III: Overall project coordination and staff supervision, QA supervision, research design, biological and chemical field sampling, macroinvertebrate identification, data quality review, reporting, grant writing.

7.2 Research Scientist I - II: Research assistant to RS II - III, assists in research design, implementation and reporting as directed by the RS II – III, biological and chemical field sampling, data processing activities, data processing QC, sample analysis, macroinvertebrate identification, secondary reporting.

7.3 Environmental Program Specialist II - III: biological and chemical field sampling, data processing activities, data processing QC, sample analysis, macroinvertebrate identification, secondary reporting.

7.4 Environmental Program Specialist I - II: biological and chemical field sampling, sampling QC, sample analysis, macroinvertebrate identification, laboratory QC, equipment and supplies maintenance, secondary reporting.

7.5 All staff shall be familiar with the procedures outlined in this standard, the Quality Assurance Plan for the sampling project and the DOW Health and Safety Program and applicable laboratory Health and Safety protocols prior to conducting field and laboratory work.

8. Equipment and Supplies

8.1 EXPENDABLE SUPPLY ITEMS REQUIRED

The following items are considered expendable and are replaced on an annual or bi-annual basis.

1. Alcohol: 80 gallons/year
2. Kick sample jars, polyethylene (1 qt.): re-useable
3. Multiplate sample wood (4' x 8' masonite): 2 sheets/year
4. Cable for sampler installing (1/8 inch): 120 feet/year
5. Turnbuckles: 35/year
6. Swivel snaps: 70/year
7. Microscope slides: 9 gross/year
8. Microscope slide coverslips: 1 pack/year
9. Mounting media: 100 ml each Euparol, CMCP-9, CMCP-10/year
10. Kim Wipes: 20 boxes/year
11. pH buffer solution: 4 cases/year
12. Forceps: 10 pair/year
13. Labels: 3 boxes/year
14. 4oz Glass jars for multiplates samples: 3 gross/year
15. ½ Gallon jugs for multiplates floats: 1case/year
16. Patio blocks for multiplates: 20/year
17. Replacement kick nets: 5/year
18. Batteries (AA, C, and D): 4 pack each/year
19. I-Chem precleaned 4oz jars for tissue samples: 10 cases/year
20. Conductivity standard (100 and 500): 1 gallon each/year
21. Caps for 4oz jars: 1 box/year
22. 1 dram glass vials for sorting: 1 case/year
23. Waders: 5 pairs/year

8.2 PERMANENT EQUIPMENT REQUIRED

Major equipment items: a complete and current inventory of equipment is maintained by the project. Major items are listed below:

1. Dissecting microscopes: 3
2. Compound microscopes: 3
3. Microscope illuminators: 7
4. Video cameras (3) for microscopes, 2 with color monitors
5. Freeze-drying unit
6. Refrigerator/freezer: 1
7. Boats: 1, 10-ft. inflatable zodiac-type boat
8. Boat motors: 1, 15-hp
9. Meters: YSI 556 and sonde (2), Eureka Amphibian and Manta (1)
10. Computers: 5 desktops, 5 laptops, with two laser printers
11. Samplers: 2 ponars, 12 nets, 1 Hess, 1 oyster dredge, 2 Surbers
12. Global Positioning System unit: 3

9. Procedures

9.1 HISTROICAL MONITORING PROGRAMS

From 1972 -1977, trend monitoring included baseline surveys of the major waterways in the State, with sampling sites located approximately every 5 miles on most systems. These large river sites were sampled almost exclusively with multiple-plate artificial substrate samplers. From 1978-1983, this survey schedule was repeated, with nearly all the same sampling sites being sampled for trend analysis. During the 1972-1977 period, the NYSDEC Avon Pollution Investigation Unit conducted biological sampling on smaller streams across the state.

From 1984-1986, sampling mostly consisted of waterbody assessments on smaller streams. During this time the "Rapid Assessment" protocol was designed, tested, and modified, using the traveling kick sample method on wadeable streams (Bode et al., 1991).

In 1987 trend monitoring began on the RIBS (Rotating Integrated Basin Studies) network. This system involved an integrated sampling effort on one third of the major drainage basins in the state, each for two years, completing all basins over a six-year period.

In 1993, beginning with the second round of RIBS sampling, a screening procedure was developed to provide broader coverage of streams. The screening procedure involves on-site evaluation of water quality based on a traveling kick sample. Early in its use, if the site was assessed as non-impacted, the sample may have been returned to the stream. If the site was assessed as impacted to some degree, the sample was retained. Currently regardless of the outcome of the screening procedure all samples are retained. The screening technique is now used as a method of prioritizing sample processing in the laboratory and for determining if additional sample collection is needed while in the field. If the site is assessed as moderately or severely impacted, a water sample is collected for toxicity testing or a sediment sample is collected for chemical analysis.

In 1998, RIBS sampling was changed to a schedule involving 3 years in each basin: Year One: planning, reconnaissance, and biological monitoring; Year Two: chemical/intensive monitoring; and Year Three: evaluation and assessment. This schedule allows for all 17 major drainage basins to be sampled over a period of 5 years.

In 2008 the Stream Biomonitoring Unit, in recognition of the expanding uses of its data began working in various other environments other than streams and rivers. Biological monitoring techniques are useful when applied in other aquatic systems such as lakes, reservoirs, wetlands, and estuaries. Beginning with lake and reservoirs the Stream Biomonitoring Unit is working towards developing new methods for these environments which will be documented in subsequent SOPs.

9.2 SITE SELECTION

9.2.1 Trend Monitoring and Individual Site Assessments

The majority of sampling conducted by the Stream Biomonitoring Unit is associated with the RIBS program and consists mainly of single site assessments from a list of sites developed on a yearly basis. The RIBS program and the data it generates must fit the needs of two primary objectives of the program: surveying targeted of-interest sites, and creating an unbiased random dataset.

Targeted sites include those which allow for the characterization of regional reference conditions, long-term temporal trend monitoring, assessment of unassessed waters, and the monitoring of sites that are of department, regional and/or public interest. A random dataset provides the ability to project aquatic life use attainment in an un-biased, statistically sound manner across the entire state. In addition random sampling provides uniform comparability between basin datasets and other national datasets.

With such variation in equally important program objectives it is difficult to provide a one-size fits all approach to the selection of sampling locations. Therefore, during each screening cycle a percentage of the total sites are divided between targeted of-interest and random sites creating two comprehensive datasets, each with the specific objectives outlined above in mind. Targeted sites make up approximately 60% of the total number of sites sampled each year while random sites comprise 40%. These percentages are not strict rules but guidelines to use during the decision process of allocating sites to the various program objectives. The number of sites in either category may fluctuate depending on the basin and current circumstances.

9.2.2 Site Selection Criteria

Sites are stratified for selection based on the categories defined above as a percentage of the total number of sites allocated to the specific basin in a given year.

Stratification Category	Percent of Total
Regional Reference	5%
Long Term Trend	15%
Unassessed Waters	20%
Department Interest	20%
Random Probabilistic	40%

9.2.3 Regional Reference

Reference sites are selected to be representative of the highest water quality or best attainable condition in a basin. They are visited during each return cycle to a basin. These sites are selected using landscape characteristics and historical datasets. Total natural cover (forest, wetland, open water etc…) is typically greater than or equal to 75% and impervious surface cover is usually less than 2%. These values may vary depending on the characteristics of the watershed. In addition previous water quality determinations should be non-impacted without record of variability in the assessment categories. However, in some heavily disturbed watersheds the best attainable condition may not be non-impacted. In such cases the highest water quality designation should be used. Water chemistries if available should indicate background condition. A good surrogate for water chemical information is specific conductance and it should be less than 150 µsiemen/cm which is the 25th percentile of all data collected in New York State's ambient water quality monitoring program but should not exceed 250 µsiemen/cm.

9.2.4 Long Term Trend

Long term trend sites represent the historical knowledge base on water quality trends in a given watershed. Trend sites are selected to be well represented in the historical database of biological water quality monitoring data maintained by the Stream Biomonitoring Unit. These sites typically have between 4 and 8 years of previous sampling records, with a minimum of 3 years.. Geographic distribution among the watershed should also be considered when selecting trend sites, trying not to over emphasize the water quality information of a single region. Long term trend sites are sampled each time a basin is monitoried. However, as programmatic desires change, new trend sites may replace older ones. Emphasis should be placed on retaining trend sites with the longest historic record.

9.2.5 Unassessed Waters

Unassessed waters are selected from the NYSDEC Waterbody Inventory and Priority Water Bodies List (WI/PWL). The WI/PWL is a statewide inventory of specific waterbodies that characterize water quality and the degree to which water uses are supported. The determination categories are as follows: impacted, threatened, needs verification, no known impact, and unassessed. For the purposes of the water quality monitoring program it is most important to survey all unassessed waters listed in a given basin in the WI/ PWL. From here sites can then be selected to focus on those which need verification of impact, or compiling information on segments that are threatened or impacted.

9.2.6 Department Interest

Regional DEC offices within the basins to be surveyed are contacted for input on water bodies that may be of special interest. In addition, sampling “kick off” meetings are held in regions before the sampling season to get input on possible sampling locations. These meetings are open to the public and are usually well attended. Sites in this category typically assist in providing data to permit writers, watershed organizations, restoration projects and the like. Of-interest sites may also be identified as PWL/WI water bodies that are either impacted, threatened, or need verification therefore this information is used directly in updating the WI/PWL/ lists.

9.2.7 Random Probabilistic

In an effort to produce an unbiased dataset for making statewide determinations about water quality a random set of sampling locations is selected. This set of sites is developed by the EPA in cooperation with SBU staff. Experts at the EPA produce a random draw of sampling locations within the designated basins for the sampling year. The total number of sites in each basin is determined based on the percentage of total sites allotted to this category. Once the draw is provided to SBU staff a “desktop recon” of each location is made to determine access feasibility, and habitat quality. If a site is inaccessible or habitat is not suitable the site may be dropped. An over-draw of sampling locations is generated by the EPA to provide additional sites in this event.

9.2.8 Waterbody assessment surveys

The selection of sampling locations for whole waterbody assessment surveys otherwise known as rapid assessment surveys (RAS) uses a combination of historical data when available, information on known pollution sources, and desktop and field reconnaissance.

The best candidate streams for RAS are those that include riffle habitats for the greatest biological diversity against which to measure alteration. An attempt is made to coordinate these surveys with the basins that are currently being sampled in the RIBS network.

Some waterbody assessment surveys require more intensive methods.These include track-down of sources of xenobiotic substances, compliance monitoring to determine if significant impairment exists as the result of a discharge, and multi-disciplinary coordinated surveys. The methods used in special surveys are dependent on the specific applicable conditions, but may include replicated sampling, collection of organisms for tissue analysis, or application of biological impairment criteria (Bode et al 1990).

The number of sampling locations is based on the approximate stream length to be surveyed, trying to split the stream into segments of even length. A good starting point is placing sites every 5 river miles when possible, placing certain sites closer together if known sources of pollution or landscape targets warrant it. If previous surveys have been conducted the historical sites should be used. The general locations are sited by desktop reconnaissance with the specific location for the sample collection determined in the field.

9.3 MONITORING PARAMETERS

The following physical and chemical parameters are measured at each sampling location and are recorded on the field sheet (Appendix 18.1).

Sampling site location: river or stream, station number, specific location (distance upstream or downstream of bridge, road, town, or other landmark), latitude and longitude in decimal degrees, access.

Collection date and time (arrival and departure), names of collectors.

Survey type:
RIBS screening, RIBS intensive, or RAS.

Site physical parameters:
Width, depth, current speed, substrate type, embeddedness, canopy cover.

Stream/River depth:
Depth is measured using the kick net handle which has been marked every 0.1 meters. Measurements are recorded to the nearest 0.1 meters.

Stream/River width:
Width is measured using a rolled 50 meter tape measure. Only the wetted width of the stream/river is measured.

Current speed:
Surface current speed is measured by timing floating objects over a fixed distance. Portions of wooden tongue depressors are timed over a distance of 1 meter, and converted to centimeters per second. Alternately, floating debris may be measured over a distance of one meter and converted to centimeters per second. Timing is done with a digital stopwatch accurate to 0.1 second.

Substrate type:
Percentage composition is estimated, using EPA size categories listed below.

Table 1. Substrate types and associated size classes

Type	Size or characteristic
Bed rock or solid rock	----------
Boulders	> 256 mm (10 in.) in diameter
Rubble	64-256 mm (2 1/2 - 10 in.) in diameter
Gravel	2-64 mm (1/2 - 2 1/2 in.) in diameter
Sand	0.06-2.0 mm in diameter; gritty texture
Silt	0.004-0.06 mm in diameter
Clay	< 0.004 mm in diameter

Canopy cover:
Canopy cover refers to the percent of overhead vegetation in the area of the sample collection. It is measured using a standard (Model-A) spherical densiometer. The instrument is held 12-18” in front of the body at elbow height. The amount of canopy cover is estimated for each square of the densiometer’s grid. The total provides the amount of canopy cover at the specific location. This procedure is performed at the center of the riffle where invertebrate samples are collected.

Embeddedness:
This is the degree to which large substrate particles (boulder, rubble, or gravel) are surrounded or covered by fine sediments (sand, silt, or clay).
Embeddedness is visually estimated by observation of the relative proportion of larger particles surrounded by fine sediment, often evidenced by a color change

Temperature:
This is measured with a YSI 556 handheld multiparameter instrument. Measurement is made in situ one meter below water surface in deep waters, or just below the water surface in riffles.

Specific conductance:
This is measured with a YSI 556 handheld multiparameter instrument. Measurement is made in situ one meter below water surface in deep waters, or just below the water surface in riffles.

pH:
This is measured with a YSI 556 handheld multiparameter instrument. Measurement is made in situ one meter below water surface in deep waters, or just below the water surface in riffles.

Dissolved oxygen and percent saturation:
This is measured with a YSI 556 handheld multiparameter instrument. Measurement is made in situ one meter below water surface, or just below the water surface in riffles.

Salinity:
This is measured with a YSI 556 handheld multiparameter instrument. Measurement is made in situ one meter below water surface, or just below the water surface in riffles.

Profile sampling:
Profile sampling (i.e. multiple measurements from a transect running the width of the stream) of chemical variables is conducted when field staff are presented with unusual readings or observe discharges or disturbances in a waterbody. Unusual readings are considered greater than the 95th or less than the 25th percentiles of select water chemical data based on historical sampling. For the basic water chemical variables profile sampling is done where one of the following is exceeded; Temperature > 25ºC, Specific Conductance > 800 µsiemen/cm, Dissolved Oxygen > 13 mg/l or < 7.0 mg/l, Percent Oxygen Saturation > 135% or < 80%, pH > 8.6 or < 6.5. Information is recorded on the field datasheet continuosly as field staff move along a transect of the stream.

Secchi Depth:
Is a measure of water clarity. A Secchi disk; a circular plate divided into quarters painted alternately black and white, is attached to a rope and lowered into the water until it is no longer visible. The line attached to the Secchi disk must be marked to the nearest 1/10 meter. Meter intervals can be tagged (e.g., with duct tape) for ease of use. The length of rope needed to lower the secchi disk until it is no longer visible is measured and recorded as the secchi depth.

Aquatic vegetation:
Presence of different types of aquatic vegetation is noted and recorded on the field data sheet. The presence of suspended and filamentous algae is simply checked off on the sheet if present. Periphyton and macrophytes are recorded as estimates of percent cover and thickness on the substrate.

Type of sample collected:
kick, multiplate, ponar, jab, other, organisms for tissue analysis, and photograph.

Occurrence of major macroinvertebrate groups.

Field assessment of water quality (faunal condition):
Based on macroinvertebrate community, aquatic vegetation, chemical parameters, other indications of impact.

Notes and observations:
Record of any important observations or notes about the sample collected, the sampling location, disturbances observed etc…

Waterbody user perception survey:
This survey documents a user's perceived abiliy to recreate on and/or in the waterbody thereby assessing recreational use attainment.

Habitat Condition:
Habitat type is noted and can be one of either of the following: adequate, impoundment, headwater, sandy, gravely, bedrock, low flow, or other. In addition, a rapid habitat assessment is conducted to evaluate the physical conditions in the line of sight upstream and downstream from the location where the biological sample was collected. A detailed assessment of habitat condition measured at the stream reach scale is also conducted. Details on this habitat assessment are located in section 9.10 Assessment of Stream Reach Physical Habitat Characteristics.

Pebble Count:
Pebble counts of 100 random particles ranging in size from silt to rock are conducted at sampling locations with hard substrates as part of the RIBS intensive sampling network and RAS surveys as well as other special studies. Pebble counts are not collected at RIBS screening sites. The pebble count provides a precise measure of substrate composition and particle diversity. Coupled with the pebble count are measures of moss, algal, and silt cover. Details on this procedure are located in section 9.11 Pebble Count.

9.4 SAMPLING OF AQUATIC BIOTA

Several different sampling methods are used to collect samples of benthic macroinvertebrates for water quality assessment. The sampling technique and methodology used is dependent upon several factors including gradient, substrate type, water depth, and the general purpose of the sampling. Currently the primary forms of sampling are the travelling kick sample for use in wadeable streams and rivers and multiplate samplers in large nonwadeable rivers. Kick sampling dominates due to the high frequency of sample collection in smaller streams and rivers. Multiplate sampling in large rivers is conducted less frequently and ponars are sometimes used under special circumstances. Detailed descriptions of these sampling methods follow.

9.4.1 Kick Sampling for benthic Macroinvertebrates

Kick sampling is a method of sampling benthic organisms by disturbing bottom sediments and catching the dislodged organisms downstream with an aquatic net. The use of a standardized traveling kick method provides a semi-quantitative sample of the resident benthic macroinvertebrate community. The kick sampling technique and analysis of the riffle community lends itself to rapid assessments of stream water quality. Its use is limited to wadeable areas of flowing waters. Kick sampling is the technique used at a majority of sampling SBU sampling locations.

Site selection:
The sampling location should be a riffle with a substrate of rock, rubble, gravel, and sand. Depth should be less than one meter, and current speed should be at least 0.4 meters per second. If conducting multiple site surveys, sites should have comparable current speed, substrate type, and canopy cover to both upstream and downstream sites to the degree possible.

Sampling Season:
The preferred sampling time for kick sampling is July-September. Spring sampling is generally avoided due to high numbers of naidid worms frequently occurring in spring samples. In cases where samples are being taken to compare with previous collections sampling should concur with the previous time-of-year as much as possible. The use of heating degree days is preferred over the use of calendar days due to emergence behaviors of aquatic invertebrates.

Sampling:
An aquatic net (size 9 in. X 18 in., mesh opening size .8 mm X .9 mm) is positioned in the water about 0.5 m downstream and the stream bottom is disturbed by foot, so that the dislodged organisms are carried into the net (Figure 1). Sampling is continued for 5 minutes for a distance of 5 meters. The preferred line of sampling is a diagonal transect of the stream. The net contents

are emptied into a pan of stream water, examined, and the major groups of organisms are recorded, usually at the ordinal level. Larger rocks, sticks, and plants may be removed from the sample if organisms are first removed from them. The net is thoroughly cleaned before further sampling by vigorous rinsing in the stream. The contents of the pan are sieved with a U.S. no. 25 standard sieve and transferred to a quart jar. The sample is then preserved by adding 95% ethyl alcohol.

Figure 1. The traveling kick sample. Rocks and sediment in the riffle are dislodged by foot upstream of a net; organisms dislodged are carried by the current into the net. Sampling is continued for five minutes, as the sampler gradually moves downstream to cover a distance of five meters.

Sample sorting and subampling:
In the laboratory the sample is drained through a U.S. no. 60 sieve to remove the alcohol. The sample is transferred to an enamel pan and a subsample is randomly removed with a spatula. This is rinsed with tap water in a sieve and placed in a 90 mm petri dish. This portion is examined under a stereo-microscope and all invertebrates larger than 1.5 mm are removed from the debris as it is drawn through the field of view. As the organisms are removed, the organisms are sorted into major taxonomic groups, placed in one-dram vials containing 70% ethyl alcohol, and counted. Sorting is continued until 100 organisms have been removed. All identified specimens are archived. Samples with large amounts of intact leaves and low numbers of individuals may be placed in a pan of water to separate organisms from debris using flotation. The

weight of the sample material processed is weighed in relation to the weight of the total unpicked sample material to determine the percentage of sample sorted.

Organism identification:
Organisms are identified to the appropriate taxonomic level (see Appendix 18.9) using the references listed in Appendix 18.12. A list of species collected by the SBU in New York State is also included in Appendix 18.10. Individuals of Chironomidae and Oligochaeta are cleared, 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 is recorded on an electronic Laboratory Data Sheet (Appendix 18.7). Representative specimens from a sample are selected and stored separately in a reference collection.

9.4.2 On-site screening procedure for benthic Macroinvertebrates

Rationale:
To determine the in-field trigger of additional sampling such as sediment toxicity, water chemistries, and invertebrate tissue analysis, and to assist in the prioritization of sample processing in the laboratory a procedure for using on-site assessment of a macroinvertebrate sample was developed. If the on-site assessment is other than non-impacted additional sampling of other parameters may be conducted to evaluate and determine the source of the impact. In the laboratory, samples field assessed as non-impacted may be processed last or the field assessment may stand without laboratory processing. This is typically dependent upon resources in any given year.

Sampling:
The traveling kick method is used, as described in section 9.4.1. The method is limited to sites with wadeable riffles. Sampling is conducted on a 5-meter reach for 5 minutes.

Sample analysis:
Analysis of the sample is conducted on-site. The entire kick sample is placed in a large enamel pan of water, and examined for macroinvertebrates without magnification. It is also helpful to have a tray of water with several compartments for placing different species.

Criteria:
The following five criteria were established for determination of non-impact. Failure of any one criterion establishes possible impact.

a. Mayflies must be present and numerous; at least 3 species must be present.
b. Stoneflies must be present.
c. Caddisflies must be present, but not more abundant than mayflies.
d. Beetles must be present.
e. Aquatic worms must be absent or sparse

Sample treatment:
If the five criteria for non-impacted conditions are met, the sample is preserved and no further action is required. Organisms may be retained for tissue analysis. If any of the five criteria are not met, the sample is preserved for processing and a water sample may be taken for toxicity testing, or a sediment sample for chemical analysis.

Limitations:
It should be recognized that this procedure is designed to answer only the question of impact vs. no impact. The inherent shortcoming of this method is the assessment lacks any quantitative documentation. The method should not be used at headwater sites or sites affected by lake outlets, as these faunas are usually already altered by natural processes.

9.4.3 Multiplate Sampling for benthic Macroinvertebrates

Multiplates are a type of artificial-substrate sampling device developed by Hester and Dendy (1962). They are used in flowing waters too deep for kick sampling. Artificial substrates collect a macroinvertebrate sample by providing a substrate for macroinvertebrate colonization for a fixed exposure period, after which the sampler is retrieved and the attached organisms are harvested. The use of artificial substrate samplers allows the comparison of results from different locations and times by providing uniformity of substrate type, depth, and exposure period. The multiplate macroinvertebrate community is influenced more by water quality than by stream bottom conditions.

Site selection:
Sites should have comparable current speed to both upstream and downstream sites to the degree possible. The specific sampling location is preferably a pool or run, rather than a riffle. Samplers should be placed in the main current, not in peripheral near-shore areas. In navigable waters, samplers should be placed at the edge of the actual navigation channel to avoid interference with boat traffic. If navigation buoys are available near the desired sampling site, these are usually chosen for the sampler location.

Sampler construction:
The sampler design is 3 square hardboard plates, separated by spacers, mounted on a turnbuckle (Figure 2). Three square plates of tempered hardboard (smooth on both sides) are cut to the size of 6 inches (15 cm) on each side. A 1/4 inch hole is drilled through the center of each. Four square spacers of 1/8 inch tempered hardboard are cut to the size of 1 inch on each side. A 1/4 inch hole is drilled through the center of each. Three of the spacers are glued together to form a triple spacer, with the sides and holes aligned. The plates and spacers are mounted on a No. 13 aluminum turnbuckle as in Figure 2. The top plates are separated by the single spacer, and the bottom plates are separated by the triple spacer. A washer is placed above the top plate and below the bottom plate. Both the top and bottom eyebolts of the turnbuckle are tightened securely to prevent loosening during exposure. The total exposed surface area of the sampler is 0.14 square meters (1.55 square feet).

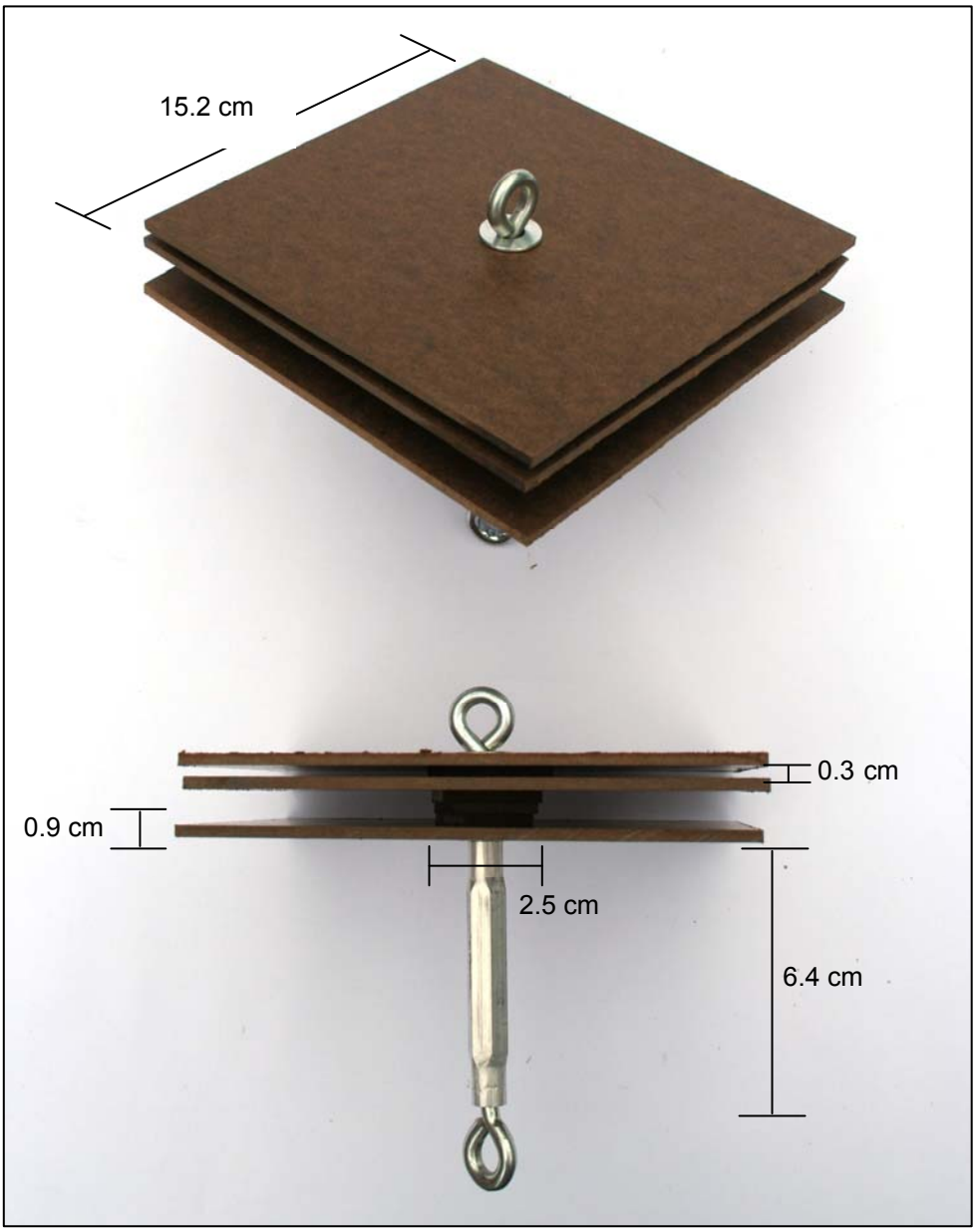

Figure 2. Multiplate samplers are made of 3 separate pieces of tempered hardboard. They are suspended in the water column and retrieved after 5 weeks of invertebrate colonizations.

Sampler placement:
Two sampling units are placed at each site during routine monitoring to increase the chances of recovering at least one sample in case of vandalism, washout, or mishandling during retrieval. The method of sampler placement is dependent on stream depth and buoy availability. If navigation buoys are used, samplers are suspended with plastic-coated cable attached to a suitable above-water portion of the buoy (Figure 3B). A plastic identification tag listing the agency is also attached with cable at this point. Samplers are attached with brass swivel snaps to facilitate sampler retrieval and replacement. In waterways with stronger

current, each sampler is stabilized with a brick weight attached to the bottom of the turnbuckle with a swivel snap. Samplers are installed 1.0 meter below the water surface. If navigation buoys are not available and stream depth is greater than 0.5 meters deep, the sampler is suspended from a float constructed of a two-liter plastic bottle filled with styrofoam chips (Figure 3A). The float is anchored with a three-holed concrete block, 4 x 8 x 16 inches. Connections are made with 1/8 inch plastic-coated cable. Brass swivel snaps are used to connect the sampler to the cable. Samplers are installed 1 meter below the water surface; in streams 0.5-2.0 meters deep, the samplers are placed midway between the water surface and the stream bottom. In streams less than 0.5 meters deep, the sampler is attached directly to a concrete block. The type of block used is a patio block, 2 x 8 x 16 inches, with a center hole drilled for attaching the sampler turnbuckle.

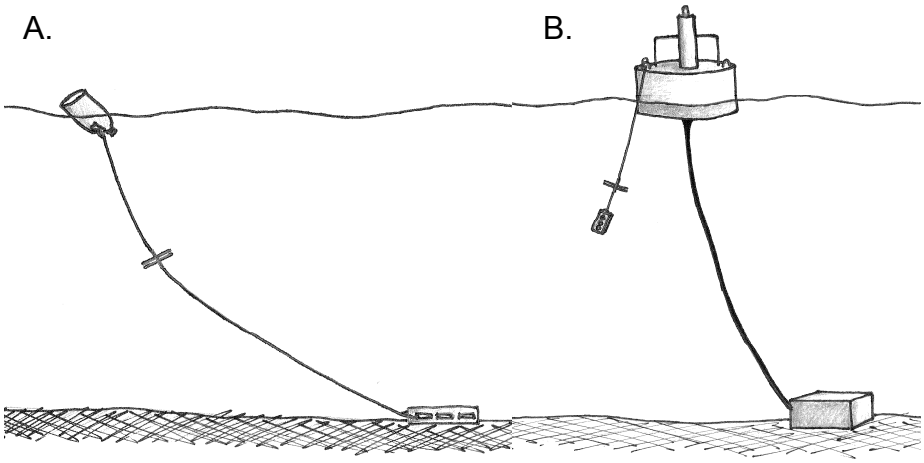

Figure 3. For navigable waters and non-wadeable, non-navigable waters multiplates are either attached to (A) a plastic-bottle flotation device and anchored to a concrete block or they are (B) suspended from a channel buoy and anchored by a brick.

Sampler retrieval:
Samplers are retrieved 5 weeks after placement. The sampler is carefully brought to the water surface and the swivel snaps are unhooked. The sampler is removed from the water and placed in a bucket of stream water. The sampler is disassembled using pliers and/or screwdrivers. All accumulated organisms and other material are scraped from the plates with a 3-inch wide paint scraper into the water in the bucket. The resultant slurry is poured into a U.S. no. 30 standard sieve, the residue rinsed with river water, and placed in a 4-ounce glass jar. 95% ethyl alcohol is added to fill the jar and preserve the sample.

Sample sorting and subsampling:
For routine monitoring, only one sample from each site/date collection is processed; the other sample is retained for possible later use. The sample with the most accumulated material is selected for processing. The sample is rinsed with tap water in a U.S. no. 40 standard sieve. The sample is then subsampled by placing the sample in a tray, evenly distributing it over the bottom, and placing

a divider in the tray that divides the sample into quarters. A quarter-subsample is examined under a dissecting stereo-microscope and organisms larger than 1.5mm are removed from the debris. As they are removed, they are sorted into major groups, placed in vials containing 70% ethyl alcohol, and counted. Quarter subsamples are sorted in their entirety; when 250 individuals have been sorted, no more quarters are sorted. For samples with a large number of a particular group of organisms, this abundant group may be subsampled, while the remaining organisms are sorted from the entire sample. Minimum subsample sizes are 50 for Oligochaeta, and 100 for all other groups. All identified specimens are archived.

Organism identification:
Procedures follow those for kick sampling with the exception of Chironomidae and Oligochaeta. Chironomidae are subsampled for 100 individuals, and Oligochaeta are subsampled for 50 individuals. The numbers of individuals in the subsample are multiplied by the inverse of the proportion of the sample to determine the total number of individuals in the sample.

9.4.4 Ponar Sediment Sampling for benthic Macroinvertebrates

The use of the Ponar grab sampler or Petite Ponar grab sampler (Figure 3) provides a quantitative sample of soft sediments in rivers or lakes. The sampler is designed to penetrate the substrate by its own weight, and enclose a portion of the bottom by means of a gravity-activated closing mechanism. The standard Ponar measures nine inches on each side, enclosing a surface area of 0.56 square feet (0.052 square meters). The Petite Ponar measures six inches on each side, enclosing a surface area of 0.25 square feet (0.023 square meters).

Site selection:
Substrates in rivers and lakes that may be sampled with a Ponar grab sampler include: gravel, sand, silt, and clay. Substrates with larger rocks or wood may be difficult or impossible to sample, since these objects may block the jaws during closing, causing loss of part of the sample.

Time of sampling:
The preferred sampling time for Ponar sampling is May-October. In cases where samples are being taken to compare with previous collections, the sampling time should concur with the previous time-of-year.

Sampling:
Sampling is usually conducted from a boat. The sampler is lowered over the side of the boat with a cable or rope, and is lowered to the bottom of the waterbody. Lowering in the final meter above the bottom should be a freefall, to allow the sampler to penetrate the bottom. Upon reaching the bottom, the closing mechanism is activated, and the sampler is retrieved. After the sampler breaks the water surface, a bucket or tub is placed beneath to catch any escaping materials. The sampler is then opened, and the contents are sieved in a bucket with a U.S. Standard No. 30 mesh sieve (0.590 mm openings). The residue may then be 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 sieve are then transferred to a quart jar. The sample is then preserved with 95% ethyl alcohol.

Figure 4. The petite ponar grab sampler. The sampler is lowered to the bottom of the waterbody, freefalling for the final meter to allow penetration of the bottom sediment. Upon reaching the bottom, the closing mechanism is activated. As the sampler is retrieved, it encloses a portion of the substrate.

Sample sorting and subsampling:
In the laboratory the sample is rinsed with tap water in a U.S. No. 40 standard sieve to remove any fine particles left in the residues from field sieving. The sample is transferred to an enamel pan and distributed homogeneously over the bottom of the pan. A small amount of the sample is randomly removed with a spatula and placed in a petri dish with water. This portion is examined under a dissecting stereomicroscope and 100 organisms are removed from the debris. As they are removed, they are sorted into major groups, placed in vials containing 70 percent alcohol, and counted.

Organism Identification:
Procedures follow those outlined in the methods for kick sampling above.

9.4.5 Multiple Habitat Sampling for Diatoms

Rationale:
Diatoms constitute a class of single-celled and colonial algae characterized by silicon cell walls. There are many advantages to using diatoms as water quality monitors: 1) they respond rapidly to water quality changes, making them valuable indicators of short-term impacts; 2) because they are primary producers and are ubiquitous in all waters, they are directly affected by water quality; 3) diatom sampling is rapid and requires few personnel; 4) the diatom community contains a naturally high number of taxa that can usually be identified to species; 5) diatom assemblages contain a high number of organisms, facilitating statistical analysis; 6) many diatom species are excellent indicators of organic pollution, eutrophication, and acidity; 7) diatoms are sensitive to abiotic factors that might not be detected in the fish or invertebrate assemblages; 8) diatom data can be analyzed using several metrics or indices to determine water quality and diagnose specific stressors; 9) diatoms bioconcentrate many contaminants, so that chemical analysis of them can be used as a monitor of toxic substances in the aquatic food chain; and 10) diatom samples can be preserved indefinitely and used for later evaluation.

Sampling:
All major benthic habitats available are sampled for diatoms - stones, macrophytes and mud - and are mixed in a single, multi-habitat sample (MHS), representative of the periphytic flora of that site. Epilithon (community growing on rocks) is scraped from pebbles, cobbles and boulders with a knife. Epiphyton (community growing on plants) is collected from nonvascular and vascular plants by adding the whole plant or parts of it to the MHS. Epipelon (community occurring on the surface of mud) is sampled using a pipette to suction up the brown flocculent material occurring on the mud. All samples are placed in a vial and preserved with 4% formaldehyde in the field.

Sample processing and organism identification:
Samples are sent to a contract laboratory for processing using the following method; Samples are processed in the laboratory with sulfuric acid following the method of Hasle and Fryxell (1970). Cleaned material is washed with distilled water eight times and then preserved in 100% ethanol. For light microscopy, the cleaned material is dried onto a cover glass with the flame of an alcohol lamp. A drop of ethanol is employed to speed the evaporation and spread the diatoms into an even layer. Permanent mounts are prepared using Naphrax® and at least 300 cells per mount are identified employing an oil immersion objective at 1,000x magnification.

9.4.6 Electroshock Sampling for Fish

Rationale:
Fish sampling is conducted at select intensive sites and during some waterbody surveys when applicable. Analysis of fish communities provides an important link between biological water quality assessment data and New York State's water body use designations. Fish are not sampled at all stations because, unlike benthic macroinvertebrates and diatoms, fish are highly mobile in the aquatic environment allowing them to avoid areas of pollution. In addition, fish community assessment is more time consuming and is therefore used less often.

Sampling:
Fish sampling is conducted by SBU staff. Sampling in wadeable streams consists of electro-fishing a single stream reach equal to 20x the stream wetted width with a minimum reach length of 75 meters and a maximum of 250 meters. A reach that cannot be effectively sampled using a single backpack electroshocker will be sampled from one bank out to 8-10 meters. Attempts are made to sample a diversity of habitats including riffles, pools, snags, and undercut banks. Sampling reaches are isolated with blocknets in the absence of natural barriers. A backpack electro-shocker is used to shock a single pass through the stream reach, working from downstream to upstream. Electro-shocking is preferred, but seining may also be used if appropriate, for example, in very deep pools or long deep runs.

Fish are identified and enumerated at the site and released. Salmonids are measured and enumerated. All specimens are counted and examined for external anomalies such as deformities, eroded fins, lesions and tumors. All information is recorded on the field datasheet (Appendix 18.6). Unidentifiable specimens are retained and preserved in a solution of 10% buffered formalin. These specimens are contained in a single site jar labeled with site identification information for later identification and confirmation in the laboratory. Specimens of unique or range extended fish are also preserved and retained as vouchers. Young of the year fish less than 20 millimeters in total length are not included in the sample and are returned directly to the stream.

Anomalies recorded include:

D = Deformaties	S = Emaciated
E = Eroded fins	BS = Black Spot
F = Fungus	YG = Yellow Grub
L = Lesions	Z = Other
M = Multiple anomalies	

Analysis of data:
Methods for interpretation of fish data with regard to water quality have not yet been regionally standardized for northeastern streams. Four indices are used to provide a provisional assessment of water quality.

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

2. Percent Non-tolerant Individuals. This is the percentage of the total individuals belonging to species considered intolerant or intermediate to environmental disturbance. Tolerance is based on listing in EPA's Rapid Bioassessment Protocols (Barbour et al., 1999) with the exception of Blacknose Dace, which are here considered intermediate rather than tolerant.

3. Percent Non-tolerant Species. Similar to Percent Non-tolerant Individuals, but calculated for species.

4. Percent Model Affinity, by trophic class. This is the highest percentage similarity to any of five models of non-impacted fish communities, by trophic class, as listed in Halliwell et al. (1999). The models are:

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

5. The collection methods outlined here also allow for the calculation of any of the fish community metrics described in the USEPA's Rapid Biological Assessment Protocols (Barbour et al 1999). This includes the use of the multimetrics community assessment method outlined in the document.

Interpretation:
The overall assessment of water quality is assigned by the profile value. This value = (weighted richness value + 0.1[% non-tolerant individuals] +0.1[non-tolerant species] + 0.1[Percent model affinity]) /4. For assessments of streams in western New York State, a correction factor of 0.75 is applied, to offset the increased diversity that these streams exhibit compared to streams in central and eastern New York.

9.5 BIOLOGICAL IMPAIRMENT CRITERIA SAMPLING

Background/rationale:
Biological impairment criteria allow determination of significant water quality impairment based on upstream/downstream changes in one of five biological indices. The criteria are used for enforcement or compliance monitoring, as distinguished from trend monitoring. Figure 5 provides an overview of the procedures used. The Biological Impairment Criteria document (Bode et al., 1990) should be consulted for a detailed description.

Sampling:
The most appropriate sampling method is determined by measuring habitat parameters at available upstream and downstream sites. Kick sampling is used for wadeable riffles with rock/gravel/sand substrates; multiplate sampling is used for all other habitats. Upstream and downstream sites are selected that meet the habitat criteria for site comparability. Sampling is conducted at the upstream and downstream site. For kick sampling, four replicates are collected at each site. For multiplate sampling, three 5-week exposures are conducted.

Sample sorting and identification:
Kick samples are sorted for 100 individuals as described in Section 9.4. Multiplate samples are sorted as described in Section 9.4. Identification procedures for both follow those described in Section 9.4. For kick samples, percentage similarity is used (as in Bode et al., 1990) to calculate similarity between three of the replicates at each site. If similarity is less than 50 for any replicate pairing, 100 organisms are re-subsampled from the replicate with the lowest average similarity. If similarity is still less than 50 for the replicate pairing, a fourth replicate is subsampled from the site. If 50% similarity cannot be achieved with these replicates or subsamples, re-sampling is necessary.

Data reduction:
The parameters are calculated for each sample, parameters A-E for kick samples and parameters A-D for multiplate samples listed below. The average index value for the 3 samples from each site is calculated for each index: Hilsenhoff Biotic Index, EPT richness, Species richness, Species dominance, and Percent Model Affinity (See Section 10.1 for details on the calculation and rationale of these indices).

Determination of impairment:
Values from the downstream site are compared to those from the upstream site. For kick samples, violation of 1 or more of the criteria for parameters A-E indicates provisional impairment. For multiplate samples, violation of 1 or more criteria for parameters A-D indicates provisional impairment A) Biotic index: +1.5 (0-10 scale), B) EPT value: -4, C) Species richness: -8, D) Species dominance: +15, E) Percent model affinity: -20. For sites with provisional impairment, perform the Student's T-test (as in Bode et al., 1990) to determine if results are statistically significant at the level P=.05. If results are significant, biological impairment is indicated.

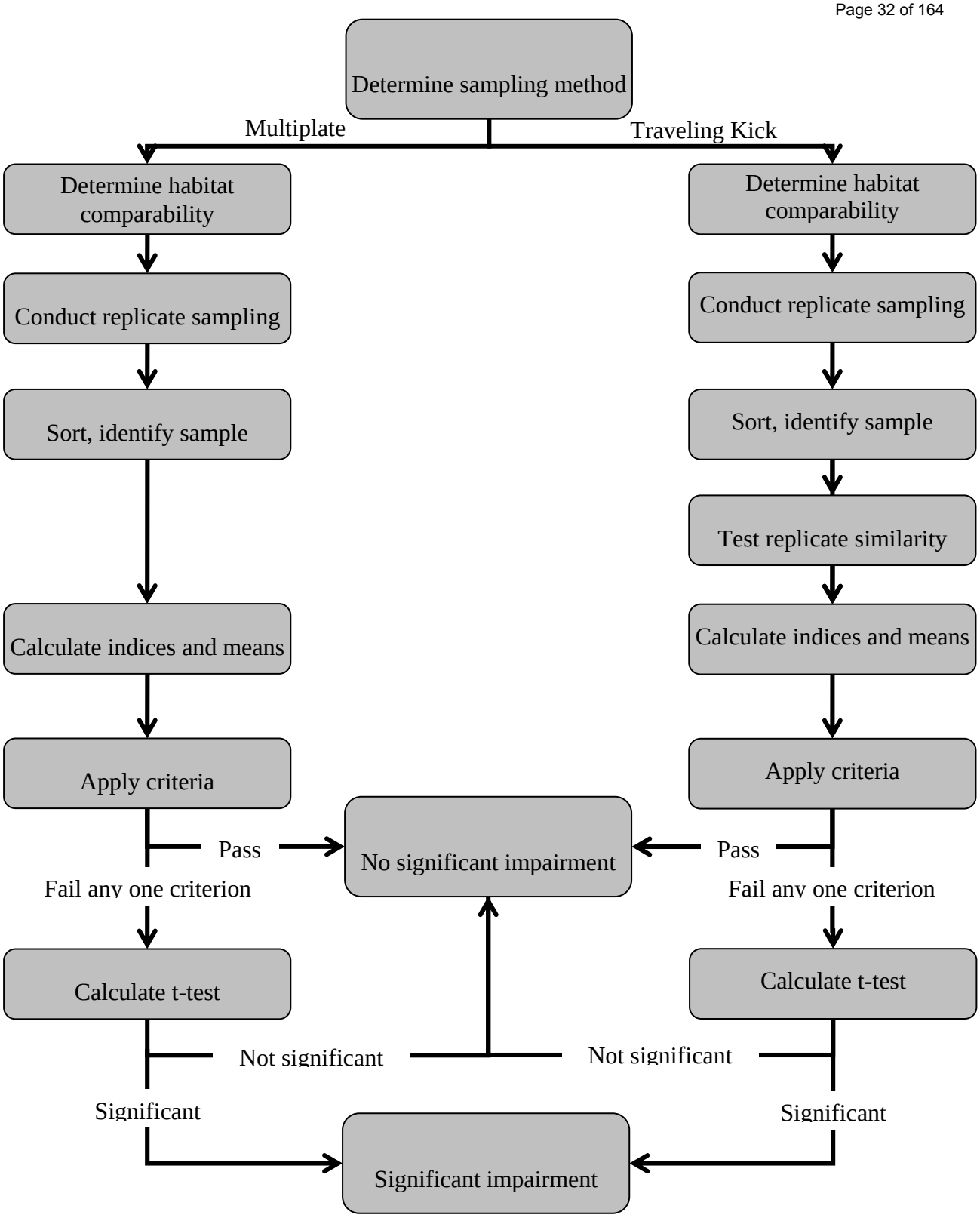

Figure 5. Biological Impairment Criteria Procedures

9.6 NONPOINT SOURCE SAMPLING

Rationale:
Nonpoint source discharges present special problems in measuring impacts to resident biotic stream communities. The primary potential problems are siting upstream control sites in agricultural areas, and detecting effects of nonpoint sources, which are often less pronounced. Bode et al. (1995) showed that the existing biological impairment criteria proposed for New York State streams (Bode et al., 1990), with certain modifications, can be effective in documenting effects of nonpoint impacts.

Sampling:
Only kick sampling in wadeable riffles with rock/gravel/sand substrates has been tested for nonpoint applications. Preliminary non-replicated kick sampling should be conducted to determine probable nonpoint impacts (Figure 6). Probable nonpoint impacts are determined by an assessment of slight impact, with probable cause indicated by Impact Source Determination and/or the Nutrient Biotic Indices (Section 10.1). To proceed with impact assessment sampling, select an upstream site and a downstream site that meet the habitat criteria for site comparability. The upstream site should be minimally affected by nonpoint discharges. Siting on a comparable surrogate stream may be necessary if no suitable minimally affected upstream site can be found. Sampling at the two sites is conducted using biological impairment methods (Section 9.5).

Sample sorting and identification:
Kick samples are sorted for 100 individuals as described in Section 9.4.1. Identification procedures also follow those described in Section 9.4.1. Use percentage similarity to calculate similarity between three of the replicates at each site. If similarity is less than 50 for any replicate pairing, re-subsample 100 organisms from the replicate with the lowest average similarity. If similarity is still less than 50 for the replicate pairing, subsample the fourth replicate from the site. If 50% similarity cannot be achieved with these replicates or subsamples, re-sampling is necessary.

Data reduction:
Parameters A-E are calculated for each sample. The average index value for the 3 samples from each site is calculated for each index: Hilsenhoff Biotic Index, EPT richness, Species richness, Species dominance, and Percent Model Affinity.

Determination of impairment:
Values from the downstream site are compared to those from the upstream site. Violation of 1 or more of the criteria for parameters A-E indicates provisional impairment A) Biotic index: +1.5 (0-10 scale), B) EPT value: -4, C) Species richness: -8, D) Species dominance: +15, E) Percent model affinity: -20. For sites with provisional impairment, the Student's T-test is performed to determine if results are statistically significant at the level P=.05. If results are significant, biological impairment is indicated.

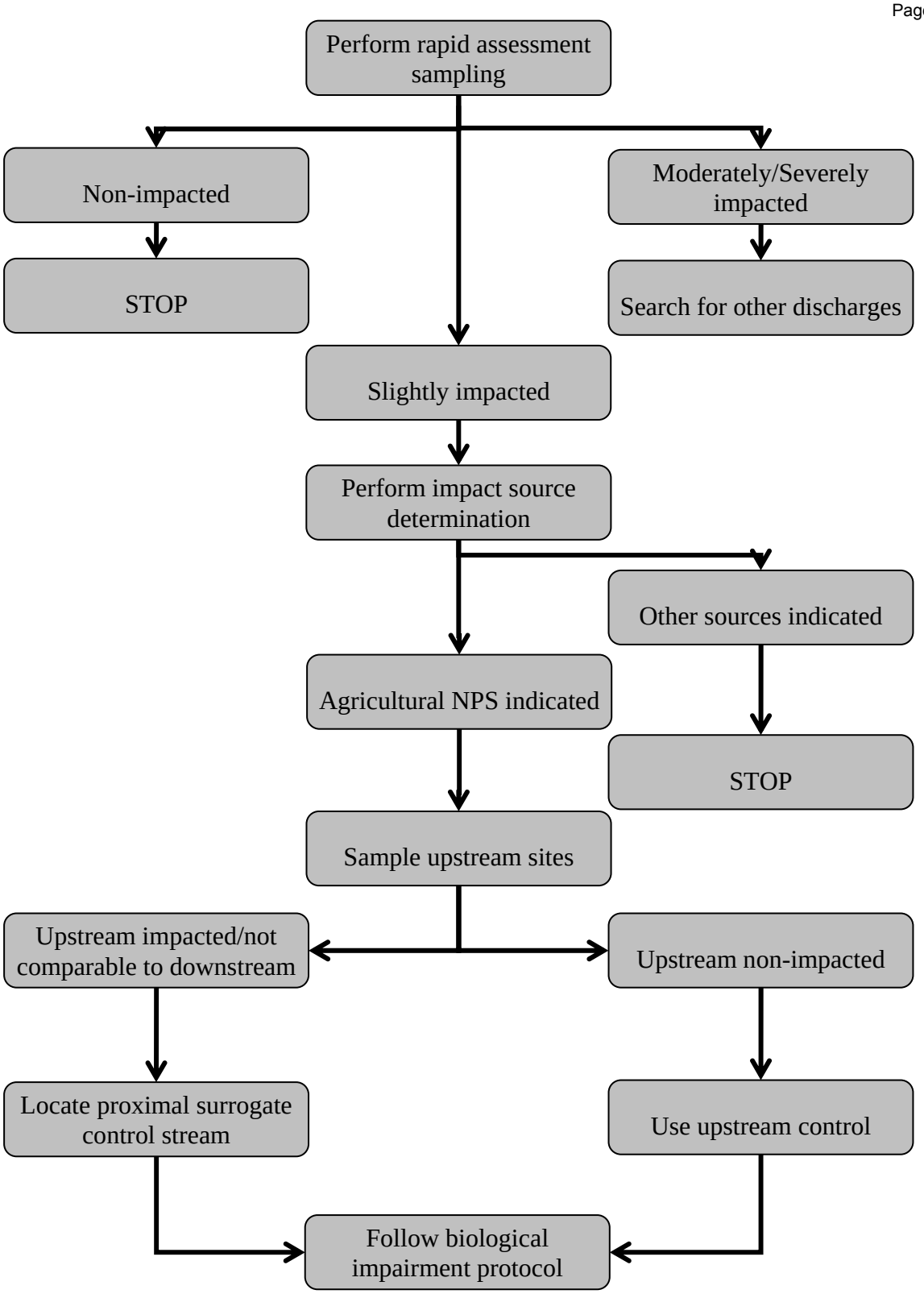

Figure 6. Procedure for determination of significant biological impairment from agricultural nonpoint source impacts.

9.7 TISSUE ANALYSIS SAMPLING

Rationale:
Macroinvertebrates are used as monitors of contaminants by collecting organisms and having their tissues chemically analyzed. They are of particular interest because 1.) they bioconcentrate many contaminants to levels several times that found in water, 2.) they occupy a middle position in the aquatic food chain, and may be linked to levels found in fish, 3.) they are less mobile and shorter lived than fish, and may be used to pinpoint a contaminant source in relation to time and location, and 4.) they are easily collected in most aquatic environments.

Field collection:
For routine monitoring, it is desirable to collect the same type of organism at each site to allow maximum comparison of results. The organisms most commonly found in the majority of aquatic environments in adequate biomass for analysis are the net-spinning caddisflies (Trichoptera: Hydropsychidae), crayfish (Crustacea: Decapoda), hellgrammites (Megaloptera), mollusks, (Mollusca - either clams, snails, or zebra mussels) and odonates (dragonflies and damselflies). Organisms are selected primarily on the basis of available numbers and size for attaining adequate biomass for analysis. Organisms are netted or hand-picked from the stream with forceps, and placed in hexane-washed 4-ounce glass jars containing water from the waterbody being sampled. The jars are kept on ice in a cooler until returned to the laboratory. At all times during the collection procedure personnel should wear disposable safety gloves.

Laboratory sorting:
In the laboratory, specimens are emptied into a washed petri dish and examined under a dissecting stereo-microscope. Larger foreign particles are removed from the organisms. Mollusk tissues are removed from the shells for analysis. Crayfish are measured for carapace length and disjointed. All organisms are placed in hexane washed 4-ounce glass jars and stored in a freezer until preparation for analysis. Prior to submitting specimens for analysis, they are weighed (wet-weight), freeze-dried, and re-weighed (dry-weight).

Chemical analysis:
All tissue analyses must be conducted in accordance with EPA SW 846 methods and minimum reporting levels (as shown in Table 2).

Table 2. Analytic specifications for priority pollutants in macroinvertebrate tissue including metals, PAHs, pesticides, and PCBs. For metals, low resolution pesticides, and PCBs minimum reporting levels listed are based on a minimum of 1 gram of sample. Minimum reporting levels for PAHs, high resolution pesticides, and AMA pesticides are based on a minimum of 10 grams of sample.

	Parameter	CAS Number	Analytic Method	Minimum Reporting level (µg/g)
Metals	Arsenic	-	EPA SW-846 3050-6010	1.000
	Cadmium	-		0.500
	Chromium	-		1.000
	Copper	-		2.500
	Lead	-		0.500
	Nickel	-		4.000
	Selenium	-		0.500
	Titanium	-		5.000
	Zinc	-		2.000
	Mercury	-	EPA SW-846 3050-7471	0.033
Polynuclear Aromatic Hydro-carbons (PAHs)	Benzo[A] Anthracene	56-55-3	EPA SW-846 8270D by SIM	0.0006
	Chrysene	218-01-9		0.0006
	Fluoranthene	206-44-0		0.0024
	Phenanthrene	85-01-8		0.0120
	Pyrene	129-00-0		0.0018
Organo-chlorine Pesticides	Aldrin	309-00-2	EPA SW-846 8081	0.040
	Chlordane	57-74-9		0.180
	DDD	72-54-8		0.090
	DDE	72-55-9		0.090
	DDT	50-29-3		0.090
	Dieldrin	60-57-1		0.040
	Endosulfan I	959-98-8		0.090
	Endosulfan II	33212-65-9		0.090
	Endosulfan Sulfate	1031-07-8		0.090
	Endrin	72-20-8		0.040
	Endrin Aldehyde	7421-36-3		0.040
	HCH, Alpha	319-84-6		0.075
	HCH, Beta	319-85-7		0.075
	HCH, Gamma (Lindane)	58-89-9		0.075
Organo-	HCH, Delta	319-86-8		0.075

	Parameter	CAS Number	Analytic Method	Minimum Reporting level (µg/g)
chlorine Pesticides	Heptachlor	76-44-8		0.090
	Heptachlor Epoxide	1024-57-3		0.090
	Methoxychlor	72-43-5		0.900
	Mirex	2385-85-5		0.090
	Toxaphene	8001-35-2		1.800
AMA (Nitrogen-Phosphorus) Pesticides	Alachlor (lasso)	15972-60-8	EPA SW-846 8141	0.00010
	Atrazine	1912-24-9		0.00005
	Azinphos-methyl	86-50-0		0.00010
	Butylate (Sutan)	2008-41-5		0.00005
	Chlorpyrifos	2921-88-2		0.00002
	Cyanazine (Bladex)	21725-46-2		0.00002
	DEET	134-62-3		0.00005
	Diazinon (Spectricide)	333-41-5		0.00003
	Disulfuton (Di-Svston)	298-04-4		0.00005
	EPTC (Eptam)	759-94-4		0.00005
	Ethion	563-12-2		0.00001
	Isofenphos (Oftanol)	25311-71-1		0.00002
	Linuron (Lorax)	330-55-2		0.00010
	Malathion	121-75-5		0.00005
	Metalaxyl	57837-19-1		0.00010
	Metochlor	51218-45-2		0.00010
	Parathion	56-38-2		0.00005
	Phosalone (Zolone)	2310-17-0		0.00005
	Prometon (Pramitol)	1610-18-0		0.00005
	Propoxur (Bagon)	114-26-1		0.00010
	Simazine	122-34-9		0.00002
	Triazophos	24017-47-8		0.00002
	Trifluralin	1582-09-8		0.00010

	Parameter	CAS Number	Analytic Method	Minimum Reporting level (µg/g)
Poly-chlorinated Bipheynl (PCBs) Aroclors	Aroclor 1221	-	EPA SW-846 8082	0.09
	Aroclor 1232	-		0.09
	Aroclor 1016/1242	-		0.09
	Aroclor 1248	-		0.09
	Aroclor 1254	-		0.09
	Aroclor 1260	-		0.09

Derivation of contaminant guidelines:
Guidelines have been developed for metals, PAHs, PCBs, and some pesticides (Tables 3 and 4). For metals, PAHs, PCBs, and pesticides, frequency distributions were compiled of concentrations in tissues from samples collected state-wide, representing a wide range of water quality. Provisional guideline levels were initially set at the level of the mean plus 2.57 standard deviations from the mean. Provisional levels were subsequently adjusted as more data became available. Values reported as below detectable levels were treated as the level of detection for frequency distribution purposes. On-going collection and analysis of tissue samples is reviewed to determine if adjustment of any guidance value is considered necessary.

Table 3. Levels of concern for priority pollutants in samples from invertebrate tissues including metals, Polynuclear Aromatic Hydrocarbons (PAHs), Polychlorinated biphenyl (PCBs) Aroclors, and select pesticides. Values are given in dry weight of sample.

	Parameter	Crayfish	Caddisflies	Hellgrammites	Mollusks	Other
Metals (µg/g)	Arsenic	6	5	3	7	5
	Cadmium	2	2	2	2	2
	Chromium	4	20	4	20	20
	Copper	210	80	45	60	100
	Lead	5	16	5	7	15
	Mercury	0.3	0.3	0.3	0.2	0.4
	Nickel	2.5	10	5	12	12
	Selenium	4	6	6	4	5
	Titanium	12	40	30	40	40
	Zinc	100	225	150	300	300
PAHs (µg/kg)	Chrysene	600	2500	1300	100	800
	Fluoranthene	200	500	200	100	200
	Phenanthrene	400	800	500	100	400
	Pyrene	400	1000	600	600	100
	Benzo [A] Anthracene	900	4000	2000	100	1000
PCBs (mg/kg)	Total PCBs	0.5	1.0	0.5	0.5	1.0*
Select Pesticides (ng/g)	DDT (4,4')	10	5	5*	-	10
	DDD (4,4')	5	5	5*	-	10
	DDE (4,4')	50	75	75*	-	75

* Stoneflies only for PCBs

Table 4. Levels of concern for organochlorine pesticides in crayfish tissue.

Pesticide	Level of Concern (ng/g)
Aldrin	0.01
a-BHC	0.1
b-BHC	0.05
g-BHC (Lindane)	1.0
a-Chlordane	5
g-Chlordane	5
oxy-Chlordane	5
DDD (2,4')	1
DDE (2,4')	1
DDT (2,4')	1
Dieldrin	4
Endosulfan sulfate	0.1
Endrin	0.1
Endrin Aldehyde	0.1
Endrin Ketone	0.1
Heptachlor	0.1
Heptachlor Epoxide	1.0
Hexachlorobenzene	5
Methoxychlor	0.2
Mirex	0.2
cis-Nonachlor	10
trans- Nonachlor	20

9.8 MORPHOLOGICAL DEFORMITY ANALYSIS

Rationale:
Morphological deformities have been shown to be associated with toxic contaminants in the environment. Warwick (1988) associated deformities in the midge *Chironomus* spp. with contaminated sediments. Subsequent studies (Lenat, 1993) have focused on the mentum mouthpart of *Chironomus* spp. as a reliable method for distinguishing toxic impacts from organic impacts, with toxic impacts resulting in deformities with greater frequency and severity.

Sampling:
Samples may be obtained through kick sampling, multiplate sampling, or Ponar sampling. Chironomus are more likely to occur in Ponar samples, because they burrow in sediments.

Analysis:
A minimum of 15 mature specimens of *Chironomus* spp. is preferred to perform morphological deformity analysis. Specimens are slide-mounted and identified prior to examination for deformities. The mentum (the principal mouthpart structure) is examined to determine frequency and severity of deformities. Deformities most frequently encountered are missing teeth, extra teeth, asymmetry, and large gaps. Severity was classified into three classes according to Lenat (1993):

- Class I: slight deformities that may be difficult to distinguish from chipped teeth.
- Class II: more conspicuous deformities, including one of the following: extra teeth, missing teeth, large gaps, and distinct asymmetry.
- Class III: severe deformities, including at least two Class II characteristics.

For each site, the total number of deformed specimens in each class is multiplied by the class number (1-3); these are added, and the mean severity is calculated, ranging from 1-3. Frequency is calculated as percent of the total midges displaying deformities in any class of severity.

Interpretation of results:
A provisional rating system was devised (Table 5), based on frequency and severity of mentum deformities. These were derived from Lenat (1993), Warwick (1988), and published and unpublished DEC data.

Table 5. Toxicity ratings based on Chironomidae morphological deformities.

Rating	Frequency (%)	Severity
Non-toxic	0-15	1.00-1.60
Slightly toxic	16-30	1.61-1.90
Moderately toxic	31-50	1.91-2.20
Severely toxic	> 50	> 2.20

9.9 ASSESSMENT OF RECREATIONAL USE ATTAINMENT – USER PERCEPTION SURVEY

Rationale:
The classification and regulation of surface waters in New York State Environmental Conservation Law, Part 701 defines designated uses of each of the State's waterbodies. Recreation is a primary component of these designated uses. The User Perception Survey is a method of determining from a user's perspective whether or not the waterbody is supporting the recreational uses it is meant to sustain. The survey attempts to assess primary and secondary contact recreation as well as a user's desire to fish. User perception surveys are conducted routinely at all biological sampling locations.

Method:
The User Perception Survey is conducted in pairs of survey crew members who collectively discuss the elements of the survey and then record their agreed upon answers. The form used is the User Perception Field Sheet (Appendix 18.2).

The first element of the field sheet is a pair of questions meant to assess both primary and secondary contact recreation. The questions are multiple choice and offer a set of answers ranging from "beautiful, could not be nicer" to "awful," recreation is impossible.

After circling one answer for each question the users circle the weather conditions for both the current and past 24 hours. Recording weather conditions is important in considering the elements that may be affecting a users perception of the waterbody. For example heavy rains could bring high, turbid water thereby reducing a users perception of their ability to swim or fish. The survey is not meant to designate a waterbody as impaired for recreation due to natural variability caused by weather conditions.

The last set of questions the user fills out on the survey are aimed at identifying the specific variables that may have affected the user's decision in the first two questions. The variables are listed and a scale from 0 (natural) – 10 (highly disturbed) is provided for each. The specific variables are A) water clarity, B) phytoplankton, C) periphyton cover, D) macrophyte cover, E) odor, F) trash and G) discharges/pipes. After ranking the variables the users are asked to circle each variable that affected their decision in questions 1 and 2. This is an important step in the survey since not all variables that may have been ranked as disturbed or unnatural affected the user's decisions on recreational use in the first two questions. For example water clarity may be ranked very poor and the stream may be very turbid. However, water clarity did not affect the user's reduced desire to recreate, it was actually a foul odor and trash scattered about the stream bank.

Interpretation of Results:
The survey results are interepreted as the answer to the questions describing the user's ability to recreate (questions 1 and 2). The remaining data on the survey is used to help interpret and identify the sources of reduced desire to recreate. All data are stored along side the biological sample information in the SBU Database.

9.10 ASSESSMENT OF STREAM REACH PHYSICAL HABITAT CHARACTERISTICS

Rationale:
The disturbance of the physical habitat of an aquatic environment can have as much an influence on the benthic invertebrate communities as any source of pollution. Often inadequate habitat conditions can obscure the assessments made regarding the effects of pollution. For this reason a complete habitat assessment of both instream and riparian condition is conducted at each sampling location. The method used follows that of the rapid habitat assessment outlined in Barbour et al (1999).

Method:
Two different assessment frameworks are utilized, one for high gradient streams and rivers the other for low gradient streams and rivers. For habitat assessments in NYS the high gradient assessment is conducted in streams with current speed >0.4m/sec with visible riffle habitat and rocky, cobble, and gravel substrates. Low gradient habitat assessments are made where current speed is <0.4m/sec, riffles are absent, and the substrate consists mainly of sand and silt.

After determining the appropriate gradient the habitat assessment is made by observing the conditions of the waterbody within the field crew's line of site both upstream and downstream from the sampling location. Ten different habitat characteristics are assessed and given a score using the Rapid Habitat Assessment Fieldsheet (Appendix 18.3 and 18.4). Seven of which are scored on a scale of 0-20, 0 being poor and 20 being optimal. Three characteristics are scored on a scale of 0-10, 0 being poor and 10 being optimal. See Appendix 18.3 and 18.4 for the complete habitat assessment sheet for both high and low gradient systems as well as descriptions of each of the 10 habitat parameters assessed.

Interpretation of Results:
The utility and applicability of EPA's Rapid Habitat Assessment protocol (Barbour et al., 1999) to New York State's Stream Biomonitoring Unit was established by Tran et al. (2010). Interpretation of habitat assessment results is conducted through calculation of Habitat Model Affinity (HMA) scores. Presently two habitat similarity models are under development, one for high gradient streams, and another for low gradient. Only the high gradient HMA is currently complete enough for use and is still considered provisional, it is described below.

The HMA for high gradient streams is calculated based on comparison to a reference condition habitat model. Habitat is one of the many influences to the biological community structure and the HMA provides a quantifiable tool for the assessment of in-stream and riparian habitat within the sampling reach. The calculated HMA scores fall into broader categorical assessments of habitat condition: natural, altered, moderate, and severe. Because of their natural differences in habitat, low gradient streams will be assessed using a different set of criteria. As mentioned above, the low gradient model is under development.

Procedure for Calculating Provisional Habitat Model Affinity (HMA) Scores

1. Determine the total score (out of 20) for each of 10 habitat parameters.
2. For each parameter, compare the stream score to the model, taking the lesser of the two values, and add up these values
3. Habitat Model Affinity = (Lesser Value Total/Model Total)*100

An example calculation of HMA and assessment category thresholds are provided below

Example Calculation of HMA (see tables below for detail)

HMA = (152/181)*100
HMA = 84

Categorical Assessment = Natural

Table 6. Example of a provisional Habitat Model Affinity (HMA) calculation for a high gradient stream. Field collected values (Stream) are compared to a pristine – natural (model) condition.

Habitat Parameter	Model	Stream	Lesser Value
1. Epifaunal Substrate/Available Cover	17	13	13
2. Embeddedness	17	19	17
3. Velocity/Depth Regime	19	16	16
4. Sediment Deposition	18	17	17
5. Channel Flow Status	19	15	15
6. Channel Alteration	18	18	18
7. Frequency of Riffles	19	19	19
8. Bank Stability (L+R)	18	13	13
9. Vegetative Protection (L+R)	18	14	14
10. Riparian Vegetative Width (L+R)	18	10	10
Model Total	**181**	**Lesser Value Total**	**152**

Table 7. Provisional Habitat Model Affinity assessment thresholds.

HMA Category Thresholds	Habitat Assessment
80 - 100	Natural
70 - 79	Altered
60 - 69	Moderate
< 60	Severe

9.11 PEBBLE COUNT

Rationale:
This method is used to describe the substrate particle size classes within the "riffle" habitat of high gradient stream types that are targeted by the NYSDEC for macroinvertebrate community assessments. The method is based on the more rigorous technigue developed by Wolmen (1954) to describe coarse river bed materials, and modifications of this technique developed by the Forest Service developed to describe the channel bed materials within stream reaches Bevenger and King (1995).

Method:
A minimum of 100 particles are to be recorded on the Pebble Count Tally Sheet (Appendix 18.5).

Diagonal transects across the stream are paced off until a minimum 100 count is reached. Transects begin at the lower end of the wetted portion of the stream bed within the macroinvertebrate sampling section or riffle. A pebble is selected as described below every two paces in larger streams > 20m across, or every pace in smaller streams <20m across.

Averting (closing) one's eyes, a pebble is selected by touching the bottom with one's index finger. The randomly selected pebble is then placed in a particle size category. Size categories were initially based on the Wentworth's size classes, which were then lumped into larger biologically based size classes used by the NYSDEC to describe substrate composition. The NYSDEC size categories are: Sand <2mm (.08"), Gravel 2-16mm(.08-2.5"), Course Gravel 16-64mm (.63-2.5"), Cobble 64-256mm (2.5-10.1"), Boulder >256mm (>10.1").

Size categories are determined by using a gravelometer, a metal or wood plate with squares of the above size classes cut out. The particle must be placed thru the smallest cut out so that the intermediate axis is perpendicular to the sides (not diagonally across) of the cut out. The smallest size category, which the pebble falls through is called out to a recorder, who keeps track of the tally until the minimum of 100 pebbles is reached. If this occurs in the middle of a transect, it is completed.

Characterization of the amount of moss, macro-algae, micro-algae, and silt cover is made separately for each substrate larger than 16 mm in diameter. If substrates are less than this diameter, conver index entries are not tallied, but the substrate size is still measured with the gravelometer as described above. Record moss and macro-algae cover using a scale from 0-3 with separate estimates for each. Cover categories for moss, macro-algae, micro-algae, and silt are provided in Table 8. Note that if substrate is too large to pick-up, algal growth should still be characterized.

Table 8. Algal and silt cover categories for use during pebble count characterization of stream substrates.

Cover Category	Moss/ Macroalgae	Microalgae	Silt
0	none present	rough , no growth	none present
1	<5%	slimy, not visible	a line can be drawn by scratching
2	5-25%	visible biofilm, a line can be drawn by scratching	0.5-5 mm
3	>25%	0.5 - 1 mm	5-20 mm
4	NA	1-5 mm	>20 mm
5	NA	5-20 mm	NA

Interpretation of Results:
Weighted Periphyton and Silt Index Calculation (PI) (0-10)

Moss and Macro Algae percent cover
((%Cat. 0*0) + (%Cat. 1*2) + (%Cat. 2*6) + (%Cat. 3*10))/100

Micro Algae Thickness
= ((%Cat. 0*0)+(%Cat. 1*.5)+(%Cat. 2*2)+(%Cat. 3*4)+(%Cat. 4*7)+(%Cat. 5*10))/100

Silt Cover Index
= (%Cat0*0)+(%Cat1*3)+(%Cat2*6)+(%Cat3*8)+(%Cat4*10)

Substrate composition
Percent fines (<16mm) at a level of 24% has been identified as a provisional threshold for concern in New York State. This is the average of the medians between slight and moderate biological impact categories (Section 10.2). This value should be used as an indicator that substrate composition (% fines) may be a stressor to the macroinvertebrate community.

Cover Indices
Statistically significant different index score values between water quality assessment categories (Section 10.2) were found for both macroalgae and silt. No significant relationships were found for microalgae however investigations continue to establish impact thresholds. An average of the medians was used to

determine provisional thresholds for concern for macroalgae (3.5) and silt (3.9). Moss index scores were not found to be significantly different, however, the presence of moss has been observed as an indicator of non-impacted biological conditions.

10. Biological Assessment of Water Quality

Overall assessment of water quality is based on the metrics in the descriptions that follow and is accomplished by interpretation of the Biological Assessment Profile, a combined, scaled ranking of the metric values. Conversion formulae transform values onto a common scale, ranging from 0-10, with 0 being very poor water quality (severely impacted), and 10 being very good water quality (non-impacted). The conversion formulae are based on the expected range for the index within each category of impact for the appropriate water body and sampling method. After all appropriate index values are converted to a common scale, they are averaged to obtain a score assigning the overall assessment of water quality into one of four categories of impact (non-, slight, moderate, and severe).

10.1 INDIVIDUAL MACROINVERTEBRATE COMMUNITY INDICES

Rationale:
16 water quality indices are currently used as measures of macroinvertebrate community health. Different sets of select indices from this list are combined to form a multimetric index of water quality known as the Biological Assessment Profile Score (BAP). Different combinations of the indices form the BAP for kick samples from riffles, net samples from sandy streams, multiplates samples from navigable waters, and ponar samples from soft bottom rivers. Each of these metrics has been specifically designed or calibrated for use within New York State aquatic systems. Use of these metrics outside the specified sampling season (June/July through September) or geographic range (New York State) should be done with acknowledgment of how they were developed. Additional regional calibration may be warranted for use outside of NY.

The benthic macroinvertebrate community metrics used for water quality assessment are 1) Species Richness 2) EPT Richness 3) Hilsenhoff's Biotic Index 4) Percent Model Affinity 5) Species Diversity 6) Dominance 7) NCO Richness 8) Nutrient Biotic Index for Phosphorus. Percent Mayfly Richness and the Acid Tolerance Index are used for assessing impacts related to acid deposition. Impact Source Determination is used to assist in stressor source identification. A complete description of each individual metric and calculation procedure follows:

Species Richness:
This is the total number of species or taxa found in the sample. Higher species richness values are mostly associated with clean-water conditions.

Ephemeropter, Plecoptera, Trichoptera (EPT) Richness:
EPT denotes the total number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) found in a subsample. These are considered to be mostly clean-water organisms, and their presence generally is correlated with good water quality.

Hilsenhoff's Biotic Index (HBI):
The Hilsenhoff Biotic Index is calculated by multiplying the number of individuals of each species by its assigned tolerance value (tolerance values can be found in Appendix 17.10), 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). Tolerance values, listed in Appendix 18.10, are mostly from Hilsenhoff (1987) however some have been recalibrated based on NYS datasets. High HBI values are indicative of organic (sewage) pollution, while low values indicate lack of sewage effects.

Procedure for Calculating HBI (Table 7):

1. Determine the tolerance value for each species in the sample. Each value is an assigned number from 0-10 based on its tolerance, 0 being very intolerant and 10 being very tolerant. These are available in the New York State species list (Appendix 18.10) or in Hilsenhoff (1987).
2. For each species, multiply the number of individuals by its tolerance value to create a set of abundance weighted tolerance values. Total all these products.
3. Divide the total of tolerance value/individuals products by the total number of individuals in the sample. This is the biotic index value.

Table 9. Example calculation of Hilsenhoff's Biotic Index (HBI) using a 100-organism subsample from a stream riffle community.

Genus/ species	Individuals	Tolerance Value	Weighted Tolerance Value (Individuals x Tolerance Value)
OLIGOCHAETA			
Nais communis	5	8	40
Pristina leidyi	3	8	24
MOLLUSCA			
Physa gyrina	2	8	16
EPHEMEROPTERA			
Baetis amplus	10	6	60
Stenonema ithaca	3	3	9
Drunella cornuta	1	0	0
PLECOPTERA			
Paragnetina media	1	1	1
COLEOPTERA			
Stenelmis crenata	9	5	45
TRICHOPTERA			
Cheumatopsyche sp.	19	5	95
Hydropsyche morosa	15	6	90
Hydroptila sp.	2	6	12
CHIRONOMIDAE			
Conchapelopia sp.	3	6	18
Cricotopus bicinctus	1	7	7
Orthocladius sp.	2	6	12
Polypedilum sp.	24	6	144
TOTAL	100		573
HBI =(tolerance subtotal 573 divided by 100 individuals)			5.73

Percent Model Affinity (PMA):
This is a measure of similarity to a model non-impacted community based on percent abundance in 7 major groups (Novak and Bode, 1992). Percentage similarity as calculated in Washington (1984) is used to measure similarity to a kick sample community of 40% Ephemeroptera, 5% Plecoptera, 10% Trichoptera, 10% Coleoptera, 20% Chironomidae, 5% Oligochaeta, and 10% Other. For Ponar samples, the model is: 20% Oligochaeta, 15% Mollusca, 15% Crustacea, 20% Non-Chironomidae Insecta, 20% Chironomidae, and 10% Other.

Procedure for Calculating PMA (Table 8):

1. Determine the percent contribution for each of the 7 major groups: Oligochaeta, Ephemeroptera, Plecoptera, Coleoptera, Trichoptera, Chironomidae, and Other. These must add up to 100.

2. For each group, compare the actual percent contribution with that of the model; find the lesser of the two values, and add up these values.

3. The sum of the lesser values for the seven groups is the Percent Model Affinity (PMA) value.

Table 10. Example calculation of Percent Model Affinity (PMA) using a 100-organism subsample from a stream riffle community. The percent contribution of 7 major groups is determined and compared to the expected contribution of those groups in a model natural community. The lesser value of the two values for each taxonomic group is summed giving the result.

Order/Group	Model	Sample	Lesser Value
OLIGOCHAETA	5	8	5
EPHEMEROPTERA	40	14	14
PLECOPTERA	5	1	1
COLEOPTERA	10	9	9
TRICHOPTERA	10	36	10
CHIRONOMIDAE	20	30	20
OTHER	10	2	2
TOTAL	100	100	61
PMA = (Sum of lesser values)			61

Species Diversity:
Species diversity is a value that combines species richness and community balance (evenness). Shannon-Wiener diversity values are calculated using the formula in Weber (1973). High species diversity values usually indicate diverse, well-balanced communities, while low values indicate stress or impact.

Procedure for Calculating Species Diversity (Table 9):
Species Diversity is calculated using the following equation:

$D = [C/N][(N\log_{10} \times N) - (\sum n_i\log_{10} \times n_i)]$

Where: C = 3.321928
N = Total number of individuals in the sample
n_i = Total number of individuals in i^{th} species

Table 11. Example calculation of Species Diversity using a hypothetical invertebrate subsample with 100 individuals.

Species (i)	Number of Individuals	$n_i\log_{10} \times n_i$
Species 1	10	10
Species 2	10	10
Species 3	10	10
Species 4	10	10
Species 5	10	10
Species 6	10	10
Species 7	10	10
Species 8	10	10
Species 9	10	10
Species 10	10	10
Total	100	100

$D = [C/N][(N\log_{10} \times N) - (\sum n_i\log_{10} \times n_i)]$
$D = [\ 3.321928 / 100\ ]\ [\ (\ 200\ ) - (\ 100\ )\ ]$
$D = [\ 0.03321928\ ]\ [\ 100\ ]$
$D = 3.32$

Dominance:
Dominance is a measure of community balance, or evenness of the distribution of individuals among the species. Simple dominance is the percent contribution of the most numerous species. Dominance-3 is the combined percent contribution of the three most numerous species. High dominance values indicate unbalanced communities strongly dominated by one or more very numerous species.

Non-Chironomidae and Oligochaeta (NCO) Richness:
NCO denotes the total number of species of organisms other than those in the groups Chironomidae and Oligochaeta. Since Chironomidae and Oligochaeta are generally the most abundant groups in impacted communities, NCO taxa are considered to be less pollution tolerant, and their presence would be expected to be more indicative of good water quality. This measure is the Sandy Stream counterpart of EPT richness.

Nutrient Biotic Index (NBI):
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 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. 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 indicate better performance by the NBI-P, with strong correlations to stream nutrient concentrations and diatom communities.

Procedure for Calculating the Nutrient Biotic Indices:
Calculation of the indices follows the approach of Hilsenhoff (1987) and described earlier in this section.

NBI Score (TP or NO3-) = $\sum (a \times b) / c$

Where: A = Number of individuals for each taxon
B = The taxon's tolerance value (for either TP of NO_3^-)
C = Total number of individuals in the sample for which tolerance values have been assigned

The results of the NBIs are placed on a scale of eutrophication from 0-10 and are as follows: Oligotrophic 0-5, Mesotrophic 5-6, Eutrophic 6-10

Percent Mayfly Richness:
Percent Mayfly Richness (PMR) is designed to assess the impacts of acidity on stream and river macroinvertebrate communities. PMR is the percent of the taxa belonging to the order Ephemeroptera. The genus Epeorus, a known acidobiontic genus, is excluded from this metric. PMR is normalized on a ten-scale, ten being >20% taxa as mayflies and 0 being 0% taxa as mayflies.

Acid Tolerance Index:
The Acid Tolerant Index (ATI) is another metric used in the assessment of acid impacts on stream and river macroinvertebrate communities. The ATI is the percent individuals belonging to any of ten genera that contain acidophilous species, as listed in several references. The genera are: Epeorus (EPHEMEROPTERA), Amphinemura, Leuctra, and Isoperla (PLECOPTERA), Rhyacophila (TRICHOPTERA), and Simulium, Conchapelopia, Cricotopus, Eukiefferiella, and Heterotrissocladius (DIPTERA). ATI is normalized on a ten-scale, ten being 0% acidophilous individuals and 0 being >40% acidophilous individuals, using data from 20 statewide reference sites.

Impact Source Determination:
Impact Source Determination (ISD) is the procedure for identifying types of impacts that exert deleterious effects on a waterbody. While the analysis of benthic macroinvertebrate communities has been shown to be an effective means of determining severity of water quality impacts, it has been less effective in determining what kind of pollution is causing the impact. Impact Source Determination uses community types or models to ascertain the primary factor influencing the fauna. It may be seen as an elaboration of Percent Model Affinity (Novak and Bode, 1992), which is based on class and order.

Procedure for Calculating ISD:
Impact Source Determination is based on similarity to existing models of community types (see Tables 10-16 following). The model that exhibits the highest similarity to the test data denotes the likely impact source type, or may indicate "natural", lacking an impact. In the graphic representation of ISD, only the highest similarity of each source type is identified. If no model exhibits a similarity to the test data of greater than 50%, the determination is inconclusive. The determination of impact source type is used in conjunction with assessment of severity of water quality impact to provide an overall assessment of water quality.

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

ISD is calculated in the same manner as PMA but uses the models and taxonomic groups found in the following tables. Results are given as percent similarities.

Table 12. Impact Source Determination (ISD) model communities for "Natural" condition stream systems where no impact is observed in the environment.

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

Table 13. Impact Source Determination (ISD) model communities for "Nonpoint Nutrient, Pesticide" impacted stream systems. These model communities are typical of systems where nutrients and pesticides are a determining factor of macroinvertebrate community structure.

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 sp.	-	-	-	-	-	-	-	5	-	-
BAETIDAE	5	15	20	5	20	10	10	5	10	5
HEPTAGENIIDAE	-	-	-	-	5	5	5	5	-	5
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	5	-	-
Caenis sp./*Tricorythodes* sp.	-	-	-	-	5	-	-	5	-	5
PLECOPTERA	-	-	-	-	-	-	-	-	-	-
Psephenus sp.	5	-	-	5	-	5	5	-	-	-
Optioservus sp.	10	-	-	5	-	-	15	5	-	5
Promoresia sp.	-	-	-	-	-	-	-	-	-	-
Stenelmis sp.	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 sp.	-	-	-	-	-	-	-	-	-	-
Cricotopus sp./Orthocladius sp.	10	15	10	5	-	-	-	-	5	5
Eukiefferiella sp./*Tvetenia* sp.	-	15	10	5	-	-	-	-	5	-
Parametriocnemus sp.	-	-	-	-	-	-	-	-	-	-
Microtendipes sp.	-	-	-	-	-	-	-	-	-	20
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-
Polypedilum sp. (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

Table 14. Impact Source Determination (ISD) model communities for "Municipal/Industrial" impacted stream systems. These model communities are typical of systems where municipal/industrial substances are a determining factor of macroinvertebrate community structure. For example, downstream of pulp/paper mills.

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

Table 15. Impact Source Determination (ISD) model communities for "Toxic" impacted stream systems. These model communities are typical of systems where toxic substances are a determining factor of macroinvertebrate community structure. For example, downstream of chemical manufacturing companies.

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

Table 16. . Impact Source Determination (ISD) model communities for "Sewage Effluent, Animal Waste" impacted stream systems. These model communities are typical of systems where sewage effluent, and animal wasters are a determining factor of macroinvertebrate community structure. For example, downstream of a municipal sewage treatment plant or concentrated animal feeding operation.

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 sp.	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	10	5	-	-	-	-	5	-
HEPTAGENIIDAE	10	10	10	-	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	5	-
Caenis sp./*Tricorythodes* sp.	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-
Psephenus sp.	-	-	-	-	-	-	-	-	-	-
Optioservus sp.	-	-	-	-	-	-	-	-	5	-
Promoresia sp.	-	-	-	-	-	-	-	-	-	-
Stenelmis sp.	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 sp.	-	-	-	-	-	-	-	-	-	-
Cricotopus sp./Orthocladius sp.	-	10	15	-	-	10	10	-	5	5
Eukiefferiella sp./*Tvetenia* sp.	-	-	10	-	-	-	-	-	-	-
Parametriocnemus sp.	-	-	-	-	-	-	-	-	-	-
Chironomus sp.	-	-	-	-	-	-	10	-	-	60
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-
Polypedilum sp. (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

Table 17. . Impact Source Determination (ISD) model communities for "Siltation" impacted stream systems. These model communities are typical of systems where siltation is a determining factor of macroinvertebrate community structure. For example, downstream of a dam, lake outlet, or construction site.

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

Table 18. Impact Source Determination (ISD) model communities for "Impoundment" impacted stream systems. These model communities are typical of systems where impoundments are a determining factor of macroinvertebrate community structure. For example, downstream of a dam, or lake outlet.

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

10.2 BIOLOGICAL ASSESSMENT PROFILE OF INDEX VALUES FOR BENTHIC MACROINVERTEBRATE COMMUNITIES

The Biological Assessment Profile (BAP) of index values is a method of plotting biological index values on a common scale of water quality impact. Individual metrics from those described previously are converted to a common 10-scale based on a series of equations. The combination of metrics used differs based on the type of sample collected and the habitat from which the sample was taken. The mean scale value of the indices represents the assessed impact for each site.

Presently, NYS categorizes the biological assessment of water quality into four impact categories based on BAP score. The impact scale is the same for each sample type and collection habitat. However, the impact category scales for individual metrics change between sample and collection habitat types. The NYS impact categories and representative BAP scores are; Non-Impact 10-7.5, Slight Impact 7.5-5, Moderate Impact 5-2.5, and Severe Impact 2.5-0. The impact category considered the decision threshold for designated use impairment based on biological data is the boundary between Slight and Moderate impact (NYSDEC 2008).

The description of overall stream water quality based on biological parameters uses a four-tiered system of classification is as follows:

Non-impacted:
Indices reflect very good water quality. The macroinvertebrate community is diverse, and virtually unaffected by human disturbance. 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.

Slightly impacted:
Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Water quality is usually not limiting to fish survival, but may be limiting to fish propagation, especially sensitive coldwater fish taxa.

Moderately impacted:
Indices reflect poor water quality. The macroinvertebrate community is altered to a large degree from the pristine state. Water quality often is limiting to fish propagation, but usually not to fish survival.

Severely impacted:
Indices reflect very poor water quality. The macroinvertebrate community is limited to a few tolerant species. 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.

10.2.1 Macroinvertebrate Biological Assessment Profile of Index Values for Riffle Habitats

For riffle habitats, the indices used in calculating the BAP are: SPP (species richness), HBI (Hilsenhoff Biotic Index), EPT (EPT richness), PMA (Percent Model Affinity), and NBI-P (Nutrient Biotic Index – Phosphorus). Values from the four indices are converted to a common 0-10 scale as shown in Figure 7. The mean scale value of the four indices represents the assessed impact for each site. Ten scale conversion formulae for these individual metrics follow.

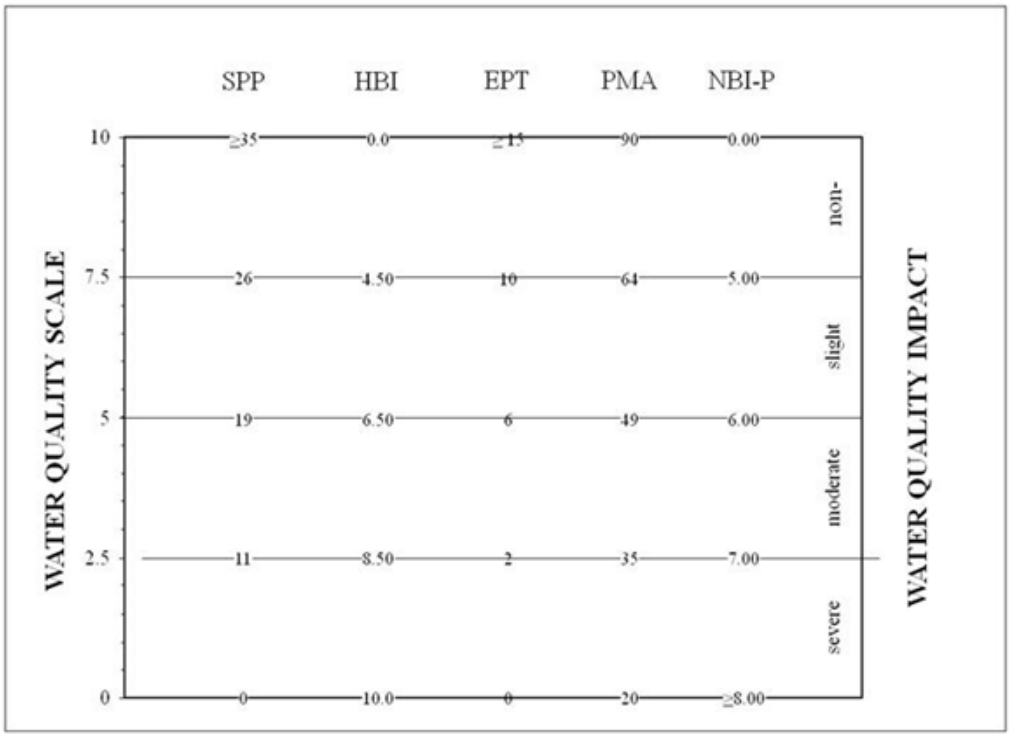

Figure 7. Biological Assessment Profile (BAP) of index values for riffle habitats sampled using the traveling kick method. Values from five indices; species richness (SPP), Hilsenhoff's Biotic Index (HBI), EPT richness (EPT), Percent Model Affinity (PMA), and Nutrient Biotic Index – Phosphorus (NBI-P) are converted to a common 0-10 scale as shown in this figure. The mean value of the four indices represents the assessed impact for each site.

Kick Sample Ten Scale Conversion Formulae (Riffle Habitats):

Species Richness

SPP>35	replace with 10
SPP>26	replace with (((SPP-26)/9)*2.5)+7.5
SPP>18	replace with (((SPP-18)/8.5)*2.5)+5
SPP>10	replace with (((SPP-10)/8.5)*2.5)+2.5
SPP<5	replace with 0
SPP<11	replace with ((SPP-4)/6.5)*2.5

EPT Richness

EPT>15	replace with 10
EPT>10	replace with (((EPT-10)/5)*2.5)+7.5
EPT>5	replace with (((EPT-5)/5.5)*2.5)+5
EPT>1	replace with (((EPT-1)/4.5)*2.5)+2.5
if EPT = 1	replace with 1.25
if EPT = 0	replace with 0

Hilsenhoff's Biotic Index

HBI <2	replace with 10
HBI <4.51	replace with 10-(HBI-2)
HBI <6.51	replace with 7.5-(((HBI-4.5)/2)*2.5)
HBI <8.51	replace with 5-(((HBI-6.5)/2)*2.5)
HBI >8.50	replace with 2.5-(((HBI-8.5)/1.5)*2.5)

Percent Model Affinity

PMA >90	replace with 10
PMA >64	replace with (((PMA-64)/26)*2.5)+7.5
PMA >49	replace with (((PMA-49)/15.5)*2.5)+5
PMA >34	replace with (((PMA-34)/15.5)*2.5)+2.5
PMA <20	replace with 0
PMA <35	replace with ((PMA-20)/14.5)*2.5

Nutrient Biotic Index - Phosphorus

NBI <3.01	replace with 10
NBI <5.01	replace with 10-(NBI-2.5)
NBI <6.01	replace with 7.5-((NBI-5.0)*2.5)
NBI <7.01	replace with 5-((NBI-6.0)*2.5)
NBI >8.00	replace with 0
NBI >7.00	replace with 2.5-((NBI-7.0)*2.5)

10.2.2 Macroinvertebrate Biological Assessment Profile of Index Values for Multiple-Plate Samples from Navigable Waters

For multiplates samples from navigable waters, the indices used in calculating the BAP are: SPP (species richness), HBI (Hilsenhoff Biotic Index), EPT (EPT richness), and DIV (species diversity). Values from the four indices are converted to a common 0-10 scale as shown in Figure 8. The mean scale value of the four indices represents the assessed impact for each site. Ten scale conversion formulae for these individual metrics follow.

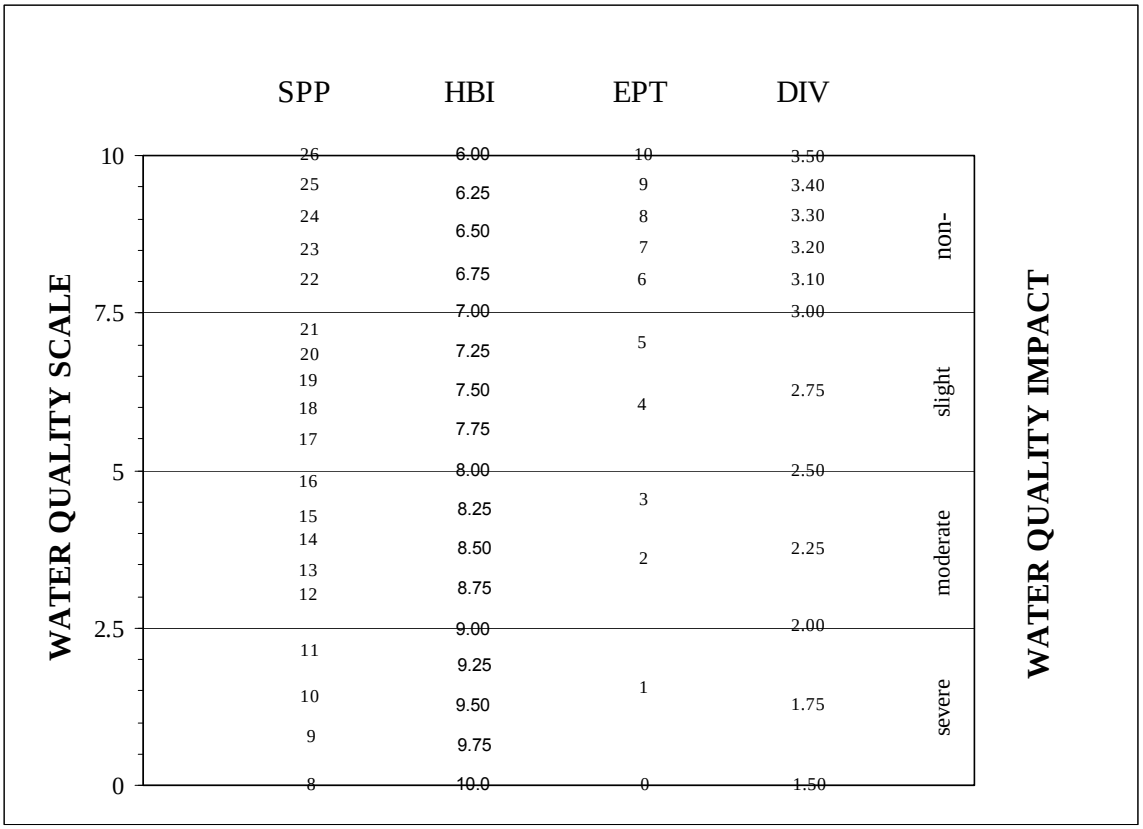

Figure 8. Biological Assessment Profile (BAP) of index values for multiple-plate samples from navigable waters. Values from four indices; species richness (SPP), Hilsenhoff's Biotic Index (HBI), EPT richness (EPT), and species diversity (DIV) are converted to a common 0-10 scale as shown in this figure. The mean value of the four indices represents the assessed impact for each site.

Multiplate Ten Scale Conversion Formulae (Navigable Waters):

Species Richness

SPP>26	replace with 10
SPP>21	replace with (((SPP-21)/5)*2.5)+7.5
SPP>16	replace with (((SPP-16)/5.5)*2.5)+5
SPP>11	replace with (((SPP-11)/5.5)*2.5)+2.5
SPP<8	replace with 0
SPP<12	replace with ((SPP-8)/3.5)*2.5

Hilsenhoff's Biotic Index

HBI<6.00	replace with 10
HBI<7.00	replace with 10.00-((HBI-6.00)*2.5)
HBI<8.00	replace with 7.50-((HBI-7.00)*2.5)
HBI<9.00	replace with 5.00-((HBI-8.00)*2.5)
HBI>=9.00	replace with 2.50-((HBI-9.00)*2.5)

EPT Richness

EPT>10	replace with 10
EPT>5	replace with (((EPT-5)/5)*2.5)+7.5
EPT>3	replace with (EPT-3)+5
EPT>1	replace with (EPT-1)+2.5
EPT=0	replace with 0
EPT>0	replace with 1.5

Species Diversity

DIV>3.50	replace with 10
DIV>3.00	replace with ((DIV-3.00)/0.5)*2.5)+7.5
DIV>2.50	replace with (((DIV-2.5)/0.5)*2.5)+5.00
DIV>2.00	replace with (((DIV-2.00)/0.5)*2.5)+2.5
DIV>1.50	replace with ((DIV-1.50)/0.5)*2.5
DIV=1.50	replace with 0
DIV<1.50	replace with 0

10.2.3 Macroinvertebrate Biological Assessment Profile of Index Values for Multiple-Plate Samples from Non-Navigable Waters

For multiplates samples from non-navigable waters, the indices used in calculating the BAP are: SPP (species richness), HBI (Hilsenhoff Biotic Index), EPT (EPT richness), and DIV (species diversity). Values from the four indices are converted to a common 0-10 scale as shown in Figure 9. The mean scale value of the four indices represents the assessed impact for each site. Ten scale conversion formulae for these individual metrics follow.

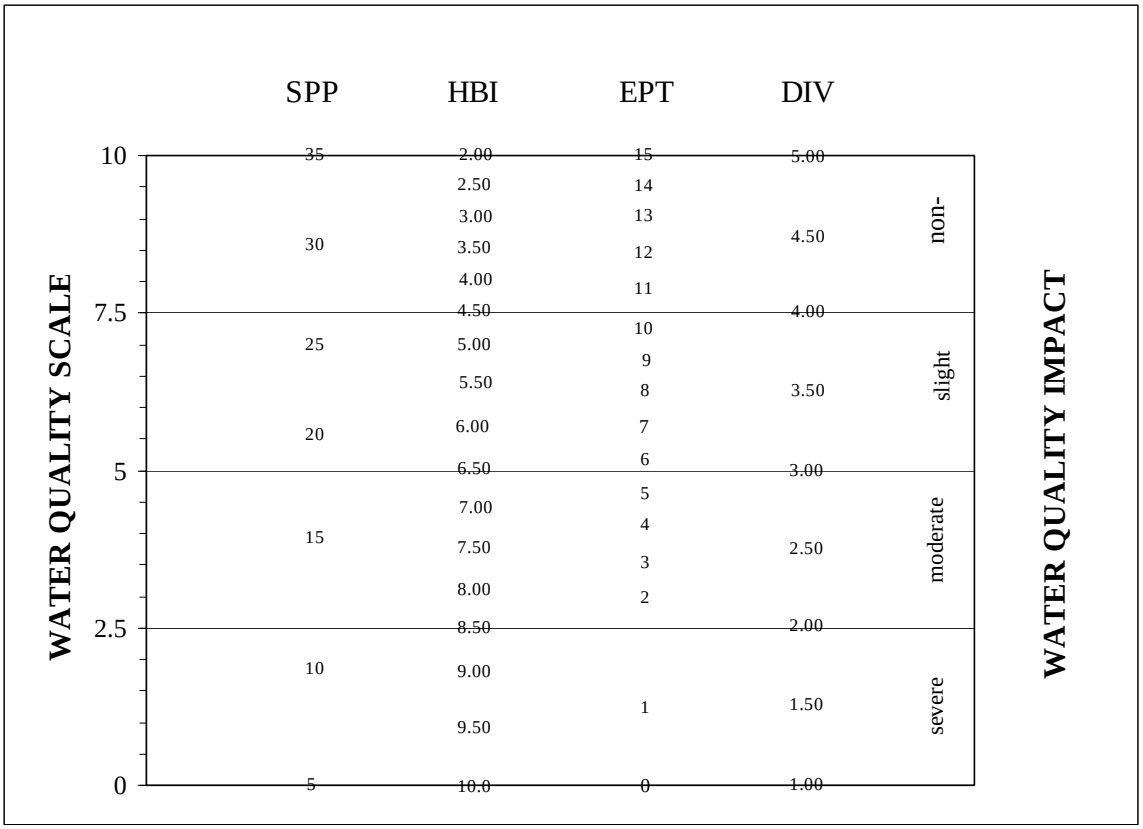

Figure 9. Biological Assessment Profile (BAP) of index values for multiple-plate samples from non-navigable waters. Values from four indices; species richness (SPP), Hilsenhoff's Biotic Index (HBI), EPT richness (EPT), and species diversity (DIV) are converted to a common 0-10 scale as shown in this figure. The mean value of the four indices represents the assessed impact for each site.

Multiplate Ten Scale Conversion Formulae (Non-Navigable Waters):

Species Richness

SPP>35	replace with 10
SPP>26	replace with (((SPP-26)/9)*2.5)+7.5
SPP>18	replace with (((SPP-18)/8.5)*2.5)+5
SPP>10	replace with (((SPP-10)/8.5)*2.5)+2.5
SPP<5	replace with 0
SPP<11	replace with ((SPP-5)/5.5)*2.5

EPT Richness

EPT>15	replace with 10
EPT>10	replace with (((EPT-10)/5)*2.5)+7.5
EPT>5	replace with (((EPT-5)/5.5)*2.5)+5
EPT>1	replace with (((EPT-1)/4.5)*2.5)+2.5
if EPT = 1	replace with 1.25
if EPT = 0	replace with 0

Hilsenhoff's Biotic Index

HBI <2	replace with 10
HBI <4.51	replace with 10-(HBI-2)
HBI <6.51	replace with 7.5-(((HBI-4.5)/2)*2.5)
HBI <8.51	replace with 5-(((HBI-6.5)/2)*2.5)
HBI >8.50	replace with 2.5-(((HBI-8.5)/1.5)*2.5)

Species Diversity

DIV >5.00	replace with 10
DIV >4.00	replace with ((DIV-4.00)*2.5)+7.5
DIV >3.00	replace with ((DIV-3.00)*2.5)+5.0
DIV >2.00	replace with ((DIV-2.00)*2.5)+2.5
DIV >1.00	replace with (DIV-1.00)*2.5
DIV <= 1.00	replace with 0

10.2.4 Macroinvertebrate Biological Assessment Profile of Index Values for Ponar Samples from Soft Sediments

For ponar samples from soft sediments, the indices used in calculating the BAP are: SPP (species richness), HBI (Hilsenhoff Biotic Index), DOM3 (Dominance-3), PMA (Percent Model Affinity), and DIV (species diversity). Values from the five indices are converted to a common 0-10 scale as shown in Figure 10. The mean scale value of the four indices represents the assessed impact for each site. Ten scale conversion formulae for these individual metrics follow.

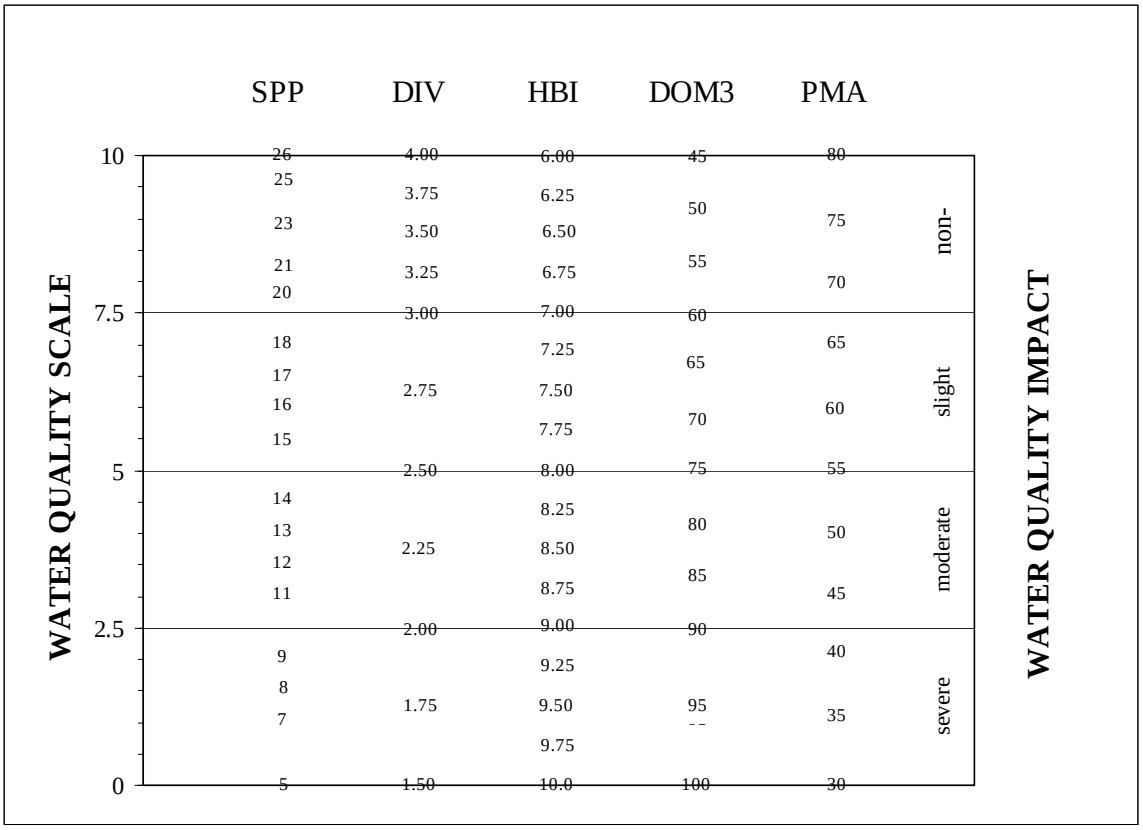

Figure 10. Biological Assessment Profile (BAP) of index values for ponar samples from soft sediments. Values from five indices; species richness (SPP), species diversity (DIV), Hilsenhoff's Biotic Index (HBI), Dominance-3 (DOM3), and Percent Model Affinity for ponar samples (PMA) are converted to a common 0-10 scale as shown in this figure. The mean value of the four indices represents the assessed impact for each site.

Ponar Ten Scale Conversion Formulae (Soft Sediments):

Species Richness

SPP>25	replace with 10
SPP>19	replace with (((SPP-19)/6.5)*2.5)+7.5
SPP>14	replace with (((SPP-14)/5.5)*2.5)+5
SPP>10	replace with (((SPP-10)/4.5)*2.5)+2.5
SPP<5	replace with 0
SPP<11	replace with ((SPP-5)/5.5)*2.5

Species Diversity

DIV>4.00	replace with 10
DIV>3.00	replace with ((DIV-3.00)*2.5)+7.5
DIV>2.50	replace with (((DIV-2.5)/0.5)*2.5)+5.00
DIV>2.00	replace with (((DIV-2.00)/0.5)*2.5)+2.5
DIV>1.50	replace with ((DIV-1.50)/0.5)*2.5
DIV<=1.50	replace with 0

Hilsenhoff's Biotic Index

HBI<6.00	replace with 10
HBI<7.00	replace with 10.00-((HBI-6.00)*2.5)
HBI<8.00	replace with 7.50-((HBI-7.00)*2.5)
HBI<9.00	replace with 5.00-((HBI-8.00)*2.5)
HBI>=9.00	replace with 2.50-((HBI-9.00)*2.5)

Ponar Percent Model Affinity

PONARPMA>80	replace with 10
PONARPMA>67.5	replace with ((PONARPMA-67.5)/5)+7.5
PONARPMA>55	replace with ((PONARPMA-55)/5)+5
PONARPMA>42.5	replace with ((PONARPMA-42.5)/5)+2.5
PONARPMA>30	replace with (PONARPMA-30)/5
PONARPMA<=30	replace with 0

Species Dominance

DOM3<=45	replace with 10
DOM3<60	replace with 10-(((DOM3-45)/15)*2.5)
DOM3<75	replace with 7.5-(((DOM3-60)/15)*2.5)
DOM3<90	replace with 5-(((DOM3-75)/15)*2.5)
DOM3<100	replace with 2.5-(((DOM3-90)/10)*2.5)
DOM3=100	replace with 0

10.2.5 Macroinvertebrate Biological Assessment Profile of Index Values for Net Jabs from Slow, Sandy Streams

For net jabs from slow sandy streams, the indices used in calculating the BAP are: SPP (species richness), HBI (Hilsenhoff Biotic Index), EPT (EPT richness), and NCO (NCO richness). Values from the four indices are converted to a common 0-10 scale as shown in Figure 11. The mean scale value of the four indices represents the assessed impact for each site. Ten scale conversion formulae for these individual metrics follow.

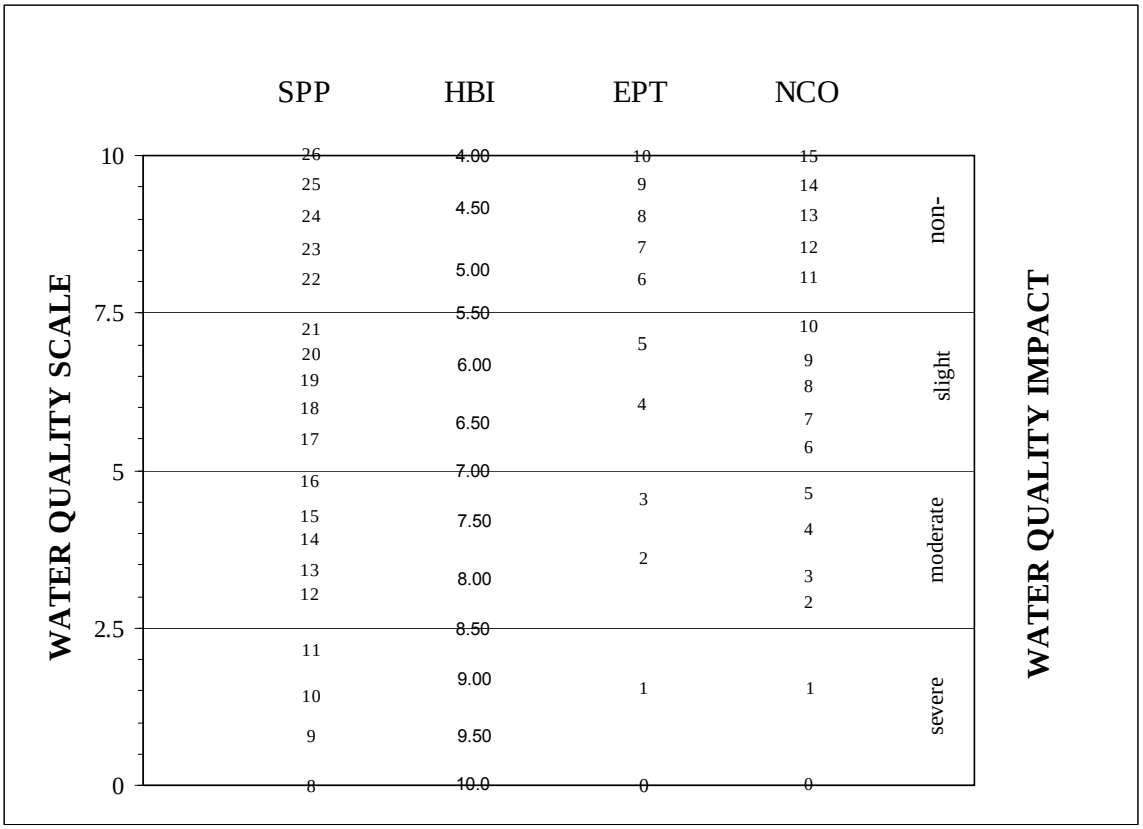

Figure 11. Biological Assessment Profile (BAP) of index values for net-jab samples from slow, sandy streams. Values from four indices; species richness (SPP), Hilsenhoff's Biotic Index (HBI), EPT richness (EPT), and non-Chironomidae and Oligochaeta richness (NCO) are converted to a common 0-10 scale as shown in this figure. The mean value of the four indices represents the assessed impact for each site.

Net Jab Ten Scale Conversion Formulae (Slow, Sandy Streams):

Species Richness

SPP>26	replace with 10
SPP>21	replace with (((SPP-21)/5)*2.5)+7.5
SPP>16	replace with (((SPP-16)/5.5)*2.5)+5
SPP>11	replace with (((SPP-11)/5.5)*2.5)+2.5
SPP<8	replace with 0
SPP<12	replace with ((SPP-8)/3.5)*2.5

Hilsenhoff's Biotic Index

HBI<4.00	replace with 10
HBI<5.50	replace with 10.00-(((HBI-4.00)/1.5)*2.5)
HBI<7.00	replace with 7.50-(((HBI-5.50)/1.5)*2.5)
HBI<8.50	replace with 5.00-(((HBI-7.00)/1.5)*2.5)
HBI>=8.50	replace with 2.50-(((HBI-8.50)/1.5)*2.5)

EPT Richness

EPT>10	replace with 10
EPT>5	replace with (((EPT-5)/5)*2.5)+7.5
EPT>3	replace with (EPT-3)+5
EPT>1	replace with (EPT-1)+2.5
EPT=0	replace with 0
EPT>0	replace with 1.5

NCO Richness

NCO>15	replace with 10
NCO>10	replace with (((NCO-10)/5)*2.5)+7.5
NCO>5	replace with (((NCO-5)/5.5)*2.5)+5
NCO>1	replace with (((NCO-1)/4.5)*2.5)+2.5
NCO=1	replace with 1.25
if NCO=0	replace with 0

10.3 INDIVIDUAL DIATOM COMMUNITY INDICES

Rationale:
Water quality assessment using diatom communities is considered complimentary to assessments made through analysis of benthic macroinvertebrate communities. In some instances diatom communities may be used by themselves or in concert with macroinvertebrate communities to make water quality assessment determinations. In NYS 6 different diatom community metrics are used to assess water quality. They are 1) Pollution Tolerance Index (PTI) 2) the Trophic Index (TRI) 3) the Salinity Index 4) the Acidity Index 5) the Siltation Index and 6) the Diatom Model Affinity (DMA). A description of these individual metrics and calculation procedures follows. Additional methods for diatom assessment in NYS can be found in Passy (2000), Passy (2000b), Passy and Bode (2004), and Passy et al 2004.

Pollution Tolerance Index:
The Pollution Tolerance Index (PTI) is calculated as the sum of the relative abundance of each species multiplied by the pollution tolerance class of that species (Bahls, 1993) and divided by the total number of individuals in the sample. Pollution tolerance classes for diatom taxa are located in the species list Appendix 15.11. Levels of impact are: >2.50, non-impacted; 2.01-2.50, slightly impacted; 1.51-2.00, moderately impacted; and <1.50, severely impacted.

Procedure for Calculating the Pollution Tolerance Index:
Calculation of the PTI follows the abundance weighted tolerance value approach of Bahls (1993) and is similar to that of Hilsenhoff (1987) and Smith et al (2007) for macroinvertebrate tolerance indices.

Trophic Index:
The Trophic Index (TRI) is a measure of % mesotrophic to hypereutrophic individuals. Levels of impact are: 0-50, non-impacted; 51-70, slightly impacted; 71-85, moderately impacted; and 86-100, severely impacted.

Procedure for Calculating the Trophic Index:
Calculation of the TRI is calculated as a percent of the total sample using the number of mesotrophic – hypereutrophic individuals identified as such in the species list Appendix 18.11.

Salinity Index:
The Salinity Index is a measure of % halophilous individuals, indicating dissolved salts. Levels of impact are: 0-10, non-impacted; 11-30, slightly impacted; 31-50, moderately impacted; and 51-100, severely impacted.

Procedure for Calculating the Salinity Index:
Calculation of the Salinity index is calculated as a percent of the total sample using the number of halophilous individuals identified as such in the species list Appendix 18.11.

Acidity Index:
The Acidity Index is a measure of % acidophilous individuals, reflecting acid effects. Levels of impact are: 0-20, non-impacted; 21-50, slightly impacted; 51-75, moderately impacted; and 76-100, severely impacted.

Procedure for Calculating the Acidity Index:
Calculation of the Acidity index is calculated as a percent of the total sample using the number of acidophilous individuals identified as such in the species list Appendix 18.11.

Siltation Index:
The Siltation Index (SI) is a measurement of the percent relative abundance of individuals belonging to motile genera, mostly Navicula, Nitzschia and Surirella, which are adapted to living on unstable substrates. SI ranges from 0 to 100, using the following provisional ranges for the levels of siltation: in mountainous streams: <20, no siltation; 20-39, minor siltation; 40-60, moderate siltation; and >60, heavy siltation. For plain streams (low elevation and slope) the ranges are: <60, no siltation; 60-69, minor siltation; 70-80, moderate siltation; and >80, heavy siltation.

Diatom Model Affinity:
Diatom Model Affinity (DMA) is a percent similarity, reference-based community metric which compliments the PMA for benthic macroinvertebrate communities. It was derived through analysis of generic and species composition from NYS reference condition streams. Using a model diatom community composed of a combination of 4 major groups the DMA compares the samples similarity to the model. High similarity to the model indicates minimal disturbance while low similarity suggests perturbation.

Procedure for Calculating Diatom Model Affinity (Table 17):
Determine the percent contribution for each of the 4 major groups Model values are in parenthesis for each: 1) *Achnanthes minutissima* + *A. linearis* + *Meridion spp.* (65) 2) *Cymbella spp.* + *Reimeria spp.* (15) 3) *Fragilaria spp.* + *Synedra spp*.(15) 4) *Navicula spp.* + *Gomphonema spp.* (5). For each group, compare the actual percent contribution with that in the model; find the lesser of the two values, and add up these values. The sum of the lesser values for the four groups is the Diatom Model Affinity value. DMA scores correspond to impact categories (Figure 12) in the following manner: Non-impacted >65%, Slight impact 51-65%, Moderate impact 36-50%, Severe impact <35%.

Table 19. Example Diatom Percent Model Affinity calculation

Group	Model	Sample	Lesser Value
Achnanthes minutissima + *A. linearis* + *Meridion spp.*	65	60	60
Cymbella spp. + *Reimeria spp.*	15	20	15
Fragilaria spp. + *Synedra spp.*	15	1	1
Navicula spp. + *Gomphonema spp.*.	5	9	5
TOTAL	100	100	81
DMA = (Sum of lesser values)			81

10.3.1 Biological Assessment Profile of Index Values for Diatom Communities

As with benthic macroinvertebrate assessments, a select set of the diatom metrics are combined to form a multimetric known as the Diatom Assessment Profile of Index Values (DAP). This multimetric score corresponds to a similar scale of four water quality impact categories as the macroinvertebrates. The individual metrics used in calculating the DAP are 1) the PTI 2) the TRI, and 3) DMA. The impact categories and corresponding DAP values are; Non-Impact 10-7.5, Slight Impact 7.5-5, Moderate Impact 5-2.5, and Sever Impact 2.5-0 respectively.

Calculation of the Diatom Biological Assessment Profile of Index Values.

Values from the three indices (PTI, TRI, and DMA) are converted to a common 0-10 scale as shown in Figure 12. The mean scale value of the three indices represents the assessed impact for each site. Ten scale conversion formulae for these individual metrics follow.

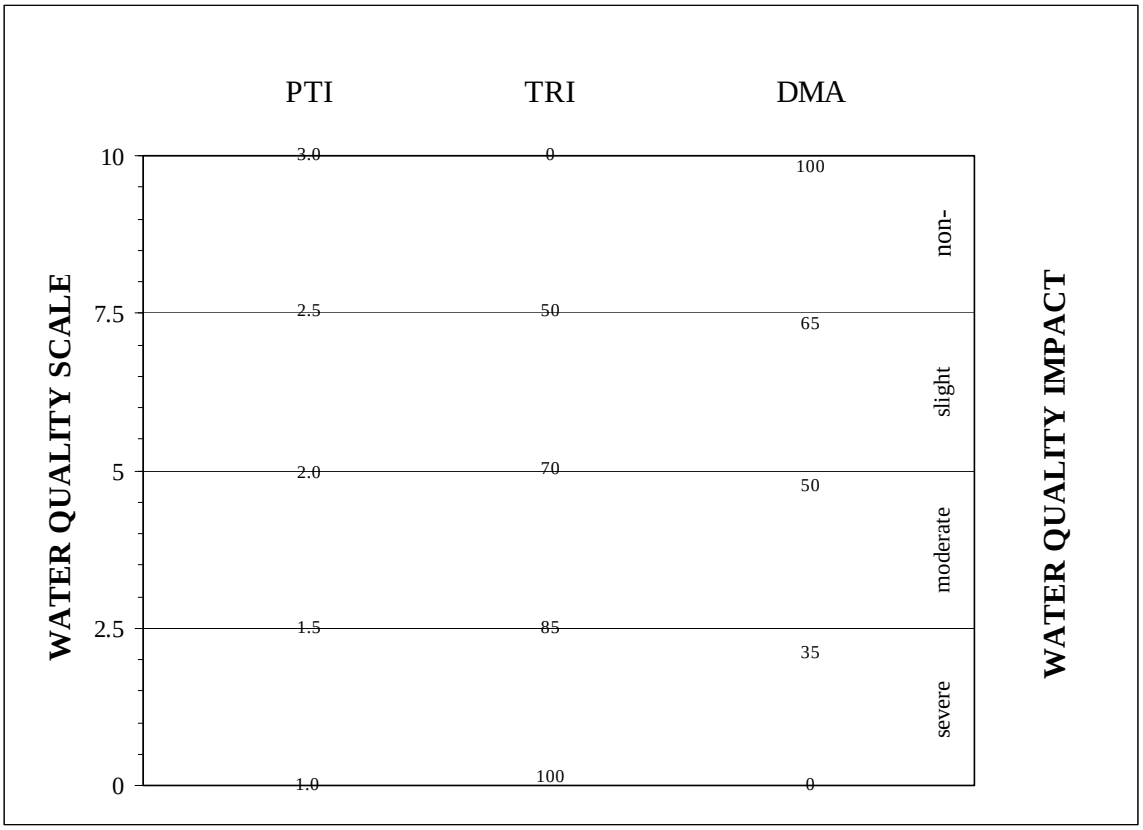

Figure 12. Diatom Biological Assessment Profile (BAP) of index values for multiple habitat samples from wadeable streams. Values from three indices; Polution Tolerance Index (PTI), Trophic Index (TRI), and Diatom Model Affinity (DMA) are converted to a common 0-10 scale as shown in this figure. The mean value of the four indices represents the assessed impact for each site.

Diatom Sample Ten Scale Conversion Formulae (Multiple Habitats):

Pollution Tolerance Index

PTI>2.5	replace with 7.5+((PTI-2.5)*5)
PTI>2.0	replace with 5+((PTI-2)*5)
PTI>1.5	replace with 2.5+((PTI-1.5)*5)
PTI>1.0	replace with (PTI-1)*5
PTI=1.0	replace with 0

Trophic Index

TRI<51	replace with 10-(TRI*0.05)
TRI<71	replace with 7.5-((TRI-50)*0.125)
TRI<86	replace with 5-((TRI-70)*0.166)
TRI>85	replace with 2.5-((TRI-85)*0.166

Diatom Model Affinity

DMA>65	replace with 7.5+((DMA-65)*0.071)
DMA>50	replace with 5+((DMA-50)*0.166)
DMA>35	replace with 2.5+((DMA-35)*0.166)
DMA<36	replace with DMA*0.07

11. Data and Records Management

All sampling information including sampling location information, field data, habitat assessments, sample species enumeration data, water chemistries and tissue data are entered into a custom built Microsoft Access relational database.

Field data including the monitoring parameters (location, physical and chemical) listed in sections 9.3, 9.9, and 9.10 of this document are recorded in the field using a series of electronic field datasheets and a pocket PC. These electronic field sheets are built off of the monitoring program's original set of field datasheets which can be referenced for hard copy use in Appendix 18.1-18.5. Pebble count data (Section 9.11) is not recorded using the electronic field datasheet process. For a complete summary of how electronic field data is collected and used see the Biomonitoring Data Management: Electronic Collection of Field Data User Manual (Duffy et al. 2011)

Station identification numbers are generated using a four to five letter identifying code which is an abbreviation for the stream or river name. For example "Lower Hudson River" would be given a four letter identifier of "LHUD." When multiple stations are sited on the same stream or river stations are given a new name after a distance of approximately twenty times the stream wetted width upstream or downstream of the previous location. Station numbers (two digit) are given to each location starting with 00 as the station located highest in the watershed. Station numbers increase with distance further downstream. Station letters may be given in addition to station numbers to signify a station "above" (A) or "below" (B) a discharge. Site IDs are developed at the beginning of every sampling season during the site selection procedure as described in Section 9.2. At the end of the sampling season during the entry of field data all sampled sites have their respective identifying information entered into the access database.

Habitat assessment information as discussed in section 9.10 is also recorded but on a separate sheet using electronic field data collection methods. Hard copies can be found in Appendix 18.3 and 18.4. At the end of every field season all field data and habitat assessment information is uploaded directly from electronic field data records to the database (Duffy et al. 2011). Figure 13 provides a flow chart documenting the process by which electronic field data is collected and entered into the database.

Once field collection is complete and samples are brought back to the laboratory each sample must be logged in. An electronic "Lab Datasheet" (Appendix 18.7) is created recording the sample identification information including the four letter identifier for the site, station number, collection date, sample type, replicate number, and subsample size. Information on the sample location, station, replicate number, collection date, survey for which it was collected, sample type, number of samples, and a hyperlink to the lab data sheet are recorded in the electronic "Sample Log Book" (Appendix 18.6).

Raw Data (species identifications and numbers of individuals of each species in a sample or subsample) generated during sample sorting and enumeration is

recorded on the Lab Datasheet. The Lab Datasheet is a customized Microsoft Excel spreadsheet / form running Visual Basic Macros. Its functionality is based on the selection the user makes when identifying the “Sample Type.”

Organism identification and enumeration are also conducted using the electronic Lab Datasheet. Beginning with any desired group of organisms, individual taxa are identified and recorded. Taxa are recorded using one of three methods; in cell drop down lists, free hand typing, or copy and paste from the “Species List” sheet of the “Lab Datasheet.”

Raw data (species identifications and numbers of individuals of each species in a sample or subsample) are recorded on a separate Lab Datasheet for each site/date collection (Appendix 18.7). Changes and additions to the Stream Biomonitoring Unit’s master species list are made directly in the access database.

Upon completion of sample processing a complete species list from the sample is created and used for import into the database. Species data are imported into the database using a custom built graphic user-interface in VisualBasic.net. Sample species data is related to sampling station information and water quality assessment metrics are calculated automatically and stored in the appropriate tables in the database. The metrics calculated are dictated on a sample-by-sample basis and depend on the selection the user made regarding the “Sample Type” during the processing stage.

For a complete set of details on the Stream Biomonitoring Unit Database and exact procedures for working within the system refer to the document Biomonitoring Data Management System User Manual, Smith et al (2007). Figure 14 shows the flow of data through the data management system from data collection to import into the database. Database backups are performed every Friday evening by computer services staff in which all electronic files stored on the computer network are recorded to tape and stored indefinitely. In addition periodic disk backups (CDrom) of the data are performed by the project manager to ensure data protection. Documentation in terms of field and lab results, reports, and processed samples are kept indefinitely while raw samples are disposed of after one year.

Field Instrumentation calibration results are stored in instrument specific bound log books for future reference and validation of data recorded.

Laboratory results from the chemical analysis of invertebrate tissues (see Section 9.7) are reported electronically as well as in hard copy, from contract laboratories and the NYS Department of Health, and appended to the data table containing tissue analysis results in the access database. The results are compared to contaminant guidance values developed for crayfish, caddisflies, hellgrammites, and mollusks (Tables 2, 3 and 4). Values exceeding these guidelines are appropriately reported.

Standard Operating Procedure (SOP) revisions are made every 2 years and audit reports are maintained by the Program Manager for review upon request.

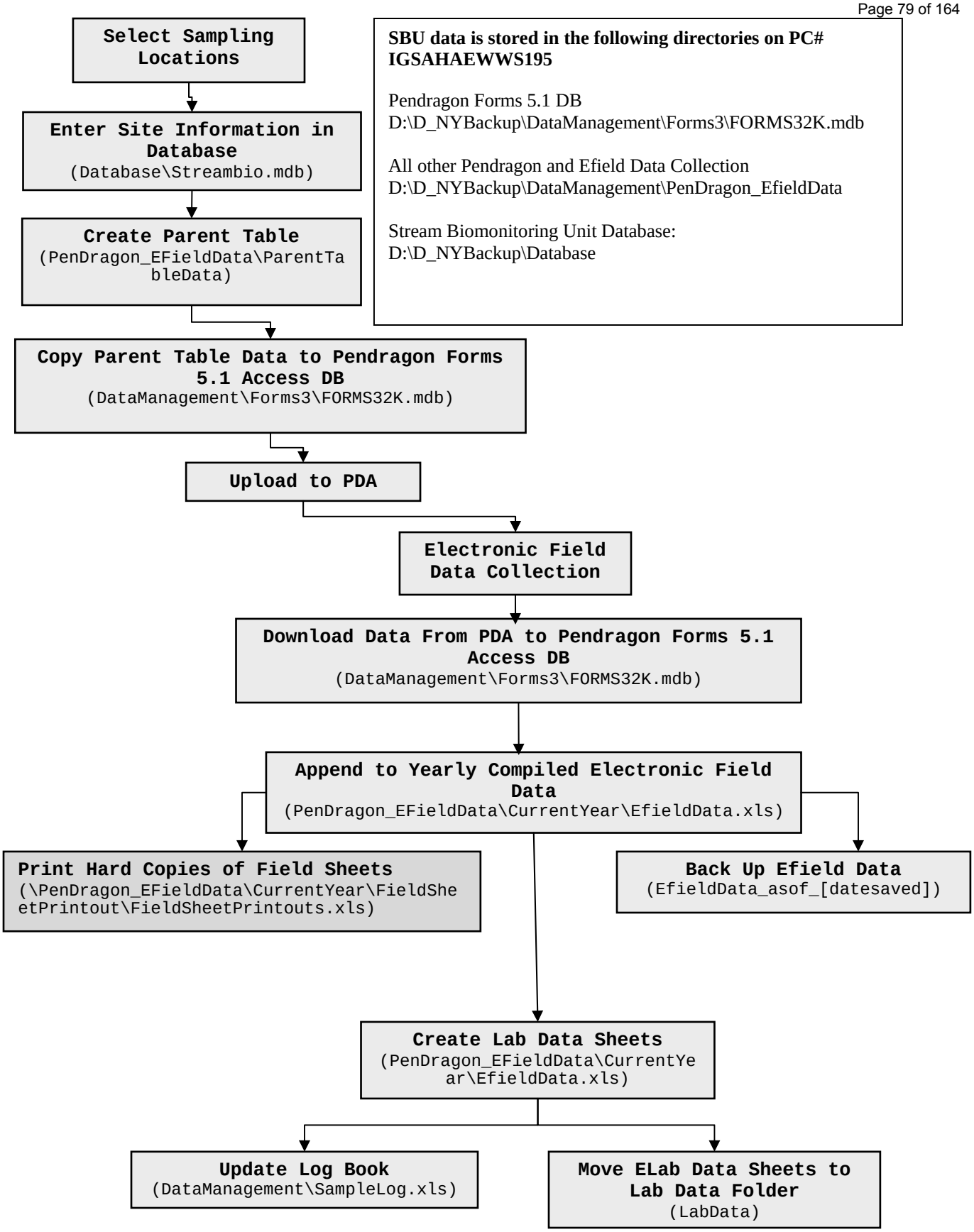

Figure 13. Stream Biomonitoring Unit Electronic Field Data Collection Flow Chart

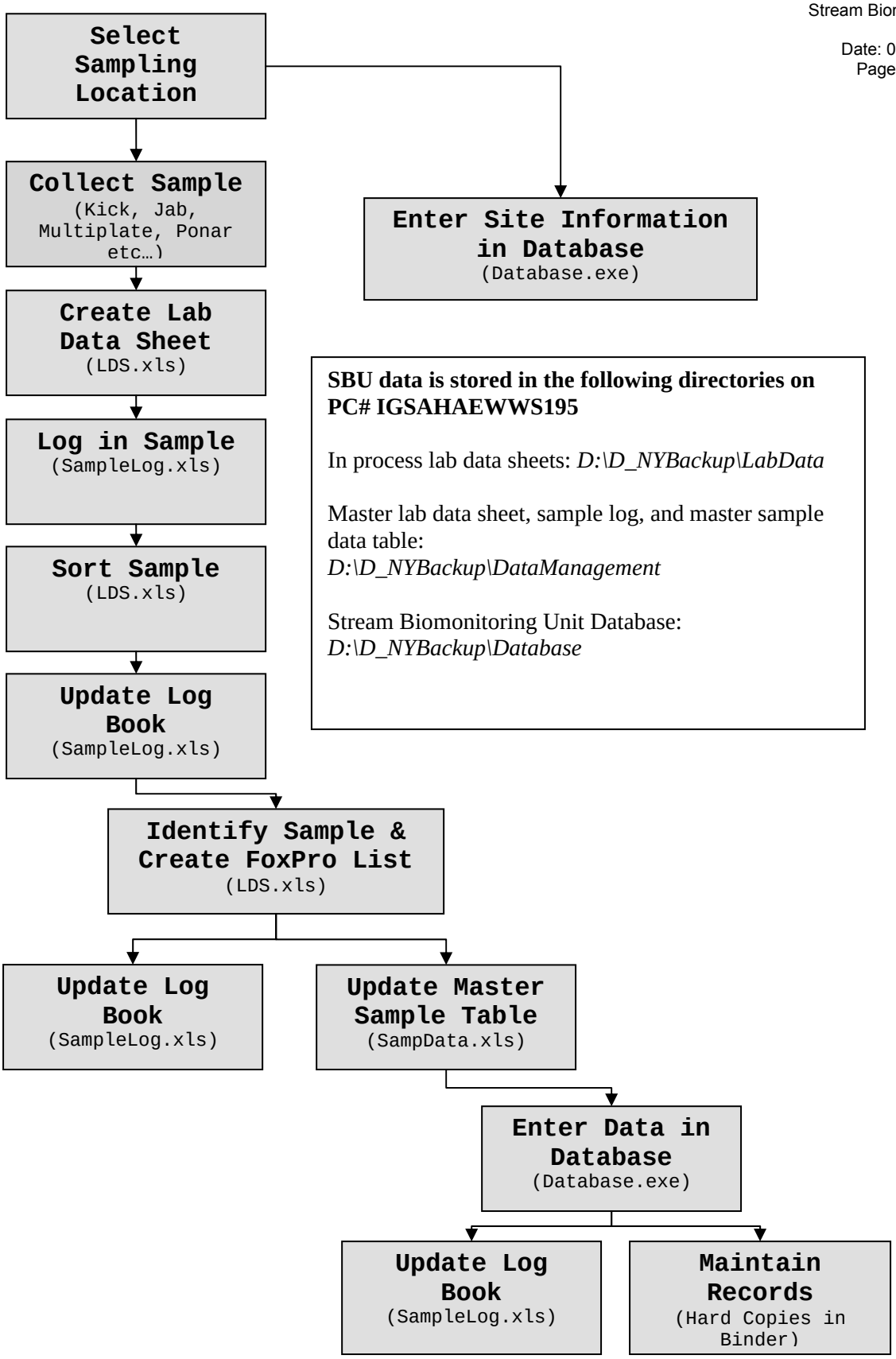

Figure 14. Stream Biomonitoring Unit Data Management Flow Chart

12. Data Validation

Organism Identification:
In addition to Quality Assurance/Quality Control procedures related to organism identification (Section 16) Internal checks are continually conducted among taxonomists to ensure consistency. Comparison of voucher specimens is made with the laboratory reference collection. All species identifications are verified on the New York State species checklist, the U.S. EPA regional checklist, and the known distribution of the species as given in the primary reference. A rigorous internal and external set of quality control samples are analyzed each year by taxonomic staff, with results integrated into the program (Section 16).

Multiplate samples:
Multiplate sample results are compared to field records of observed organisms to determine if the sample is representative of the fauna in the area sampled. Samples that show less than 50% of the major groups observed in the field will be invalidated unless confirmed by replicate sampling or additional subsampling.

Kick samples:
Kick sample results are compared to field records of observed organisms to determine if the kick sample is representative of the fauna in the area sampled. Samples that show less than 50% of the major groups observed in the field will be invalidated unless confirmed by replicate sampling or additional subsampling.

Subsamples:
Quality control subsampling is performed on 5% of all samples to assure validity of subsampling procedures. Percent similarity between subsamples should be 75% or greater at the ordinal level. New taxonomists are required to pass a quality control subsampling series scoring greater than or equal to 75% to pass at the ordinal level (Section 16).

Sample results:
Results are re-evaluated if the index values occur in more than two impact categories. Best professional judgment is used to determine if outlying indices are spurious and should be eliminated from consideration of impact category. Samples with a dominant taxon contributing more than 40% of the sample are recognized as a subsampling artifact, and corrective action may be taken to minimize the influence of the taxon in assignment of water quality category (see Section 14).

Data entry validation and transmittal errors:
All data entered into computer files are validated by comparison of number of individuals and number of species from each Laboratory Data Sheet. The electronic lab datasheet automatically checks the number of individuals identified with the total number of organisms sorted and recorded on the sheet. If the two values do not match an error message is provided to the user. The database automatically checks the spelling and presence of an organism with its master species list before allowing import. Unrecognized taxa are referred to the user for reconciliation.

13. Performance and System Audits

Frequent internal audits, consisting of two or more laboratory personnel conferring on identification occurs on average, once daily. In addition, the laboratory has participated in external performance evaluation studies by the U.S. EPA. Identification of macroinvertebrate test samples have been evaluated by the U.S. EPA, and samples are sent to an outside laboratory yearly for audit. The laboratory has also been evaluated by on-site visits and field audits by the U.S. EPA.

Performance/system audits are scheduled annually.

14. Corrective Action

Revisions to the Stanard Operating Procedures are to be made by the Project Manager. The Project Quality Assurance Officer will ensure that the plan is distributed to those on the distribution list upon completion of revision.

Corrective action procedures are outlined for the major program elements:

Organism identification:
Species identifications that are not found on the New York State species list or the U.S. EPA regional species checklist, and which are outside of the known distribution of the species as given in the primary reference must be verified by consultation with regional biologists or the appropriate taxonomic authority. Internal taxonomic discrepancies are corrected by auditing previous identifications of the species in question and making necessary changes to insure consistency. All species name changes are corrected on the species list, and a record made of the previous name.

Multiplate samples:
Samples that are shown to be invalid and cannot be resolved by additional subsampling are not included in the data analysis process.

Kick samples:
Samples that are shown to be invalid (see Section 12) and cannot be resolved by additional subsampling are not included in the data analysis process.

Subsamples:
For multiplate samples, subsampling procedures which repeatedly yield invalid subsamples must be re-evaluated and appropriately modified. For kick samples, replicate sampling must be conducted for subsamples shown to be invalid.

Sample results:
Outlying indices determined to be spurious may be rejected. Samples with a dominant species contributing more than 40% of the sample may have supplemental subsampling performed, limiting the dominant species to 40%. Adjustments in assessments may be made for headwater sites or sites affected by lake outlets or poor habitats (Appendices 18.13 and 18.14).

Data entry validation and transmittal errors:
Computer-entered data is considered invalid if it is not verified by number of individuals and number of species in the Laboratory Data Sheet. Errors found in spot checks of individual entries must be corrected, and additional spot checks conducted. Invalid entries which fail to be recognized during the creation of species lists by the lab datasheet are identified during data entry. Species information is double-checked by the database automatically and invalid information is rejected for correction by the user. Once corrections are made the data may be tried for import again. Once free of error the database will allow the entry of the information. The same is true for all field, tissue and site information.

Microscopy Equipment Calibration and Maintenance:
Proper calibration and maintenance of laboratory microscopy equipment is imperative to sound quality control in the processing of biological samples. Annually, all moving parts and internal and external magnifying lenses of laboratory microscopes are cleaned and re-calibrated to industry standards. This work is typically completed by an independent contractor. Periodic maintenance is performed on microscopy equipment as problems arise. Weekly cleaning of external magnifying lenses such as oculars and objective lenses is performed by SBU laboratory staff.

15. Reports

Monthly reports are issued to inform appropriate management personnel of progress in the execution of the work plan. The reports include major accomplishments or findings, significant meetings or workshops attended, training courses completed, and outstanding problems.

Final assessment reports are written by the Project Manager and other staff upon completion of the processing of samples from the previous field season's screening and intensive site locations. These reports are provided to other Division of Water staff and are incorporated into the Water Body Inventory and Priority Water Bodies List, the 305(b) and 303(d) reports. Every ten years a cumulative report on sampling efforts is produced which highlights trends and significant changes in water quality thruought New York State.

Individual water quality assessment reports are written for streams studied as Rapid Biological Assessment Surveys. These reports are typically detail oriented and contain raw species information, assessment results, photographs, maps, and comparisons to data collected previously.

Data analysis and incorporation of data into the Stream Biomonitoring Unit data management system is executed by programs in the database. Elements of many of the reports are automatically generated by the program's database after field, tissue, and sample data have been entered. Calculations performed by the database include the biological community and water quality metrics described in earlier sections of this document (see Section 10.1). Report elements automatically generated by the database include sampling location maps, macroinvertebrate species data reports, laboratory data summary reports and field data summary reports. These data reports can be exported from the database in multiple electronic formats including Microsoft Word and PDF.

In addition to water quality assessment reports manuscripts describing research in the field of applied freshwater ecology are written by Stream Biomonitoring Unit Staff and are published in peer reviewed scientific journals.

16. Quality Assurance/Quality Control

The objective of this quality assurance methodology is to establish and maintain standards that will ensure the integrity of data generated by the Stream Biomonitoring unit. There are various quality assurance methods used in the program and different procedures have been developed for the different aspects of data collection and generation. The Stream Biomonitoring Unit is dedicated to providing high quality information on the water quality of New York State's surface waters. To that end the unit is continually reviewing its quality assurance/quality control procedures, removing those that do not work, implementing, and expanding upon those that do.

Site selection and field data:
Site selection is conducted in the office using various sources of map data and aerial photography, the majority of which is digital and viewed in ArcGIS. These datasets include hydrography data for NY, United States Geological Survey topographic maps, and NYS GIS Clearinghouse high resolution orthoimagery. Thes map datasets are used to select sampling point coordinates which are then verified in the field. Selection of regional reference, long term trend, random probabilistic and unassessed waters relies heavily on the use of these datasets and historical sampling the Division of Water conducted. Quality control for the selection of department interest sites relies on the yearly inquiry of regional and central office Division of Water Staff. The information provided by other staff regarding possible sampling locations is retained and reviewed by SBU staff. The information is compared to historical records and a decision to sample the location is made if little or no information exists for the location or if a long period of time has lapsed since its last sampling.

In the field Sampling point coordinates are validated using a hand held GPS unit which acquires a fix once communication occurs with a minimum of three satellites. In addition, information on sampling site location is gathered in the field based on street maps and the exact location of the site. Collection date and time is verified using personal time devices and automobile clocks. Physical parameters such as depth, width, canopy cover, and embeddedness are recorded by one member of the field crew and verified by the second member. Disagreements are discussed and corrected before leaving the station. Current Speed is recorded using the average of at least three measurements.

Water chemistry information is collected using a multiprobe water quality meter. Calibration of the multiprobe is made before sampling occurs and is performed against known standards. The meter is placed in the water at the sampling location upstream of where the biological sample was collected. All calibration records are stored in a bound notebook specific to each probe.

The assessment of habitat conditions is done jointly by two members of the field crew. Disagreements are discussed and an agreed upon result is recorded on the habitat assessment sheet.

While on site, field sheets are reviewed before leaving the station to ensure completeness of data collection. Information missed is then collected.

Field data is entered into an excel spreadsheet. It is then error checked by a separate individual before being entered into the database. Upon data entry the database automatically verifies the sampling location information for the dataset. If no sampling point is verified the data is rejected. Sampling station information must then be entered for the data being imported. This quality assurance check ensures that field data is not entered into the database which does not have the appropriate sampling point information associated with it.

Sample collection:
For kick sampling the field crew member uses a stop watch to maintain consistency in effort in the 5 minute duration of sample collection between sites. For periphyton collection sampling effort is maintained by collecting the same amounts of material at each location. Ponar and multiplate sampling effort is easily made consist between sites due to the constructed boundaries of the sampling devices. For ponars it is the size of the opening of the device and the depth of walls of the ponar's chamber. Muliplates are constructed in the same dimensions at all times and are deployed for the same five week period at each station.

Organism identification:
The Stream Biomonitoring Unit employees a rigorous quality assurance/quality control program for its identification of organisms. 10% of all samples collected are shipped to a contract laboratory for QAQC identification and enumeration. Results of the contract labs identifications are directly compared to those of the SBU. Percent similarity between the two labs is calculated. A goal of 85% similarity between labs is recommended. Conference calls are held with the contract laboratory to discuss problem specimens.

Additionally internal QAQC samples are analyzed in-house among the taxonomists of the SBU. Bi-weekly, one previously processed sample is randomly selected from the entire set of sorted samples for review. Over the course of two weeks each individual taxonomist identifies all organisms in the sample. The results are recorded on a spreadsheet maintained by the SBU's quality assurance coordinator. Percent similarities of identification results are calculated and recorded on the same spreadsheet. Roundtable discussions are held upon completion of sample identification. Problem specimens are discussed and revised when needed.

Data entry:
Sample information is recorded in the lab on the "Lab Datasheet" (Appendix 18.7). When samples are first brought into the lab they are electronically logged in by creating a lab data sheet for the sample, recording the station information at the top of the page. The entry of this information electronically triggers the "Sample Log Book" (Appendix 18.6) to open automatically. At this time the user is prompted to enter collection information for the sample in the log book which creates a running record of the progress of sample processing for each sample.

During sample processing the electronic sample log book will open automatically after 1) the sample sorting target is reached and 2) after the species list has been created for the sample after identification has been completed. These two occurrences allow the user to enter in the date the sample was sorted and when identification was completed. When identification has been completed the sample information is entered into the database and water quality metrics are run based on the species data recorded.

Several quality assurance procedures are also built into the database which control data entry. When species information is imported into the database the system first checks to ensure there is a sampling station in the system for which the sample record can be related to. If a sampling site for the sample does not exist in the database the system will reject the entry until the user updates the site table in the database. This makes sure that orphan sample species data is not entered in the database. If all site information is accurate the database then verifies the species information with a master species table in the system. If species in the data being entered are not found on the master species table in the database the sample data is rejected from entry. The user is prompted about the problem and must then add the species information to the master species table or correct the errors in the sample data being entered. If all sample data is correct and free of error the information will be imported directly without problem, into the database.

Reporting:
Quality assurance is built into the final products of the SBU by employing a rigorous review process for all reports on water quality findings. A draft report is written by the author and then distributed electronically by the author to the other members of the SBU. Additionally reports are sent to other involved parties or those who may be affected by the results presented such as regional water staff for the department. Once comments from these reviewers have been incorporated into the draft report it is sent to the NYSDEC's Division of Public Affairs for review by a department staff editor. Corrections from this review are incorporated into the document and a final copy is then sent for printing. In route, reports are also read and signed off on by the appropriate bureau director and division director.

Manuscripts for publication in peer reviewed journals go through a similar review process, but with the added step of review and acceptance or rejection by the journal submitted to.

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18. Appendices

18.1 FIELDSHEET FOR THE COLLECTION OF BIOLOGICAL MONITORING DATA

New York State Department of Environmental Conservation

FIELD DATA SHEET 4-letter identifier _____

STREAM / STATION _____ CITY/TOWN/VILLAGE _____
ROUTE NO. _____

DATE _____
TIME : ARRIVAL _____ UNIQUE FEATURES _____
DEPARTURE _____
COLLECTORS _____ SITE TYPE: RIBS SCREENING _____
LATITUDE\ LONGITUDE _____ RIBS INTENSIVE _____
MULTI-SITE SURVEY _____

PHYSICAL AND CHEMICAL PARAMETERS

DEPTH (meters) _____ TEMPERATURE (ºC) _____

WIDTH (meters) _____ SPEC. CONDUCT. (µmhos) _____

CURRENT (cm/sec) _____ pH _____

CANOPY (%) 0 10 25 50 75 90 100 D.O. (mg/l; ppm) _____ / sat. % _____

EMBEDDEDNESS (%) _____ SALINITY _____

SECCHI DISK _____

SUBSTRATE: (%) Rock _____ Rubble _____ Gravel _____ Sand _____ Silt _____

AQUATIC VEGETATION: Algae (suspended) _____ Algae (filamentous) _____

Diatoms (on rocks) (%) _____ Thickness _____ Macrophytes (%) _____

TYPE OF SAMPLE		OCCURRENCE OF MACROINVERTEBRATES			
Multiplate	_____	Ephemeroptera	_____	Chironomidae	_____
Kick, sample retained	_____	Plecoptera	_____	Simuliidae	_____
Kick, sample not retained	_____	Trichoptera	_____	Decapoda	_____
Ponar	_____	Coleoptera	_____	Gammaridae	_____
Organisms for toxics	_____	Megaloptera	_____	Mollusca	_____
Photograph	_____	Odonata	_____	Oligochaeta	_____
Microtox sample	_____	Other	_____		_____
Other	_____				

FAUNAL CONDITION: very good _____ good _____ poor _____ very poor _____
Habitat: adequate _____ impoundment _____ headwater _____ sand _____ gravel _____
bedrock _____ low flow _____ other _____
Landuse: Residential _____ Agriculture _____ Commmerical _____ Industrial _____
Forest _____ Recreational _____ Wetland _____

NOTES, OBSERVATIONS	RIBS SCREENING SITE CRITERIA
	1. Mayflies (3 or more taxa) _____
	2. Stoneflies (present) _____
	3. Caddisflies (less abund. than mayflies) _____
	4. Beetles (present) _____
	5. Worms (sparse or absent) _____

18.2 FIELDSHEET FOR THE ASSESSMENT OF RECREATIONAL USE

NYSDEC - Assessment of Recreational Use Perception

Circle the one answer which best describes your ability to participate in 1^0 contact recreation:

a. Beautiful, could not be nicer. Ability to swim, wade, dive, water ski etc…fully attained.
b. Minor aesthetic problems, but still excellent for 1^0 contact recreation.
c. 1^0 contact recreation slightly impacted.
d. Desire to participate in 1^0 contact recreation substantially reduced.
e. Awful! 1^0 contact recreation impossible.
f. Not applicable (headwater/high flows/dry, etc.)

Circle the one answer which best describes your ability to participate in 2^0 contact recreation:

a. Beautiful, could not be nicer. Ability to fish and boat fully attained.
b. Minor aesthetic problems, but still excellent for 2^0 contact recreation.
c. 2^0 contact recreation slightly impacted.
d. Desire to participate in 2^0 contact recreation substantially reduced.
e. Awful! 2^0 contact recreation impossible.
f. Not applicable (headwater/high flows/dry, etc.)

Weather conditions (Current):	Sun	Rain	Clouds
Weather conditions (Past 24hrs):	Sun	Rain	Clouds

Water Clarity:	0	1	2	3	4	5	6	7	8	9	10
	Clear				Intermediate						Turbid
Phytoplankton: (suspended)	0	1	2	3	4	5	6	7	8	9	10
	Natural				Intermediate						Severe
Periphyton Cover:	0	1	2	3	4	5	6	7	8	9	10
	Natural				Intermediate						Severe
Macrophyte Cover:	0	1	2	3	4	5	6	7	8	9	10
	Natural				Intermediate						Severe
Odor:	0	1	2	3	4	5	6	7	8	9	10
	Natural				Intermediate						Noxious
Trash:	0	1	2	3	4	5	6	7	8	9	10
	None				Intermediate						Landfill
Discharges/Pipes:	0	1	2	3	4	5	6	7	8	9	10
	None				Intermediate						Dominant

Circle all the variables that negatively affect your opinion of recreational use of the waterbody today.

Water Clarity Phytoplankton Periphyton Macrophytes Odor Trash Discharges/Pipes

Other (Please list):

18.3 FIELDSHEET FOR RAPID ASSESSMENT OF HABITAT CONDITION IN HIGH GRADIENT STREAMS

New York State Department of Environmental Conservation
Field Sheet for Rapid Assessment of Habitat Condition (High Gradient)

Stream Name:_____
4-letter Identifier/Station Number:_____
Collectors:_____
Biological Sample: Y N
Site Type: Screening Intensive Multi-Site

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
	1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover, mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	40 – 70% mix of stable habitat; well-suited for full colonization potential, adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	20 – 40 % mix of stable habitat; habitat availability less than desirable, substrate frequently disturbed or removed.	Less than 20 % stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	2. Embeddedness	Gravel, cobble and boulder particles are 0-25 % surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble and boulder particles are 25-50 % surrounded by fine sediment.	Gravel, cobble and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble and boulder particles are more than 75 % surrounded by fine sediment.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderated deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constructions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable, infrequent, small areas of erosion; mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion potential during floods.	Unstable, many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation very high vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Parameters to be evaluated in sampling reach

Note: determine left or right side by facing downstream.

18.4 FIELDSHEET FOR RAPID ASSESSMENT OF HABITAT CONDITION IN LOW GRADIENT STREAMS

New York State Department of Environmental Conservation
Field Sheet for Rapid Assessment of Habitat Condition (Low Gradient)

Stream Name:_____
4-letter Identifier/Station Number:_____
Collectors:_____
Biological Sample: Y N
Site Type: Screening Intensive Multi-Site

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
	1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover, mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient)	30 – 50% mix of stable habitat; well-suited for full colonization potential, adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	10 – 30 % mix of stable habitat; habitat availability less than desirable, substrate frequently disturbed or removed.	Less than 10 % stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderated deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constructions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
	6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note – channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long time.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable, infrequent, small areas of erosion; mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion potential during floods.	Unstable, many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation very high vegetation has been removed to 5 centimeters or less in average stubble height.
	SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
	SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Note: determine left or right side by facing downstream.

18.5 FIELDSHEET FOR RECORDING PEBBLE COUNT AND ALGAL/SILTATION SUBSTRATE COVER

New York State Department of Environmental Conservation
Pebble Count and Algae Cover Field Form

Stream Name: _____
4-letter Identifier/Station Number: _____
Collectors: _____
Biological Sample: Y N
Site Type: Screening Intensive Multi-Site

Pebble Count Observations

Particle	Millimeters	Transect 1 (100 pebbles)		Item %
		Dry	Wet	
Silt	.004 -0.6			
Sand	0.06 – 2.0			
Gravel	2.0 - 16			
Crse. Gravel	16 - 64			
Rubble	64 – 256			
Rock	>256			
Bedrock	----------			
TOTALS				

Periphyton Cover Observations

	Moss Cover Index			
Category	0	1(<5%)	2(5-25%)	3(>25%)
Tally				

	Macro-Algae Cover Index			
Category	0	1(<5%)	2(5-25%)	3(>25%)
Tally				

	Micro-Algae Cover Index						
Category	0	1 (slimy)	2 (draw line)	3(.5-1mm)	4(1-5mm)	5(5-20mm)	6(>20mm)
Tally							

	Siltation Cover Index				
Category	0	1 (draw line)	2(.5-5mm)	3(5-20mm)	4(>20mm)
Tally					

Other Observations

18.6 FIELDSHEET FOR FISH COMMUNITY SURVEYS

New York State Department of Environmental Conservation
Stream Biomonitoring Unit

v2011.1

Fish Population Field Sheet

					4-Letter ID		
Stream		Personnel (circle Ider)					
Date		Time		Reach Length		avg Reach Width	
Arrival		Depart		Shock Time		# Anodes 1 2 3	
Lat/Long				Shocker Settings			
Sampling Method: Backpack ElectroShocker							
Site Description							

Species	Counts	Anomalies	Totals

Anomaly Codes

D=deformity, E=eroded fin, F=fungus, L=lesions, S=emaciated, BS=black spot, YG=yellow grub, M=multiple anomolies

18.7 EXAMPLE OF LABORATORY SAMPLE LOG SHEET FOR TRACKING SAMPLE PROCESSING

NYSDEC Stream Biomonitoring Unit - Sample Processing Record										
Location	Station	Replicate	Collection Date	Survey	Sample Type	Number of Samples	Lab Datasheet Prepared	Date Sorted	Date ID Completed	Date Entered in Database
GLOW	01		6/28/2007	Upper Hudson RAS	Kick	1	GLOW01.xls	10/10/2007	10/16/2007	6/1/2008
GLOW	03		6/28/2007	Upper Hudson RAS	Kick	1	GLOW03.xls	10/10/2007	11/1/2007	6/1/2008
GLOW	04		6/28/2007	Upper Hudson RAS	Kick	1	GLOW04.xls	10/11/2007	11/1/2007	6/1/2008
GLOW	05		6/28/2007	Upper Hudson RAS	Kick	1	GLOW05.xls	10/11/2007	11/1/2007	6/1/2008
LHUD	01	A	7/9/2007	Lower Hudson Screening	Multiplate	2	LHUD01A_Jul.xls	9/6/2008	10/6/2008	7/1/2008
LHUD	10	A	7/9/2007	Lower Hudson Screening	Multiplate	2	LHUD10A_Jul.xls	9/15/2008	10/1/2008	7/1/2008
LHUD	10	B	7/9/2007	Lower Hudson Screening	Multiplate	2	LHUD10B_Jul.xls	9/15/2008	10/1/2008	7/1/2008
LHUD	06	A	7/9/2007	Lower Hudson Screening	Multiplate	2	LHUD06A_Jul.xls	9/15/2008	10/10/2008	7/1/2008
LHUD	06	B	7/9/2007	Lower Hudson Screening	Multiplate	2	LHUD06B_Jul.xls	9/15/2008	10/1/2008	7/1/2008
LHUD	14	A	7/9/2007	Lower Hudson Screening	Multiplate	2	LHUD14A_Jul.xls	9/15/2008	10/6/2008	7/1/2008
LHUD	14	B	7/9/2007	Lower Hudson Screening	Multiplate	2	LHUD14B_Jul.xls	9/15/2008	10/1/2008	7/1/2008
TOBE	01		7/31/2007	Chemung Screening	Kick	1	TOBE01.xls	1/23/2008	6/17/2008	2/5/2009
SMIR	01		7/31/2007	Chemung Screening	Kick	1	SMIR01.xls	1/2/2008	6/2/2008	2/5/2009
COON	01		7/31/2007	Chemung Screening	Kick	1	COON01.xls	1/3/2008	6/2/2008	2/5/2009
STEO	03B		7/31/2007	Chemung Screening	Kick	1	STEO03B.xls	1/23/2008	6/2/2008	2/5/2009
STEO	02		7/31/2007	Chemung Screening	Kick	1	STEO02.xls	1/23/2008	6/2/2008	2/5/2009
STEP	01		7/31/2007	Chemung Screening	Kick	1	STEP01.xls	1/2/2008	6/17/2008	2/5/2009
PURD	01		7/31/2007	Chemung Screening	Kick	1	PURD01.xls	12/19/2007	6/2/2008	2/5/2009
BENN	02		7/31/2007	Chemung Screening	Kick	1	BENN02.xls	12/20/2007	6/2/2008	2/5/2009
CARI	01		7/31/2007	Chemung Screening	Kick	1	CARI01.xls	1/8/2008	5/21/2008	2/5/2009
BILL	01		7/31/2007	Chemung Screening	Kick	1	BILL01.xls	1/7/2008	6/19/2008	2/5/2009
COHO	03		7/31/2007	Chemung Screening	Kick	1	COHO03.xls	1/2/2008	6/1/2008	2/5/2009
ALGY	08A		8/7/2007	Allgheny Intensive	Kick	1	ALGY08A.xls	4/2/2008	6/2/2008	2/5/2009
WANG	01		8/7/2007	Allgheny Intensive	Kick	1	WANG01.xls	4/9/2008	6/2/2008	2/5/2009
QRUN	01		8/7/2007	Allgheny Intensive	Kick	1	QRUN01.xls	4/9/2008	11/26/2008	2/5/2009
TUNG	01		8/7/2007	Allgheny Intensive	Kick	1	TUNG01.xls	4/9/2008	11/28/2008	2/5/2009
CASS	03		8/7/2007	Allgheny Intensive	Kick	1	CASS03f.xls	4/9/2008	11/10/2008	2/5/2009

18.8 LABORATORY DATASHEET FOR RECORDING SAMPLE SPECIES AND OTHER PROCESSING INFORMATION. Sheets are maintained in MS Excel (double sided when printed).

River Stream:				
Station Number:				
Date:				
Sample Type:				
Replicate:				
Sub-sample:				
Sorted by:				
	Sort Count	*Genus species*	Subsample	Total
Ephemeroptera - (E)	**0**			
Taxonomist:				
Plecoptera - (P)	**0**			
Taxonomist:				
Trichoptera - (T)	**0**			
Taxonomist:				
Coleoptera - (B)	**0**			
Taxonomist:				
Megaloptera - (M)	**0**			
Taxonomist:				
Other Diptera - (D)	**0**			
Taxonomist:				

Chiro. Larvae - (L)	**0**			
Pupae - (A)	**0**			
Taxonomist:				
Other Insecta - (O)	**0**			
Taxonomist:				
Mollusca - (S)	**0**			
Taxonomist:				
Crustacea - (K)	**0**			
Taxonomist:				
Nemertea - (N)	**0**			
Taxonomist:				
Platyhelminthes - (F)	**0**			
Taxonomist:				
Oligochaeta - (W)	**0**			
Taxonomist:				
Hirudinea - (H)	**0**			
Taxonomist:				
Sample Processing Notes				

18.9 EXAMPLE OF MASTER SPECIES LIST USED FOR IMPORTING SAMPLE DATA INTO THE BIOLOGICAL DATABASE. The list is maintained in MS Excel.

LOCATION	STATION	DATE	GENSPECIES	INDIV	COLLECT	REPLICATE
BISH	01	8/28/2008	Isonychia bicolor	1	1	
BISH	01	8/28/2008	Baetis flavistriga	2	1	
BISH	01	8/28/2008	Baetis intercalaris	2	1	
BISH	01	8/28/2008	Stenonema sp.	1	1	
BISH	01	8/28/2008	Hydropsyche betteni	2	1	
BISH	01	8/28/2008	Hydropsyche bronta	3	1	
BISH	01	8/28/2008	Brachycentrus appalachia	1	1	
BISH	01	8/28/2008	Stenelmis sp.	2	1	
BISH	01	8/28/2008	Antocha sp.	2	1	
BISH	01	8/28/2008	Atherix sp.	1	1	
BISH	01	8/28/2008	Cricotopus trifascia gr.	23	1	
BISH	01	8/28/2008	Eukiefferiella devonica gr.	30	1	
BISH	01	8/28/2008	Cricotopus tremulus gr.	10	1	
BISH	01	8/28/2008	Tvetenia vitracies	1	1	
BISH	01	8/28/2008	Cricotopus bicinctus	13	1	
BISH	01	8/28/2008	Cricotopus vierriensis	1	1	
BISH	01	8/28/2008	Thienemannimyia gr. Spp.	1	1	
BISH	01	8/28/2008	Cryptochironomus sp.	1	1	
BISH	01	8/28/2008	Polypedilum aviceps	2	1	
BLAR	01	7/24/2008	Isonychia bicolor	2	1	
BLAR	01	7/24/2008	Baetis intercalaris	1	1	
BLAR	01	7/24/2008	Centroptilum sp.	2	1	
BLAR	01	7/24/2008	Leucrocuta sp.	1	1	
BLAR	01	7/24/2008	Stenonema ithaca	5	1	
BLAR	01	7/24/2008	Stenonema modestum	2	1	
BLAR	01	7/24/2008	Ephemerella aurivillii	1	1	
BLAR	01	7/24/2008	Perlesta sp.	4	1	
BLAR	01	7/24/2008	Cheumatopsyche sp.	1	1	
BLAR	01	7/24/2008	Hydropsyche sparna	2	1	
BLAR	01	7/24/2008	Hydrobius sp.	1	1	
BLAR	01	7/24/2008	Optioservus trivittatus	1	1	
BLAR	01	7/24/2008	Stenelmis sp.	2	1	
BLAR	01	7/24/2008	Nigronia serricornis	2	1	
BLAR	01	7/24/2008	Atherix sp.	2	1	
BLAR	01	7/24/2008	Micropsectra dives gr.	2	1	
BLAR	01	7/24/2008	Rheocricotopus robacki	1	1	
BLAR	01	7/24/2008	Polypedilum illinoense	5	1	
BLAR	01	7/24/2008	Parametriocnemus sp.	1	1	
BLAR	01	7/24/2008	Tvetenia vitracies	1	1	
BLAR	01	7/24/2008	Microtendipes rydalensis gr.	1	1	

18.10 Levels of taxonomic effort for identification of macroinvertebrates and associated keys

This list standardizes the minimum level of taxonomic effort used in biological monitoring of surface waters by the NYSDEC Stream Biomonitoring Unit. The levels of effort listed are a guide for monitoring studies and are not necessarily the level each organism is identified to. Individual circumstances dictate the resolution possible including developmental state of the organism and its physical completeness. The level of taxonomy required for each group is based on these factors: differences in water quality tolerances within a group, likelihood of increased accuracy of species richness with more refined taxonomy, availability of identification keys, and history of identification of the group by the Stream Biomonitoring Unit.

Phylogenetic group	Taxonomic level	Identification ref. no.
Coelenterata:	order	108
Nemertea:	order	108
Platyhelminthes:	class	108
Polychaeta:	order	83,108
Sabellida:	genus	
Oligochaeta		
Lumbricina:	order	83
Lumbriculidae:	family	18 or 83
Enchytraeidae:	family	18 or 83
Tubificidae:	genus species	18 or 83
Naididae:	genus species	18 or 83
Hirudinea:	order	83 or 108
Aphanoneura:	genus	83 or 108
Branchiobdellida:	order	108
Gastropoda		
Physidae:	family	60 or 83
Lymnaeidae:	family	60 or 83
Planorbidae:	family	60 or 83
Ancylidae:	family	60 or 83
Viviparidae:	family	60 or 83
Pleuroceridae:	family	60 or 83
Hydrobiidae:	family	60 or 83
Valvatidae:	family	60 or 83
Pelecypoda		
Unionidae:	family	116 or 83
Sphaeriidae:	family	83

Phylogenetic group	Taxonomic level	Identification ref. no.
Crustacea		
Anthuridae:	family	48
Idoteidae:	family	48
Asellidae:	genus species	108 or 83
Gammaridae:	genus	108 or 83
Oedicerotidae:	family	48
Talitridae:	genus	108 or 83
Cumacea:	order	48
Decapoda:	family	108 or 83
Ephemeroptera		
Isonychiidae:	genus	83, 64
Ameletidae:	genus	34, 83
Siphlonuridae:	genus	34, 83
Baetidae		
Acerpenna:	genus species	74, 117
Baetis:	genus species	74
Diphetor:	genus species (monotypic)	
All others:	genus	34, 83,
Heptageniidae		
Stenonema:	genus species	9
Epeorus:	genus species	
Heptagenia:	genus species	
All others:	genus	34, 83
Leptophlebiidae:	genus	
Ephemerellidae:	genus species	2, 3, 4, 5, 6, 7
Tricorythidae:	genus	83
Caenidae:	genus	84
Baetiscidae:	genus	83
Potamanthidae:	genus	83
Ephemeridae:	genus	83
Polymitarcidae:	genus	83
Odonata		
Gomphidae:	genus	83, 122
Aeschnidae:	genus	83, 122
Cordulegasteridae:	genus	83, 122
Libellulidae:	genus	83, 122
Calopterygidae:	genus	83, 122
Agrionidae:	genus	83, 122
Coenagrionidae:	genus	83, 122
Hemiptera		
Corixidae:	family	83

Phylogenetic group	Taxonomic level	Identification ref. no.
Plecoptera		
Capniidae:	genus	83, 114
Leuctridae:	genus	83, 114
Nemouridae:	genus	83, 114
Taeniopterygidae:	genus species	45
Perlidae:	genus species	55, 112, 114
Peltoperlidae:	family	83, 114
Chloroperlidae:	genus	83, 114
Perlodidae:	genus	83, 114
Pteronarcidae:	genus species	83, 114
Coleoptera		
Haliplidae:	genus	83, 123
Dytiscidae:	genus	83, 123
Gyrinidae:	genus	83, 123
Hydrophilidae:	genus	83, 123
Psephenidae:	genus species	83, 123
Dryopidae:	family	83, 123
Scirtidae:	family	83, 123
Elmidae:		
Promoresia :	species (adults)	19
Optioservus :	species (adults)	19
Stenelmis :	genus except for *S. crenata*	19
All others :	genus	19
Megaloptera		
Corydalidae:	genus	37, 83
Sialidae:	genus	37, 83
Neuroptera		
Sisyridae:	family	37
Trichoptera		
Philopotamidae:		
Chimarra:	genus species	
All others:	genus	83, 125
Psychomyiidae:	species	41, 125
Polycentropodidae:	genus	83, 125
Hydropsychidae		
Arctopsyche:	genus species (monotypic)	
Hydropsyche:	genus species	103, 105
Parapsyche:	genus species (monotypic)	
All others:	genus	83, 125
Rhyacophilidae:	genus species	40
Glossosomatidae:	genus	83, 125
Hydroptilidae:	genus	83, 125
Phryganeidae:	genus	83, 125

Phylogenetic group	Taxonomic level	Identification ref. no.
Brachycentridae		
Brachycentrus:	genus species	42
All others:	genus	83, 125
Limnephilidae:	genus	83, 125
Lepidostomatidae:	genus	83, 125
Odontoceridae:	genus	83, 125
Molannidae:	genus	83, 125
Helicopsychidae:	genus species (monotypic)	83, 125
Leptoceridae:	genus	83, 125
Lepidoptera:	order	66, 83
Diptera		
Tipulidae:	genus	25, 83
Psychodidae:	family	83, 117
Ptychopteridae:	family	83
Blephariceridae:	genus (monotypic)	83, 117
Dixidae:	family	83, 127
Chaoboridae:	genus	83
Ceratopogonidae:	family	83
Simuliidae:	genus except for *S. vittatum*	115, 128
Tabanidae:	family	83, 117
Athericidae:	genus (monotypic)	83, 117
Empididae:	genus	83, 117
Dolichopodidae:	family	83, 117
Ephydridae:	family	83, 117
Muscidae:	family	83, 117
Anthomyiidae:	family	83, 117
Scathophagidae:	family	83, 117
Chironomidae		
Ablabesmyia:	genus species	95
Cricotopus:	genus species group	106, 107
Eukiefferiella:	genus species group	13
Nanocladius:	genus species	100
Orthocladius:	genus	109, 110
Psectrocladius:	genus species group	124
Tvetenia:	genus species group	13
Dicrotendipes:	genus species	35
Polypedilum:	genus species	69
Rheotanytarsus:	genus species group	106
Tanytarsus:	genus species group	106
All others:	genus	83, 124

18.11 BENTHIC MACROINVERTEBRATE SPECIES LIST

Species list of benthic macroinvertebrates collected in New York State during biological monitoring studies of surface waters. Included in the table are the; reference number (Ref) for the taxonomic literature reference used in the identification of the taxon (See the taxonomic reference list Appendix 18.12), the functional feeding group the taxon belongs to (Fd), the taxons Hilsenhoff's Biotic Index tolerance value (HBI) and the nutrient tolerance values for calculating the nutrient biotic indices for both phosphorus (NBI-P) and nitrogen (NBI-N).

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
COELENTERATA					
HYDROZOA					
HYDROIDA					
Hydridae					
Hydra sp.	108	prd	5		
Undetermined Hydridae	108	prd	5		
NEMERTEA					
ENOPLA					
HOPLONEMERTEA					
Tetrastemmatidae					
Prostoma graecense	108	prd	8	2	7
Undetermined Nemertea	108	prd	8		
PLATYHELMINTHES					
TURBELLARIA					
TRICLADIDA					
Planariidae					
Dugesia tigrina	62	prd	6		
Dugesia sp.	62	prd	6		
Undetermined Turbellaria	62	c-g	6	8	6
NEMATODA					
Undetermined Nematoda		c-g	5		
ANNELIDA					
POLYCHAETA					
SABELLIDA					
Sabellidae					
Manayunkia speciosa	83	c-g	6		
Manayunkia sp.	83	c-g	6		
Undetermined Sabellidae	83	c-g	6		
Undetermined Polychaeta	83	c-g	6		
ANNELIDA					
OLIGOCHAETA					
HAPLOTAXIDA					
Haplotaxidae					
Undetermined Haplotaxidae	18	prd	5		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
LUMBRICIDA					
Undetermined Lumbricina	83	c-g	6		
LUMBRICULIDA					
Lumbriculidae					
Eclipidrilus sp.	18	c-g	5		
Stylodrilus heringianus	18	c-g	5		
Stylodrilus sp.	18	c-g	5		
Undetermined Lumbriculidae	18	c-g	5	5	6
TUBIFICIDA					
Enchytraeidae					
Undetermined Enchytraeidae	18,83	c-g	10	7	8
TUBIFICIDA					
Tubificidae					
Aulodrilus americanus	18,83	c-g	7		
Aulodrilus limnobius	18,83	c-g	7		
Aulodrilus piqueti	18,83	c-g	7		
Aulodrilus pluriseta	18,83	c-g	7		
Aulodrilus sp.	18,83	c-g	7		
Bothrioneurum vejdovskyanum	18	c-g	7		
Bothrioneurum sp.	18	c-g	7		
Branchiura sowerbyi	18,83	c-g	6		
Branchiura sp.	18,83	c-g	6		
Ilyodrilus templetoni	18,83	c-g	10		
Ilyodrilus sp.	18,83	c-g	10		
Isochaetides freyi	18,83	c-g	8		
Isochaetides sp.	18,83	c-g	8		
Limnodrilus cervix	18,83	c-g	10		
Limnodrilus claparedeianus	18,83	c-g	10		
Limnodrilus hoffmeisteri	18,83	c-g	10		
Limnodrilus profundicola	18,83	c-g	10		
Limnodrilus udekemianus	18,83	c-g	10		
Limnodrilus sp.	18,83	c-g	10		
Potamothrix moldaviensis	18,83	c-g	8		
Potamothrix vejdovskyi	18	c-g	8		
Potamothrix sp.	18	c-g	8		
Quistadrilus multisetosus	18,83	c-g	10		
Quistadrilus sp.	18,83	c-g	10		
Rhyacodrilus subterraneus	18	c-g	10		
Rhyacodrilus sp.	18	c-g	10		
Spirosperma ferox	18,83	c-g	6		
Spirosperma sp.	18,83	c-g	6		
Tubifex tubifex	18,83	c-g	10		
Tubifex sp.	18,83	c-g	10		
Undet. Tubificidae w/ cap. setae	18,83	c-g	10	10	8
Undet. Tubificidae w/o cap. setae	18,83	c-g	10	7	7

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Undetermined Tubificidae	83	c-g	9		
Naididae					
Amphichaeta americana	18,83	c-g	6		
Amphichaeta sp.	18,83	c-g	6		
Arcteonais lomondi	18,83	c-g	6		
Arcteonais sp.	18,83	c-g	6		
Chaetogaster diaphanus	18,83	prd	7		
Chaetogaster diastrophus	18,83	prd	7		
Chaetogaster limnaei	18,83	prd	7		
Chaetogaster setosus	18,83	prd	7		
Chaetogaster sp.	18,83	prd	7		
Dero digitata	18,83	c-g	10		
Dero furcata	18,83	c-g	10		
Dero nivea	18,83	c-g	10		
Dero obtusa	18,83	c-g	10		
Dero pectinata	18,83	c-g	10		
Dero sp.	18,83	c-g	10		
Haemonais waldvogeli	18,83	c-g	8		
Haemonais sp.	18,83	c-g	8		
Nais barbata	18,83	c-g	8		
Nais behningi	18,83	c-g	6		
Nais bretscheri	18,83	c-g	6		
Nais communis	18,83	c-g	8		
Nais elinguis	18,83	c-g	10		
Nais pardalis	18,83	c-g	8		
Nais simplex	18,83	c-g	6		
Nais variabilis	18,83	c-g	10	5	0
Nais sp.	18,83	c-g	8		
Ophidonais serpentina	18,83	c-g	6		
Ophidonais sp.	18,83	c-g	6		
Paranais frici	61	c-g	10		
Paranais sp.	61	c-g	10		
Piguetiella michiganensis	18	c-g	6		
Piguetiella sp.	18	c-g	6		
Pristina aequiseta	18,83	c-g	8		
Pristina breviseta	18,83	c-g	8		
Pristina leidyi	18,83	c-g	8		
Pristina menoni	18,83	c-g	8		
Pristina synclites	18,83	c-g	8		
Pristina sp.	18,83	c-g	8		
Pristinella jenkinae	18,83	c-g	8		
Pristinella osborni	18,83	c-g	8		
Pristinella sp.	18,83	c-g	8		
Ripistes parasita	18,83	c-f	8		
Ripistes sp.	18,83	c-f	8		
Slavina appendiculata	18,83	c-g	6		
Slavina sp.	18,83	c-g	6		
Specaria josinae	18,83	c-g	6		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Specaria sp.	18,83	c-g	6		
Stylaria lacustris	18,83	c-g	6	5	2
Stylaria sp.	18,83	c-g	6		
Vejdovskyella comata	18,83	c-g	6		
Vejdovskyella intermedia	18,83	c-g	6		
Vejdovskyella sp.	18,83	c-g	6		
Undetermined Naididae	18,83	c-g	8		
Undetermined Oligochaeta	18,83	c-g	8		
ANNELIDA					
HIRUDINEA					
ARHYNCHOBDELLIDA					
Erpobdellidae					
Erpobdella sp.	83, 63	prd	8		
Undetermined Erpobdellidae	83, 63	prd	8		
RHYNCHOBDELLIDA					
Glossiphoniidae					
Batracobdella phalera	83,63	prd	8		
Batracobdella sp.	83,63	prd	8		
Helobdella elongata	83,63	prd	8		
Helobdella stagnalis	83,63	prd	8		
Helobdella triserialis	83,63	prd	8		
Helobdella sp.	63	prd	8		
Placobdella montifera	83,63	prd	8		
Placobdella sp.	83,63	prd	8		
Undetermined Glossiphoniidae	83, 63	prd	8		
Undetermined Hirudinea	83,63	prd	8	9	10
ANNELIDA					
APHANONEURA					
AEOLOSOMATIDA					
Aeolosomatidae					
Aeolosoma headleyi?	29	c-f	8		
Aeolosoma leidyi?	29	c-f	8		
Aeolosoma quarternarium?	29	c-f	8		
Aeolosoma tenebrarum?	29	c-f	8		
Aeolosoma travancorense?	29	c-f	8		
Aeolosoma sp.	29	c-f	8		
Undetermined Aeolosomatidae	29	c-f	8		
BRANCHIOBDELLA					
BRANCHIOBDELLIDA					
Branchiobdellidae					
Branchiobdella sp.	108	c-g	6		
Undetermined Branchiobdellidae	108	c-g	6		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
MOLLUSCA					
GASTROPODA					
BASOMMATOPHORA					
Physidae					
Physella ancillaria	83,60	c-g	8		
Physella gyrina	83,60	c-g	8		
Physella heterostropha	83,60	c-g	8		
Physella integra	83,60	c-g	8		
Physella sp.	83,60	c-g	8	8	7
Undetermined Physidae	83,60	c-g	8		
Lymnaeidae					
Fossaria sp.	60,83	c-g	6		
Lymnaea stagnalis	60,83	c-g	6		
Lymnaea sp.	60,83	c-g	6		
Pseudosuccinea columella	60,83	c-g	6		
Pseudosuccinea sp.	60,83	c-g	6		
Radix auricularia	60,83	c-g	6		
Radix sp.	60,83	c-g	6		
Stagnicola catascopium	60,83	c-g	6		
Stagnicola elodes	60,83	c-g	6		
Stagnicola sp.	83	c-g	6		
Undetermined Lymnaeidae	60,83	c-g	6		
Planorbidae					
Gyraulus circumstriatus	60,83	scr	8		
Gyraulus deflectus	60,83	scr	8		
Gyraulus parvus	60,83	scr	8		
Gyraulus sp.	60,83	scr	8		
Helisoma anceps	60,83	scr	6		
Helisoma campanulata	60	scr	6		
Helisoma trivolvis	60	scr	6		
Helisoma sp.	60	scr	6		
Micromenetus dilatatus	60	scr	6		
Micromenetus sp.	60	scr	6		
Undetermined Planorbidae	60,83	scr	6		
Ancylidae					
Ferrissia parallela	60,83	scr	6		
Ferrissia rivularis	60,83	scr	6		
Ferrissia walkeri	60,83	scr	6		
Ferrissia sp.	60,83	scr	6	9	5
Undetermined Ancylidae	60,83	scr	6		
MESOGASTROPODA					
Viviparidae					
Campeloma decisum	60,83	scr	6		
Campeloma sp.	60,83	scr	6		
Viviparus georgianus	60,83	scr	6		
Viviparus sp.	60,83	scr	6		
Undetermined Viviparidae	60,83	scr	6		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Pleuroceridae					
Goniobasis livescens	60,83	scr	6	10	10
Goniobasis virginica	60,83	scr	6		
Goniobasis sp.	60,83	scr	6		
Pleurocera acuta	60,83	scr	6		
Pleurocera sp.	60,83	scr	6		
Undetermined Pleuroceridae	60,83	scr	6		
Bithyniidae					
Bithynia tentaculata	60,83	scr	8		
Bithynia sp.	60,83	scr	8		
Undetermined Bithyniidae	60,83	scr	8		
Hydrobiidae					
Amnicola decepta	83,60	scr	5		
Amnicola grana	60,83	scr	5		
Amnicola limosa	60,83	scr	5		
Amnicola sp.	60,83	scr	5		
Cincinnatia cincinnatiensis	60,83	scr	5		
Cincinnatia sp.	60,83	scr	5		
Pomatiopsis lapidaria	51,22	scr	8		
Pomatiopsis sp.	51,22	scr	8		
Probythinella lacustris	60,83	scr	8		
Probythinella sp.	60,83	scr	8		
Undetermined Hydrobiidae	60,83	scr	8	6	7
Valvatidae					
Valvata lewisi	60,83	scr	8		
Valvata piscinalis	60,83	scr	8		
Valvata sincera	60,83	scr	8		
Valvata tricarinata	60,83	scr	8		
Valvata sp.	60,83	scr	8		
Undetermined Valvatidae	60,83	scr	8		
Undetermined Gastropoda	60,83	scr	7		
PELECYPODA					
UNIONIDA					
Unionidae					
Anodonta implicata	116,83	c-f	6		
Anodonta sp.	116,83	c-f	6		
Elliptio complanata	116,83	c-f	8		
Elliptio sp.	116,83	c-f	8		
Lampsilis radiata	116,83	c-f	6		
Lampsilis sp.	116,83	c-f	6		
Pyganodon cataracta	116,83	c-f	6		
Pyganodon sp.	116,83	c-f	6		
Undetermined Unionidae	116,83	c-f	6		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
VENEROIDEA					
Corbiculidae					
Corbicula fluminea	83	c-f	6		
Corbicula sp.	83	c-f	6		
Undetermined Corbiculidae	83	c-f	6		
Dreisseniidae					
Dreissena polymorpha	82	c-f	8		
Dreissena sp.	82	c-f	8		
Undetermined Dreisseniidae	82	c-f	8		
Sphaeriidae					
Musculium partumeium	68,22	c-f	6		
Musculium transversum	68,22	c-f	6		
Musculium sp.	83	c-f	6		
Pisidium amnicum	68,22	c-f	6		
Pisidium casertanum	68,22	c-f	6		
Pisidium compressum	68,22	c-f	6		
Pisidium variabile	68,22	c-f	6		
Pisidium sp.	83	c-f	6	8	10
Sphaerium corneum	68,22	c-f	6		
Sphaerium rhomboideum	68,22	c-f	6		
Sphaerium striatinum	68,22	c-f	6		
Sphaerium sp.	68,22	c-f	6	9	4
Undetermined Sphaeriidae	83	c-f	6		
ARTHROPODA					
CRUSTACEA					
ISOPODA					
Anthuridae					
Cyathura polita	48	c-g	5		
Cyathura sp.	48	c-g	5		
Undetermined Anthuridae	48	c-g	5		
Idoteidae					
Chiridotea almyra	48	c-g	5		
Chiridotea sp.	48	c-g	5		
Edotea sp.	48	c-g	5		
Undetermined Idoteidae	48	c-g	5		
Asellidae					
Caecidotea communis	108, 126	c-g	8		
Caecidotea intermedius	126	c-g	8		
Caecidotea racovitzai	108, 126	c-g	8	6	2
Caecidotea sp.	108, 83	c-g	8	7	9
Lirceus sp.	126, 83	c-g	8		
Undetermined Asellidae	108, 83	c-g	8		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
AMPHIPODA					
Crangonyctidae					
Crangonyx sp.	108	c-g	6		
Undetermined Crangonyctidae	108	c-g	6		
Gammaridae					
Gammarus fasciatus	17,57	c-g	6		
Gammarus pseudolimnaeus	17,57	c-g	4		
Gammarus tigrinus	17,57	c-g	6		
Gammarus sp.	17,57	c-g	6	8	9
Undetermined Gammaridae	17,57	c-g	6		
Oedicerotidae					
Monoculodes edwardsi	17	c-g	5		
Monoculodes sp.	17	c-g	5		
Undetermined Oedicerotidae	17	c-g	5		
Talitridae					
Hyalella azteca	17	c-g	8		
Hyalella sp.	17	c-g	8		
Undetermined Talitridae	17	c-g	8		
CUMACEA					
Nannastacidae					
Almyracuma proximoculi	48	c-g	5		
Almyracuma sp.	48	c-g	5		
Undetermined Nannastacidae	48	c-g	5		
DECAPODA					
Cambaridae					
Cambarus bartonii	83,108	c-g	6		
Cambarus sp.	83,108	c-g	6		
Orconectes obscurus	83,108	c-g	6		
Orconectes propinquus	83,108	c-g	6		
Orconectes rusticus	83,108	c-g	6		
Orconectes sp.	83,108	c-g	6		
Undetermined Cambaridae	83,108	c-g	6	6	5
Penaeidae					
Undetermined Penaeidae	48	c-g	6		
OSTRACODA					
Undetermined Ostracoda	108	c-g	6		
Undetermined Crustacean		c-g	6		
ARTHROPODA					
ARACHNOIDEA					
Arrenuridae					
Arrenurus sp.	108	prd	6		
Lebertiidae					
Lebertia sp.	108	prd	6		
Atractideidae					

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Atractides sp.	108	prd	6		
Mideopsidae					
Mideopsis sp.	108	prd	6		
Tyrellidae					
Tyrellia sp.	108	prd	6		
Limnesidae					
Limnesia sp.	108	prd	6		
Limnocharidae					
Limnochares sp.	108	prd	6		
Sperchonidae					
Sperchon sp.	108	prd	6		
Unionicolidae					
Unionicola sp.	108	prd	6		
Undetermined Acariformes	108	prd	6		
ARTHROPODA					
DIPLOPODA					
POLYDESMIDA					
Undetermined Polydesmida	16	c-g	6		
INSECTA					
COLLEMBOLA					
Isotomidae					
Isotomurus sp.	83	c-g	5		
Undetermined Isotomidae	83	c-g	5		
EPHEMEROPTERA					
Ameletidae					
Ameletus ludens	83,34	c-g	0		
Ameletus sp.	83,34	c-g	0		
Undetermined Ameletidae	83,34	c-g	0		
Siphlonuridae					
Siphlonurus sp.	83	c-g	4		
Undetermined Siphlonuridae	83	c-g	4		
Isonychiidae					
Isonychia bicolor	83,64	c-f	2	5	2
Isonychia obscura	83,64	c-f	2		
Isonychia sp.	83	c-f	2		
Undetermined Isonychiidae	83	c-f	2		
Baetidae					
Acentrella ampla	74,119	c-g	6		
Acentrella turbida	83	c-g	4		
Acentrella sp.	83	c-g	4	5	5
Acerpenna macdunnoughi	74,120	c-g	5		
Acerpenna pygmaea	74,120	c-g	4	0	4
Acerpenna sp.	74,120	c-g	4		
Baetis brunneicolor	74	c-g	4	1	5
Baetis flavistriga	74	c-g	4	7	7

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Baetis intercalaris	74	c-g	5	6	5
Baetis pluto	74	c-g	6		
Baetis tricaudatus	74	c-g	6	8	9
Baetis sp.	74	c-g	6	6	3
Callibaetis sp.	83	c-g	7		
Centroptilum sp.	83	c-g	2		
Cloeon sp.	83	c-g	4		
Diphetor hageni	74	c-g	6		
Diphetor sp.	74	c-g	6		
Heterocloeon curiosum	83,34	scr	2		
Heterocloeon sp.	83	scr	2		
Iswaeon anoka	83, 34	scr	2		
Plauditus dubius	67	c-g	4		
Plauditus sp.	67	c-g	4	2	6
Pseudocloeon propinquum	74,120	c-g	6		
Pseudocloeon sp.	83	c-g	6		
Undetermined Baetidae	83	c-g	6		
Heptageniidae					
Cinygmula subaequalis	83,34	scr	2		
Cinygmula sp.	83,34	scr	2		
Epeorus vitreus	83	scr	0		
Epeorus (*Iron*) sp.	83	scr	0	0	0
Epeorus sp.	83	scr	0		
Heptagenia culacantha	83,38	scr	2		
Heptagenia flavescens	83,24	scr	4		
Heptagenia marginalis	83,24	scr	4		
Heptagenia pulla gr.	83,24	scr	4		
Heptagenia sp.	83	scr	4	0	0
Leucrocuta sp.	83,43	scr	1	1	3
Nixe (*Nixe*) sp.	83,43	scr	2	1	5
Rhithrogena sp.	83	c-g	0	0	1
Stenacron carolina		scr	7		
Stenacron interpunctatum	83,9	scr	7	7	7
Stenacron sp.	83,9	scr	7		
Stenonema exiguum	9	scr	5		
Stenonema femoratum	9	scr	7		
Stenonema ithaca	9	scr	3		
Stenonema luteum	9	scr	4		
Stenonema mediopunctatum	9	scr	3	3	3
Stenonema meririvulanum	9	scr	2		
Stenonema mexicanum integrum	9	scr	4		
Stenonema modestum	9	scr	1	2	5
Stenonema pulchellum	9	scr	3		
Stenonema terminatum	9	scr	4	2	3
Stenonema vicarium	9	scr	2	6	7
Stenonema sp.	9	scr	3	5	5
Undetermined Heptageniidae	83	scr	3	5	2

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Leptophlebiidae					
Choroterpes sp.	83	c-g	2		
Habrophlebia vibrans	83,34	c-g	4		
Habrophlebia sp.	83	c-g	4		
Habrophlebiodes sp.	83	scr	6		
Leptophlebia sp.	83	c-g	4		
Paraleptophlebia adoptiva	24	c-g	1		
Paraleptophlebia debilis	24	c-g	1		
Paraleptophlebia guttata	24	c-g	1		
Paraleptophlebia moerens	24	c-g	1		
Paraleptophlebia mollis	24	c-g	1	2	1
Paraleptophlebia volitans	24	c-g	1		
Paraleptophlebia sp.	83	c-g	1	2	3
Undetermined Leptophlebiidae	83	c-g	4		
Metretopodidae					
Siphloplecton sp.	4,2	c-g	2		
Undetermined Metretopodidae	4,2	c-g	2		
Ephemerellidae					
Attenella attenuata	2	c-g	1		
Attenella margarita	2	c-g	1		
Attenella sp.	2	c-g	1		
Dannella simplex	3	c-g	2		
Dannella sp.	3	c-g	2		
Drunella cornuta	4	c-g	0		
Drunella cornutella	4	scr	0	4	4
Drunella lata	4	scr	0		
Drunella tuberculata	4	scr	0		
Drunella walkeri	4	scr	0		
Drunella sp.	4	scr	0		
Ephemerella aurivillii	7	c-g	0		
Ephemerella dorothea	7	c-g	1		
Ephemerella excrucians?	7	c-g	1		
Ephemerella invaria	7	c-g	1		
Ephemerella needhami	7	c-g	1		
Ephemerella rotunda	7	c-g	1		
Ephemerella subvaria	7	c-g	1	4	1
Ephemerella sp.	7	c-g	1	4	4
Eurylophella funeralis	6,46	c-g	0		
Eurylophella temporalis	6,46	c-g	5		
Eurylophella verisimilis	6,46	c-g	2		
Eurylophella sp.	6	c-g	2		
Serratella deficiens	5	c-g	2	5	2
Serratella serrata	5	c-g	2	1	0
Serratella serratoides	5	c-g	2	0	1
Serratella sordida	5	c-g	2		
Serratella sp.	5	c-g	2	1	1
Undetermined Ephemerellidae	83	c-g	2	3	6

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Leptohyphidae					
Tricorythodes sp.	83	c-g	4	4	9
Undetermined Leptohyphidae	83	c-g	4		
Caenidae					
Brachycercus maculatus	83,23	c-g	3		
Brachycercus sp.	83,23	c-g	3		
Caenis amica	84	c-g	6		
Caenis anceps	84	c-g	6		
Caenis diminuta	84	c-g	6		
Caenis latipennis	84	c-g	6		
Caenis macafferti	84	c-g	6		
Caenis punctata	84	c-g	6		
Caenis sp.	83	c-g	6	3	3
Undetermined Caenidae	83	c-g	6		
Baetiscidae					
Baetisca sp.	83	c-g	4		
Undetermined Baetiscidae	83	c-g	4		
Potamanthidae					
Anthopotamus verticus	72,73	c-g	4		
Anthopotamus sp.	83,73	c-g	4	4	5
Undetermined Potamanthidae	83,73	c-g	4		
Ephemeridae					
Ephemera guttulata	83,72,24	c-g	2		
Ephemera sp.	83,72,24	c-g	2		
Hexagenia sp.	83	c-g	6		
Litobrancha recurvata	72	c-g	2		
Litobrancha sp.	83	c-g	2		
Undetermined Ephemeridae	83	c-g	2		
Polymitarcyidae					
Ephoron leukon?	83,24	c-g	2	1	1
Ephoron sp.	83,24	c-g	2		
Undetermined Polymitarcyidae	83,24	c-g	2		
ODONATA					
Gomphidae					
Gomphus sp.	83,122	prd	5		
Hagenius sp.	83,122	prd	1		
Lanthus parvulus		prd	5		
Lanthus vernalis		prd	5		
Lanthus sp.	83,122	prd	5		
Ophiogomphus carolus	83,122	prd	3		
Ophiogomphus sp.	83,122	prd	3	1	3
Stylogomphus albystilus	83,122	prd	1		
Stylogomphus sp.	83,122	prd	1		
Stylurus sp.	83,122	prd	4		
Undetermined Gomphidae	83,122	prd	4	2	0

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Aeshnidae					
Anax longipes	83,122	prd	5		
Anax sp.	83,122	prd	5		
Basiaeschna sp.	83,122	prd	6		
Boyeria vinosa	83,122	prd	2		
Boyeria sp.	83,122	prd	2		
Undetermined Aeshnidae	83,122	prd	5		
Cordulegastridae					
Cordulegaster maculata	83,122,	prd	3		
Cordulegaster sp.	83,122	prd	3		
Undetermined Cordulegastridae	83,122	prd	3		
Corduliidae					
Neurocordulia sp.	83,122	prd	2		
Undetermined Corduliidae	83,122	prd	2		
Libellulidae					
Erythemis sp.	83	prd	2		
Sympetrum janeae	83,122	prd	4		
Sympetrum sp.	83,122	prd	4		
Undetermined Libellulidae	83,122	prd	2		
Macromiidae					
Macromia sp.	83,122	prd	2		
Undetermined Macromiidae	83,122	prd	2		
Calopterygidae					
Calopteryx sp.	83,122	prd	6		
Hetaerina sp.	83,122	prd	6		
Undetermined Calopterygidae	83,122	prd	6		
Coenagrionidae					
Argia moesta	83,122	prd	6		
Argia sp.	83,122	prd	6		
Chromagrion sp.	83,122	prd	8		
Enallagma sp.	83,122	prd	8		
Ischnura sp.	83,122	prd	9		
Undetermined Coenagrionidae	83,122	prd	8		
Lestidae					
Lestes sp.	83,122	prd	6		
Undetermined Lestidae	83,122	prd	6		
HEMIPTERA					
Corixidae					
Hesperocorixa sp.	83	prd	5		
Undetermined Corixidae	83	prd	5		
Undetermined Hemiptera	83	prd	5		
PLECOPTERA					
Capniidae					
Allocapnia vivipara	52,114	shr	3		
Allocapnia sp.	52,114	shr	3		
Paracapnia sp.	114	shr	1		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Undetermined Capniidae	114	shr	3		
Leuctridae					
Leuctra ferruginea	53	shr	0		
Leuctra maria	53	shr	0		
Leuctra tenuis	53	shr	0		
Leuctra truncata	53	shr	0		
Leuctra sp.	83,114	shr	0		
Zealeuctra sp.	83,114	shr	0		
Undetermined Leuctridae	83,114	shr	0		
Nemouridae					
Amphinemura delosa	54	shr	3		
Amphinemura nigritta	54	shr	3		
Amphinemura wui	54	shr	3		
Amphinemura sp.	83,114	shr	3		
Nemoura sp.	83,114	shr	1		
Ostrocerca sp.	83,114	shr	2		
Prostoia sp.	83	shr	2		
Shipsa rotunda	114	shr	2		
Shipsa sp.	114	shr	2		
Soyedina sp.	83	c-g	2		
Undetermined Nemouridae	114	shr	2		
Taeniopterygidae					
Strophopteryx fasciata	114	shr	3		
Strophopteryx sp.	114	shr	3		
Taenionema atlanticum	114	shr	2		
Taenionema sp.	114	shr	2		
Taeniopteryx burksi	45	shr	2		
Taeniopteryx lonicera	45	shr	2		
Taeniopteryx nivalis	45	shr	2		
Taeniopteryx parvula	45	shr	2		
Taeniopteryx sp.	114	shr	2		
Undetermined Taeniopterygidae	114	shr	2		
Perlidae					
Acroneuria abnormis	55,114	prd	0	0	0
Acroneuria arenosa	55,114	prd	0		
Acroneuria carolinensis	55,114	prd	0		
Acroneuria lycorias	55,114	prd	0		
Acroneuria sp.	55,114	prd	0	0	0
Agnetina annulipes	112,114	prd	2		
Agnetina capitata	112,114	prd	2	3	6
Agnetina flavescens	112,114	prd	2		
Agnetina sp.	112,114	prd	2		
Claassenia sabulosa		prd	3		
Claassenia sp.		prd	3		
Eccoptura xanthenes	114	prd	3		
Eccoptura sp.	114	prd	3		
Neoperla sp.	83,114	prd	3	5	5
Paragnetina immarginata	55,114	prd	1	1	2

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Paragnetina media	55,114	prd	4	6	3
Paragnetina sp.	55,114	prd	2	1	6
Perlesta sp.	114	prd	4		
Undetermined Perlidae	114	prd	3	5	7
Peltoperlidae					
Tallaperla sp.	83,114	shr	0		
Undetermined Peltoperlidae	83,114	shr	0		
Chloroperlidae					
Alloperla sp.	83,114	c-g	0		
Haploperla brevis	114	prd	1		
Haploperla sp.	114	prd	1		
Rasvena terna	114	c-g	0		
Rasvena sp.	114	c-g	0		
Suwallia marginata	114,1	prd	0		
Sweltsa sp.	83,114	prd	0		
Undetermined Chloroperlidae	83,114	prd	0		
Perlodidae					
Cultus decisus	114	prd	2		
Cultus sp.	114	prd	2		
Diura sp.	113	prd	2		
Helopicus subvarians	114,86	prd	2		
Helopicus sp.	114,86	prd	2		
Isogenoides hansoni	114,86	prd	0		
Isogenoides sp.	114,86	prd	0		
Isoperla frisoni	55	prd	2		
Isoperla holochlora	55	prd	2		
Isoperla marlynia	55	prd	2		
Isoperla namata	55	prd	2		
Isoperla nana	55	prd	2		
Isoperla transmarina	55	prd	2		
Isoperla sp.	114,113	prd	2		
Malirekus iroquois	114,86	prd	2		
Malirekus sp.	83	prd	2		
Remenus sp.	83, 86	prd	2		
Undetermined Perlodidae	83,114	prd	2		
Pteronarcidae					
Pteronarcys biloba	30	shr	0		
Pteronarcys comstocki	30	shr	2		
Pteronarcys dorsata	30	shr	0		
Pteronarcys proteus	30	shr	0		
Pteronarcys sp.	83,114	shr	0		
Undetermined Pteronarcidae	83,114	shr	0		
Undetermined Plecoptera	83		2		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
COLEOPTERA					
Haliplidae					
Haliplus sp.	83,123	shr	5		
Peltodytes sp.	83,123	shr	5		
Undetermined Haliplidae	83,123	shr	5		
Dytiscidae					
Agabetes sp.	83,123	prd	5		
Agabus sp.	83,123	prd	5		
Celina sp.	83,123	prd	5		
Hydroporous sp.	83,123	prd	5		
Laccophilus sp.	83,123	prd	5		
Undetermined Dytiscidae	83,123	prd	5		
Gyrinidae					
Dineutus sp.	83,123	prd	4		
Gyrinus sp.	83,123	prd	4		
Undetermined Gyrinidae	83,123	prd	4		
Hydrophilidae					
Anacaena sp.	83, 123	c-g	5		
Berosus sp.	83,123	c-g	5		
Crenitis sp.	83,123	c-g	5		
Helochares sp.	83,123	prd	5		
Helophorus sp.	83,123	shr	5		
Hydrobius sp.	83,123	prd	5		
Hydrochara sp.	83,123	prd	5		
Hydrochus sp.	83,123	shr	5		
Laccobius sp.	83,123	prd	5		
Undetermined Hydrophilidae	83,123	prd	5		
Hydraenidae					
Hydraena sp.	83,123	prd	5		
Undetermined Hydraenidae	83, 123	prd	5		
Noteridae					
Hydrocanthus sp.	83	prd	5		
Undetermined Noteridae	83	prd	5		
Psephenidae					
Ectopria nervosa	83,19	scr	5	10	9
Ectopria sp.	83,19	scr	5		
Psephenus herricki	19	scr	4	10	9
Psephenus sp.	83,19	scr	4	3	4
Undetermined Psephenidae	83,19	scr	4		
Ptilodactylidae					
Anchytarsus bicolor	19	shr	3		
Undetermined Ptilodactylidae	19	shr	3		
Dryopidae					
Helichus sp.	83,19	scr	5		
Undetermined Dryopidae	83	scr	5		
Scirtidae					
Undetermined Scirtidae	83	scr	5		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Elmidae					
Ancyronyx variegatus	19	c-g	5		
Ancyronyx sp.	19	c-g	5		
Dubiraphia bivittata	19	c-g	6		
Dubiraphia quadrinotata	19	c-g	5		
Dubiraphia vittata	19	c-g	6		
Dubiraphia sp.	83,19	c-g	6		
Macronychus glabratus	19	c-g	5		
Macronychus sp.	19	c-g	5		
Microcylloepus pusillus	19	scr	3		
Microcylloepus sp.	19	scr	3		
Optioservus cryophilus	19	scr	4		
Optioservus fastiditus	19	scr	4	6	7
Optioservus immunis	19	scr	4		
Optioservus ovalis	19	scr	4	9	4
Optioservus nr. *sandersoni*	19	scr	4		
Optioservus trivittatus	19	scr	4	7	6
Optioservus sp.	83,19	scr	4	7	8
Oulimnius latiusculus	19	scr	4		
Oulimnius nitidulus	19	scr	4		
Oulimnius sp.	19	scr	4		
Promoresia elegans	19	scr	2	10	10
Promoresia tardella	19	scr	2		
Promoresia sp.	83,19	scr	2		
Stenelmis bicarinata	19,104	scr	5		
Stenelmis cheryl	20	scr	5		
Stenelmis concinna	19	scr	5	5	0
Stenelmis crenata	19	scr	5	7	7
Stenelmis mera	19	scr	5		
Stenelmis musgravei	19	scr	5		
Stenelmis sandersoni	19	scr	5		
Stenelmis vittapennis	19	scr	5		
Stenelmis sp.	83,19	scr	5	7	7
Undetermined Elmidae	83,19	scr	5		
Curculionidae					
Undetermined Curculionidae	83	shr	5		
COLLEMBOLA					
Isotomidae					
Isotomurus sp.	83	c-g	5		
Undetermined Isotomidae	83	c-g	5		
Undetermined Collembola	83	c-g	5		
MEGALOPTERA					
Corydalidae					
Chauliodes sp.	83,37	prd	4		
Corydalus cornutus	83,37	prd	4	2	2
Corydalus sp.	83,37	prd	4		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Nigronia serricornis	83,76	prd	4	10	8
Undetermined Corydalidae	83,76	prd	4		
Sialidae					
Sialis sp.	83,37	prd	4	5	6
Undetermined Sialidae	83,37	prd	4		
NEUROPTERA					
Sisyridae					
Climacia areolaris	37	prd	5		
Climacia sp.	37	prd	5		
Undetermined Sisyridae	37	prd	5		
TRICHOPTERA					
Calamoceratidae					
Heteroplectron americanum	83,125	shr	3		
Heteroplectron sp.	83,125	shr	3		
Undetermined Calamoceratidae	83,125	shr	3		
Philopotamidae					
Chimarra aterrima?	125,98	c-f	4	2	3
Chimarra obscura	125,98	c-f	4	6	4
Chimarra socia	125,98	c-f	2	4	1
Chimarra sp.	125	c-f	4	2	0
Dolophilodes sp.	125	c-f	0	4	3
Wormaldia sp.	125	c-f	2		
Undetermined Philopotamidae	125	c-f	4		
Psychomyiidae					
Lype diversa	125	scr	2		
Lype sp.	125	scr	2		
Psychomyia flavida	125,41	c-g	2	1	0
Psychomyia sp.	125,41	c-g	2		
Undetermined Psychomyiidae	125	c-g	2		
Polycentropodidae					
Cyrnellus fraternus	125	c-f	8		
Cyrnellus sp.	125	c-f	8		
Neureclipsis bimaculata	125	c-f	7		
Neureclipsis sp.	125	c-f	7	3	1
Nyctiophylax celta	125,98	prd	5		
Nyctiophylax moestus	125,98	prd	5		
Nyctiophylax sp.	125,98	prd	5		
Polycentropus remotus	125,98	prd	6		
Polycentropus sp.	125	prd	6	4	2
Undetermined Polycentropodidae	125	prd	6		
Dipseudopsidae					
Phylocentropus sp.	125	c-f	5		
Undetermined Dipseudopsidae	125	c-f	5		
Hydropsychidae					
Arctopsyche sp.	125,83	c-f	1		
Cheumatopsyche sp.	125,83	c-f	5	6	6

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Diplectrona sp.	125,83	c-f	5		
Homoplectra sp.	125	c-f	4		
Hydropsyche betteni	105	c-f	7	7	9
Hydropsyche bidens	98, 105	c-f	3		
Hydropsyche bronta	103,105	c-f	6	7	6
Hydropsyche nr. *depravata*	105	c-f	6		
Hydropsyche dicantha	105	c-f	2		
Hydropsyche leonardi	105	c-f	0		
Hydropsyche morosa	103,105	c-f	6	5	1
Hydropsyche orris	105	c-f	5		
Hydropsyche phalerata	105	c-f	1		
Hydropsyche recurvata	105	c-f	4		
Hydropsyche scalaris	105	c-f	2	3	3
Hydropsyche separata	105	c-f	4		
Hydropsyche slossonae	103	c-f	4	6	10
Hydropsyche sparna	103	c-f	6	6	7
Hydropsyche valanis	105	c-f	6		
Hydropsyche ventura		c-f	5		
Hydropsyche venularis	105	c-f	4		
Hydropsyche walkeri	103	c-f	4		
Hydropsyche sp.	125	c-f	4	5	4
Macrostemum carolina	125,98	c-f	3	7	2
Macrostemum zebratum	125,98	c-f	3		
Macrostemum sp.	125	c-f	3	4	2
Parapsyche apicalis		c-f	0		
Parapsyche sp.	125	c-f	0		
Potamyia sp.	125	c-f	5		
Undetermined Hydropsychidae	125	c-f	5		
Rhyacophilidae					
Rhyacophila acropedes	40	prd	1		
Rhyacophila acutiloba		prd	1		
Rhyacophila brunnea		prd	1		
Rhyacophila carolina?	40	prd	1		
Rhyacophila carpenteri?	40	prd	1		
Rhyacophila formosa	121	prd	1		
Rhyacophila fuscula	40	prd	0	2	5
Rhyacophila glaberrima	40	prd	1		
Rhyacophila mainensis	40	prd	1		
Rhyacophila manistee	40	prd	1		
Rhyacophila minora		prd	0		
Rhyacophila nigrita	40	prd	1		
Rhyacophila torva	40	prd	1		
Rhyacophila sp.	125	prd	1	0	1
Undetermined Rhyacophilidae	125	prd	1		
Glossosomatidae					
Agapetus sp.	125	scr	0		
Culoptila sp.	125	scr	1		
Glossosoma sp.	125	scr	0	6	0

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Protoptila sp.	125	scr	1		
Undetermined Glossosomatidae	125	scr	1		
Hydroptilidae					
Agraylea sp.	125	c-g	8		
Alisotrichia sp.	125	scr	6		
Hydroptila ajax	98	scr	6		
Hydroptila nr. *albicornis*	98	scr	6		
Hydroptila nr. *armata*	98	scr	6		
Hydroptila consimilis	98	scr	6	9	10
Hydroptila nr. *hamata*	98	scr	6		
Hydroptila spatulata	98	scr	6	9	8
Hydroptila nr. *waubesiana*	98	scr	6		
Hydroptila sp.	125	scr	6	6	6
Ithytrichia sp.	125	scr	4		
Leucotrichia sp.	125	scr	6	6	2
Mayatrichia ayama	125,98	scr	6		
Mayatrichia sp.	125,98	scr	6		
Neotrichia sp.	125	scr	2		
Orthotrichia sp.	125	shr	6		
Oxyethira sp.	125	c-g	3		
Palaeagapetus celsus	125	shr	4		
Palaeagapetus sp.	125	shr	1		
Undetermined Hydroptilidae	125	scr	6	5	2
Phryganeidae					
Oligostomis sp.	125	prd	2		
Phryganea sp.	125	shr	4		
Ptilostomis sp.	125	shr	5		
Undetermined Phryganeidae	125	shr	4		
Brachycentridae					
Adicrophleps hitchcocki	125	shr	2		
Adicrophleps sp.	125	shr	2		
Brachycentrus americanus	42	c-f	1		
Brachycentrus appalachia	42	c-f	0	3	4
Brachycentrus incanus	42	c-f	0		
Brachycentrus lateralis	42	c-f	1		
Brachycentrus nigrosoma	42	c-f	1		
Brachycentrus numerosus	42	c-f	1		
Brachycentrus solomoni	42	c-f	1		
Brachycentrus sp.	42	c-f	1		
Micrasema sp.	125,42	shr	2	1	0
Undetermined Brachycentridae	125,42	shr	2		
Goeridae					
Goera sp.	125	scr	3		
Undetermined Goeridae	125	scr	3		
Apataniidae					
Apatania sp.	125	scr	3	3	4
Undetermined Apataniidae	125	scr	3		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Uenoidae					
Neophylax concinnus	39	scr	3		
Neophylax fuscus	39	scr	3		
Neophylax oligius	125	scr	3		
Neophylax sp.	125	scr	3		
Undetermined Uenoidae	39	scr	3		
Limnephilidae					
Hesperophylax designatus	125	shr	3		
Hesperophylax sp.	125	shr	3		
Hydatophylax sp.	125	shr	2		
Limnephilus sp.	125	shr	3		
Nemotaulius hostilis	125	scr	3		
Nemotaulius sp.	125	scr	3		
Platycentropus sp.	125	shr	4		
Pseudostenophylax sp.	125	shr	0		
Psychoglypha sp.	125	c-g	0		
Pycnopsyche sp.	125	shr	4		
Undetermined Limnephilidae	125	shr	4	3	4
Lepidostomatidae					
Lepidostoma sp.	125	shr	1	2	0
Undetermined Lepidostomatidae	125	shr	1		
Odontoceridae					
Psilotreta labida	125	scr	0		
Psilotreta sp.	125	scr	0		
Undetermined Odontoceridae	83	scr	0		
Molannidae					
Molanna sp.	125	scr	6		
Undetermined Molannidae	125	scr	6		
Helicopsychidae					
Helicopsyche borealis	125,83	scr	3	1	2
Helicopsyche sp.	125,83	scr	3		
Undetermined Helicopsychidae	125,83	scr	3		
Leptoceridae					
Ceraclea alces	85	c-g	3		
Ceraclea punctata	85	c-g	3		
Ceraclea sp.	125	c-g	3		
Leptocerus americanus	125	shr	4		
Leptocerus sp.	125	shr	4		
Mystacides alafimbriata	129	c-g	4		
Mystacides sepulchralis	129	c-g	4		
Mystacides sp.	129	c-g	4		
Nectopsyche sp.	125,50	shr	3		
Oecetis avara	44	prd	5		
Oecetis cinerascens	44	prd	5		
Oecetis inconspicua	44	prd	5		
Oecetis sp.	125	prd	5		
Setodes sp.	125	c-g	2		
Triaenodes sp.	125,47	shr	6		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Undetermined Leptoceridae	125	prd	4		
Undetermined Trichoptera	83, 125		3		
LEPIDOPTERA					
Arctiidae					
Estigmene sp.	66	shr	5		
Undetermined Arctiidae	66	shr	5		
Nepticulidae					
Undetermined Nepticulidae	66	shr	5		
Pyralidae					
Acentria sp.	83,66	shr	5		
Nymphula sp.	83,66	shr	7		
Parapoynx sp.	83,66	shr	5		
Petrophila sp.	83,66	scr	5	5	3
Undetermined Pyralidae	83,66	scr	5		
Undetermined Lepidoptera	83,66	shr	5		
DIPTERA					
Tanyderidae					
Protoplasa sp.	83	c-g	3		
Undetermined Tanyderidae	83	c-g	3		
Tipulidae					
Antocha sp.	83,25	c-g	3	8	6
Dicranota sp.	83,25	prd	3	5	10
Helius sp.	83,25	c-g	4		
Hexatoma sp.	83,25	prd	2	0	1
Hesperoconopa sp.	25	c-g	2		
Limnophila sp.	83	prd	3		
Limonia sp.	83,25	shr	6		
Molophilus sp.	83	shr	4		
Ormosia sp.	83	c-g	4		
Pedicia sp.	83	prd	4		
Pilaria sp.	25	prd	7		
Pseudolimnophila sp.	83,25	prd	2		
Tipula sp.	83,25	shr	6	10	10
Ulomorpha sp.	25	prd	4		
Undetermined Tipulidae	83,25	shr	4		
Psychodidae					
Pericoma sp.	83,117	c-g	4		
Psychoda sp.	117,127	c-g	10		
Undetermined Psychodidae	83,117	c-g	10		
Ptychopteridae					
Bittacomorpha sp.	83	c-g	9		
Ptychoptera sp.	83	c-g	9		
Undetermined Ptychopteridae	83	c-g	9		
Blephariceridae					
Undetermined Blephariceridae	83,117	scr	0		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Dixidae					
Dixa sp.	83,127	c-f	1		
Undetermined Dixidae	83,127	c-f	1		
Chaoboridae					
Chaoborus sp.	83	prd	8		
Undetermined Chaoboridae	83	prd	8		
Culicidae					
Anopheles sp.	83	c-f	8		
Undetermined Culicidae	83	c-f	8		
Ceratopogonidae					
Atrichopogon sp.	83	prd	6		
Bezzia sp.	83	prd	6		
Culicoides? sp.	83	prd	10		
Forcipomyia sp.	83	scr	6		
Probezzia sp.	83	prd	6		
Sphaeromais sp.	83	prd	6		
Undetermined Ceratopogonidae	83	prd	6	8	9
Simuliidae					
Cnephia mutata	115	c-f	2		
Cnephia sp.	115	c-f	2		
Prosimulium arvum	130	c-f	2		
Prosimulium clandestinum	130	c-f	2		
Prosimulium fuscum	130	c-f	2		
Prosimulium magnum	115,128	c-f	1		
Prosimulium rhizophorum	115,128	c-f	2		
Prosimulium sp.	115,128	c-f	2		
Simulium aureum	115,128	c-f	7		
Simulium decorum	115,128	c-f	7		
Simulium fibrinflatum	115,128	c-f	6		
Simulium gouldingi	115,128	c-f	3		
Simulium jenningsi	115,128	c-f	4	6	2
Simulium latipes	115,128	c-f	4		
Simulium parnassum	115,128	c-f	7		
Simulium pictipes	115	c-f	4		
Simulium rugglesi	115,128	c-f	5		
Simulium tuberosum	115,128	c-f	4	1	0
Simulium venustum	115,128	c-f	5		
Simulium vittatum	115,128	c-f	7	7	10
Simulium sp.	115,128	c-f	5	7	6
Stegopterna sp.	115,128	c-f	1		
Undetermined Simuliidae	115,128	c-f	5		
Tabanidae					
Chrysops sp.	83,117	c-g	5		
Hybomitra sp.	83	prd	5		
Tabanus sp.	83	prd	5		
Undetermined Tabanidae	83,117	prd	5		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Athericidae					
Atherix sp.	117	prd	4	8	5
Undetermined Athericidae	117	prd	4		
Stratiomyidae					
Euparyphus sp.	83,59	c-g	7		
Nemotelus sp.	83, 59	c-g	7		
Stratiomys sp.	83	c-g	7		
Undetermined Stratiomyidae	83	c-g	7		
Empididae					
Chelifera sp.	83,117	prd	6		
Clinocera sp.	83,117	prd	6		
Hemerodromia sp.	83,117	prd	6	5	6
Neoplasta sp.	83	prd	6		
Oreogeton sp.	83	prd	6		
Wiedemannia sp.	83,117	prd	6		
Undetermined Empididae	83	prd	6		
Dolichopodidae					
Undetermined Dolichopodidae	83,117	prd	4		
Syrphidae					
Eristalis sp.	83	c-g	10		
Undetermined Syrphidae	83	c-g	10		
Ephydridae					
Dimecoenia spinosa	71	shr	6		
Ephydra sp.	117	shr	8		
Hydrellia sp.	127	shr	6		
Undetermined Ephydridae	117	shr	7		
Muscidae					
Undetermined Muscidae	83,117	prd	6		
Anthomyiidae					
Undetermined Anthomyiidae	117	prd	6		
Scathophagidae					
Undetermined Scathophagidae	83	shr	6		
Nymphomyiidae					
Nymphomyia sp.	83	c-g	5		
Undetermined Nymphomyiidae	83	c-g	5		
Undetermined Diptera			6		
Chironomidae					
Ablabesmyia annulata	95	prd	8		
Ablabesmyia idei	95	prd	8		
Ablabesmyia illinoensis	36	prd	8		
Ablabesmyia janta	95	prd	8		
Ablabesmyia mallochi	95	prd	8		
Ablabesmyia monilis	95	prd	8		
Ablabesmyia peleensis	95	prd	8		
Ablabesmyia philosphagnos	95	prd	8		
Ablabesmyia rhamphe	36	prd	8		
Ablabesmyia simpsoni	95	prd	8		
Ablabesmyia sp.	95	prd	8		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Alotanypus aris	36	prd	9		
Alotanypus sp.	36	prd	9		
Apsectrotanypus johnsoni	92,36	prd	7		
Clinotanypus pinguis	14	prd	8		
Clinotanypus sp.	14	prd	8		
Coelotanypus scapularis	91,90	prd	4		
Coelotanypus sp.	91,90	prd	4		
Conchapelopia aleta	94	prd	6		
Conchapelopia americana	94	prd	6		
Conchapelopia dusena	94	prd	6		
Conchapelopia goniodes	94	prd	6		
Conchapelopia rurika	94	prd	6		
Conchapelopia telema	94	prd	6		
Conchapelopia sp.	94	prd	6		
Guttipelopia guttipennis	12	prd	5		
Guttipelopia sp.	12	prd	5		
Hayesomyia senata	94,75	prd	6		
Hayesomyia sp.	94,75	prd	6		
Helopelopia cornuticaudata	94,124	prd	6		
Helopelopia sp.	94,124	prd	6		
Hudsonimyia karelena	28	prd	2		
Hudsonimyia parrishi	28	prd	2		
Hudsonimyia sp.	28	prd	2		
Krenopelopia sp.	83	prd	4		
Labrundinia pilosella	97	prd	7		
Labrundinia nr. *virescens*	97	prd	7		
Labrundinia sp.	97	prd	7		
Larsia canadensis	11,65	prd	6		
Larsia sp.	11,65	prd	6		
Macropelopia decedens	92	prd	9		
Macropelopia sp.	92	prd	9		
Meropelopia americana	94,36	prd	6		
Meropelopia flavifrons	94,36	prd	6		
Meropelopia sp.	94,36	prd	6		
Natarsia baltimorea	92,36	prd	8		
Natarsia sp.	92	prd	8		
Nilotanypus fimbriatus	96	prd	8		
Nilotanypus sp.	96	prd	6		
Paramerina sp.	83	prd	6		
Pentaneura inconspicua	90,36	prd	6		
Pentaneura sp.	83	prd	6	0	1
Procladius bellus	93	prd	9		
Procladius sublettei	93	prd	9		
Procladius sp.	93	prd	9		
Psectrotanypus dyari	92	prd	10		
Psectrotanypus sp.	92	prd	10		
Rheopelopia acra gr.	94,36	prd	4		
Rheopelopia sp.	94	prd	4		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Tanypus neopunctipennis	89	prd	10		
Tanypus punctipennis	89	prd	10		
Tanypus stellatus	89	prd	10		
Tanypus sp.	89	prd	10		
Telopelopia okoboji	94	prd	8		
Telopelopia sp.	94	prd	8		
Thienemannimyia gr. spp.	94	prd	6	8	8
Thienemannimyia norena	94	prd	6		
Thienemannimyia sp.	94	prd	6		
Trissopelopia ogemawi	91	prd	4		
Trissopelopia sp.	91	prd	4		
Zavrelimyia sinuosa	90	prd	8		
Zavrelimyia sp.	83	prd	8		
Undetermined Tanypodinae	83	prd	7		
Paraboreochlus sp.	124	c-g	1		
Diamesa sp.	124	c-g	5	10	10
Pagastia orthogonia	79,36	c-g	1	4	8
Potthastia gaedii gr.	124,36	c-g	2	9	10
Potthastia longimana gr.	105,36	c-g	2		
Potthastia sp.	36	c-g	2		
Pseudokiefferiella sp.	124	c-g	1		
Sympotthastia sp.	124	c-g	2		
Undetermined Diamesinae	124	c-g	2		
Monodiamesa sp.	36	c-g	7		
Odontomesa fulva	83,36	c-g	5		
Odontomesa sp.	83,36	c-g	5		
Prodiamesa olivacea	124	c-g	8		
Prodiamesa sp.	83	c-g	8		
Undetermined Prodiamesinae	83	c-g	8		
Acricotopus nitidellus	124,36	c-g	10		
Acricotopus sp.	124,36	c-g	10		
Brillia flavifrons	80	shr	5		
Brillia parva	80	shr	5		
Brillia sera	80	shr	5		
Brillia sp.	80	shr	5		
Camptocladius sp.	36	c-g	8		
Cardiocladius albiplumus	77	prd	5		
Cardiocladius obscurus	106,83	prd	5	8	6
Cardiocladius sp.	106	prd	5		
Chaetocladius vitellinus gr.	124	c-g	6		
Chaetocladius sp.	124	c-g	6		
Corynoneura nr. *celeripes*	106	c-g	4		
Corynoneura lobata	106,36	c-g	4		
Corynoneura sp.	124,83	c-g	4		
Cricotopus absurdus	106,36	shr	5		
Cricotopus annulator gr.	107	shr	7		
Cricotopus bicinctus	106,107	scr	7	7	6
Cricotopus nr. *cylindraceus*	107	shr	7		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Cricotopus elegans	107	shr	7		
Cricotopus festivellus gr.	107	c-g	7		
Cricotopus fugax	107	shr	7		
Cricotopus intersectus gr.	106,107	shr	7		
Cricotopus nostocicola	124	shr	7		
Cricotopus nr. *patens*	36	shr	7		
Cricotopus sylvestris gr.	106,107	scr	7		
Cricotopus tremulus gr.	106,107	shr	7	8	9
Cricotopus triannulatus	107	shr	7		
Cricotopus trifascia gr.	106,107	shr	6	9	9
Cricotopus vierriensis	107	shr	7	6	5
Cricotopus sp. "*ozarks*"	106	shr	7		
Cricotopus/Orthocladius Complex	83, 36	c-g	6		
Cricotopus sp.	106	shr	7		
Diplocladius cultriger	124,36	c-g	8		
Diplocladius sp.	124,36	c-g	8		
Epoicocladius sp.	124,83	c-g	4		
Eukiefferiella brehmi gr.	13	c-g	4		
Eukiefferiella brevicalcar gr.	13	c-g	4		
Eukiefferiella claripennis gr.	13	c-g	8		
Eukiefferiella coerulescens gr.	13	c-g	4		
Eukiefferiella devonica gr.	13	c-g	4	9	9
Eukiefferiella gracei gr.	13	c-g	4		
Eukiefferiella pseudomontana gr.	13	c-g	8		
Eukiefferiella similis gr.	13	c-g	6		
Eukiefferiella sp.	83	c-g	5		
Gymnometriocnemus sp.	124,83	c-g	4		
Heleniella sp.		prd	6		
Heterotrissocladius marcidus gr.	106,36	c-g	4		
Heterotrissocladius sp.	106,36	c-g	4		
Hydrobaenus pilipes	99	c-g	8		
Hydrobaenus sp.	99	c-g	8		
Krenosmittia sp.	124,83	c-g	1		
Limnophyes sp.	124,83	c-g	8		
Lopescladius sp.	124,83	c-g	4		
Nanocladius (*Plecopt.*) *branchicolus*	36,33	prd	3		
Nanocladius (*Plecopteracoluthus*) *downesi*	36	prd	3		
Nanocladius (*Plecopteracoluthus*) sp. 5	124	c-g	7		
Nanocladius (*Plecopteracoluthus*) sp.	124	prd	3		
Nanocladius alternantherae?	100	c-g	7		
Nanocladius nr. *balticus*	100	c-g	7		
Nanocladius crassicornus	100	c-g	7		
Nanocladius distinctus	100	c-g	7		
Nanocladius minimus	100	c-g	7		
Nanocladius rectinervis	100	c-g	7		
Nanocladius spiniplenus	100	c-g	6		
Nanocladius sp.	100	c-g	7		
Orthocladius (*Eudactylocladius*) sp.	109	c-g	6		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Orthocladius (*Euorthoclad.*) *luteipes*	109,110	c-g	6		
Orthocladius (*Euorthoclad.*) *rivicola*	109,110	c-g	6		
Orthocladius (*Euorthoclad.*) *rivulorum*	109,110	c-g	6		
Orthocladius (*Euorthoclad.*) sp.	109,110	c-g	6		
Orthocladius annectens	109	c-g	6		
Orthocladius carlatus	109	c-g	6		
Orthocladius curtiseta	109	c-g	6		
Orthocladius nr. *dentifer*	109	c-g	6	3	7
Orthocladius dorenus	36	c-g	7		
Orthocladius dubitatus	36	c-g	6		
Orthocladius obumbratus	109	c-g	6		
Orthocladius oliverei	109	c-g	6		
Orthocladius nr. *robacki*	109	c-g	6		
Orthocladius trigonolabis	109	c-g	6		
Orthocladius (*Symposiocladius*) *lignicola*	124	c-g	5		
Orthocladius vaillanti	36	c-g	6		
Orthocladius sp.	124,83	c-g	6		
Parachaetocladius sp.	124,83	c-g	2		
Paracricotopus sp.	124,83	c-g	4		
Parakiefferiella nr. *triquetra*	36	c-g	4		
Parakiefferiella sp.	124,83	c-g	4		
Paralimnophyes sp.	83	c-g	7		
Parametriocnemus lundbecki	106	c-g	5	8	10
Parametriocnemus sp.	106	c-g	5		
Paraphaenocladius sp.	124,83	c-g	4		
Paratrichocladius sp.	124,83	shr	5		
Parorthocladius sp.	83	c-g	6		
Psectrocladius dilatatus gr.	124	c-g	8		
Psectrocladius nigrus	124	c-g	8		
Psectrocladius psilopterus gr.	124	c-g	8		
Psectrocladius sordidellus gr.	124	c-g	8		
Psectrocladius vernalis	124	c-g	8		
Psectrocladius sp.	124	c-g	8		
Pseudorthocladius sp.	124,83	c-g	0		
Psilometriocnemus triannulatus	124,36	c-g	4		
Psilometriocnemus sp.	124,36	c-g	4		
Rheocricotopus robacki	106	c-g	5	4	4
Rheocricotopus tuberculatus	26	c-g	6		
Rheocricotopus sp.	124	c-g	6		
Smittia sp.	83	c-g	6		
Stilocladius sp.	124	c-g	3		
Symbiocladius equitans	124	prd	2		
Symbiocladius sp.	124	prd	2		
Synorthocladius nr. *semivirens*	106	c-g	6	6	9
Synorthocladius sp.	106	c-g	6		
Thienemanniella lobapodema	106,36	c-g	6		
Thienemanniella xena	106,36	c-g	6		
Thienemanniella sp.	124,83	c-g	6		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Trissocladius sp.	124,83	c-g	5		
Tvetenia bavarica gr.	13	c-g	4	9	10
Tvetenia vitracies	13,70	c-g	5	7	6
Tvetenia sp.	13	c-g	5		
Unniella multivirga	27	c-g	4		
Unniella sp.	27	c-g	4		
Xylotopus par	83,124	shr	5		
Xylotopus sp.	83,124	shr	5		
Zalutschia zalutschicola	99	shr	4		
Zalutschia sp.	99	shr	4		
Orthocladiinae sp. C	36	c-g	5		
Undetermined Orthocladiinae	124	c-g	5		
Axarus festivus gr.	88,124	c-g	6		
Axarus sp.	88,124	c-g	6		
Chironomus decorus gr.	81	c-g	10		
Chironomus riparius gr.	81	c-g	10		
Chironomus sp.	81	c-g	10		
Cladopelma sp.	124	c-g	9	9	6
Cryptochironomus fulvus gr.	32	prd	8	5	6
Cryptochironomus ponderosus	32	prd	8		
Cryptochironomus sp.	32	prd	8		
Cryptotendipes casuarius	118	c-g	6		
Cryptotendipes emorsus	118	c-g	6		
Cryptotendipes pseudotener	118	c-g	6		
Cryptotendipes sp.	124	c-g	6		
Demicryptochironomus cuneatus	124	c-g	8		
Demicryptochironomus sp.	124	c-g	8		
Dicrotendipes fumidus	35	c-g	8		
Dicrotendipes lucifer	35	c-g	8		
Dicrotendipes modestus	35	c-g	8		
Dicrotendipes neomodestus	35	c-g	8	10	4
Dicrotendipes nervosus	35	c-g	8		
Dicrotendipes simpsoni	35	c-g	8		
Dicrotendipes sp.	35	c-g	8		
Einfeldia natchitocheae	124,36	c-g	9		
Einfeldia sp.	124	c-g	9		
Endochironomus nigricans	49,106	shr	10		
Endochironomus subtendens	49,106	shr	10		
Endochironomus sp.	124	shr	10		
Glyptotendipes dreisbachi	10	shr	10		
Glyptotendipes lobiferus	106	shr	10		
Glyptotendipes sp.	124	shr	10		
Goeldichironomus sp.	124	c-g	8		
Harnischia curtilamellata	106	c-g	8		
Harnischia sp.	106	c-g	8		
Hyporhygma sp.	36	shr	7		
Lauterborniella agrayloides	124	c-g	8		
Lauterborniella sp.	124	c-g	8		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Microchironomus sp.	124	c-g	8		
Microtendipes pedellus gr.	124	c-f	6	7	7
Microtendipes rydalensis gr.	124	c-f	4	2	1
Microtendipes sp.	124	c-f	5		
Nilothauma babiyi	106	c-g	6		
Nilothauma sp.	106	c-g	6		
Pagastiella sp.	83	c-g	7		
Parachironomus abortivus	106	prd	10		
Parachironomus carinatus	106	prd	10		
Parachironomus frequens	106	prd	10		
Parachironomus hirtalatus	106	prd	10		
Parachironomus potamogeton	106	prd	10		
Parachironomus sp.	106	prd	10		
Paracladopelma nais	58	c-g	7		
Paracladopelma nereis	58	c-g	7		
Paracladopelma sp.	58	c-g	7		
Paralauterborniella nigrohalteralis	8	c-g	8		
Paralauterborniella sp.	124	c-g	8		
Paratendipes albimanus	106	c-g	6		
Paratendipes sp.	106	c-g	6		
Phaenopsectra dyari?	106	scr	7	4	5
Phaenopsectra flavipes	106	scr	7		
Phaenopsectra obdiens gr.	106	scr	7		
Phaenopsectra punctipes gr.	106	scr	7		
Phaenopsectra sp.	124	scr	7		
Polypedilum aviceps	69	shr	4	5	7
Polypedilum digitifer	69,111	shr	8		
Polypedilum fallax gr.	69	shr	6		
Polypedilum flavum	69	shr	6	9	7
Polypedilum griseopunctatum	111	shr	6		
Polypedilum halterale gr.	69,36	shr	6		
Polypedilum illinoense	69	shr	7	10	7
Polypedilum laetum	69	shr	6	7	6
Polypedilum obtusum	69	shr	6		
Polypedilum ontario	69	shr	3		
Polypedilum scalaenum gr.	69	shr	6	10	6
Polypedilum simulans gr.	69	shr	6		
Polypedilum sordens	69	shr	6		
Polypedilum trigonum	36	shr	7		
Polypedilum tritum	69	shr	7		
Polypedilum tuberculum	69	shr	6		
Polypedilum (Tripodura) sp.	69	shr	6		
Polypedilum sp.	69	shr	6		
Pseudochironomus sp.	100	c-g	5		
Robackia claviger	100	c-g	4		
Robackia demeijerei	100	c-g	4		
Robackia sp.	100	c-g	4		
Saetheria tylus	58,124	c-g	4		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Saetheria sp.	58	c-g	4		
Sergentia? sp.	49	c-g	5		
Stelechomyia perpulchra	124,36	c-g	7		
Stelechomyia sp.	124,36	c-g	7		
Stenochironomus hilaris	15	c-g	5		
Stenochironomus macateei	15	c-g	5		
Stenochironomus poecilopterus	15	c-g	5		
Stenochironomus sp.	15	c-g	5	4	3
Stictochironomus sp.	124	c-g	9		
Tribelos atrum	49	c-g	7		
Tribelos fuscicorne	49	c-g	7		
Tribelos jucundum	49	c-g	7		
Tribelos sp.	49	c-g	7		
Tribelos/*Endochironomus*/*Phaenopsectra* Co	124	c-g	8		
Xenochironomus xenolabis	88	prd	4		
Xenochironomus sp.	88	prd	4		
Undetermined Chironomini	124	c-g	6		
Cladotanytarsus daviesi	87	c-f	5		
Cladotanytarsus nr. *dispersopilosus*	87	c-f	5		
Cladotanytarsus nr. *mancus*	87	c-f	5		
Cladotanytarsus sp.	87	c-f	5	6	4
Constempellina sp.	124	c-g	4		
Micropsectra aristata gr.	102	c-f	5		
Micropsectra deflecta	87	c-f	4		
Micropsectra dives gr.	78	c-f	4	6	9
Micropsectra notescens gr.	101	c-f	7		
Micropsectra polita	78	c-f	7	0	7
Micropsectra nr. sp. B	36	c-f	4		
Micropsectra/Tanytarsus Complex	36, 78, 87	c-f	6		
Micropsectra sp.	83	c-f	7	3	1
Neostempellina reissi	21	c-g	2		
Neostempellina sp.	21	c-g	2		
Paratanytarsus confusus	87	c-f	6	5	8
Paratanytarsus dimorphis	87	c-f	6		
Paratanytarsus sp.	87	c-f	6		
Rheotanytarsus exiguus gr.	106	c-f	6	6	5
Rheotanytarsus pellucidus	106,36	c-f	4	3	2
Rheotanytarsus sp.	106	c-f	6		
Stempellina nr. *bausei*	21	c-g	2		
Stempellina johannseni	21	c-g	2		
Stempellina nr. *subglabripennis*	21	c-g	2		
Stempellina sp.	21	c-g	2		
Stempellinella sp.	21	c-g	4		
Sublettea coffmani	124	c-f	4	3	5
Sublettea sp.	124	c-f	4		
Tanytarsus brundini	87	c-f	6		
Tanytarsus curticornis gr.		c-f	6		
Tanytarsus eminulus gr.	87	c-f	6		

Phylogenetic group/ Genus species	Ref	Fd	HBI	NBI-P	NBI-N
Tanytarsus glabrescens gr.	87	c-f	6	5	6
Tanytarsus guerlus gr.	87	c-f	6	5	5
Tanytarsus sp. O	36	c-f	6		
Tanytarsus sp.	87	c-f	6		
Zavrelia sp.	124	c-f	4	9	9
Zavreliella sp.	36		6		
Undetermined Tanytarsini	124	c-f	6		
Undetermined Chironominae	124	c-g	6		
Undetermined Chironomidae	83		6		

18.12 DIATOM SPECIES LIST

New York State Department of Environmental Conservation Stream Biomonitoring Unit List of Diatom Species Collected. The table lists the species of diatoms collected in NYS during biological monitoring of surface waters. The table also includes; taxa marked for use in the acid, salt and trophic state indices as well as tolerance values for calculating the pollution tolerance index.

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Bacillariophyta				
Bacillariophyceae				
Achnanthales				
Achnanthaceae				
Achnanthes affinis		x		3
Achnanthes bioretii				3
Achnanthes conspicua		x		
Achnanthes deflexa				3
Achnanthes detha				
Achnanthes daonensis				3
Achnanthes exigua			x	3
Achnanthes flexella				3
Achnanthes hauckiana				2
Achnanthes hauckiana var. *rostrata*				2
Achnanthes lacunarum				
Achnanthes laevis				3
Achnanthes lanceolata			x	2
Achnanthes lanceolata var. *abbreviata*				
Achnanthes lanceolata var. *apiculata*				2
Achnanthes lanceolata var. *dubia*				2
Achnanthes lanceolata var. *rostrata*		x	x	2
Achnanthes linearis				3
Achnanthes marginulata	x			3
Achnanthes microcephala				3
Achnanthes minutissima			x	3
Achnanthes parvula		x	x	
Achnanthes pseudoswazi				
Achnanthes plonensis		x	x	3
Achnanthes subatamoides (*austriaca*)	x			3
Achnanthes subhudsonis				
Achnanthes subhudsonis var. *kraeuselii*				3
Planothidium frequentissimum				
Achnanthidiaceae				
Cocconeidaceae				
Achnanthidium rivulare				
Cocconeis cholnokyana				
Cocconeis diminuta				
Cocconeis pediculus		x	x	2

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Cocconeis placentula			x	2
Cocconeis placentula et. var		x	x	2.5
Cocconeis placentula var. *euglypta*			x	3
Cocconeis placentula var. *lineata*			x	3
Bacillariales				
Bacillariaceae				
Bacillaria paradoxa (*paxillifer*)		x	x	2
Denticula elegans		x		3
Denticula kuetzingii				
Denticula tenuis			x	2
Hantzschia amphioxys			x	2
Nitzschia acicularis			x	2
Nitzschia amphibia		x	x	1.5
Nitzschia angustata				2
Nitzschia apiculata				2
Nitzschia bryophila				3
Nitzschia cf. *bita*				
Nitzschia calida			x	
Nitzschia capitellata			x	1
Nitzschia clausii		x	x	2
Nitzschia communis			x	1
Nitzschia commutata		x		
Nitzschia debilis				
Nitzschia denticula				3
Nitzschia dissipata		x	x	2
Nitzschia dubia			x	2
Nitzschia filiformis		x	x	2
Nitzschia flexa				
Nitzschia fonticola		x	x	2
Nitzschia frustulum		x	x	2
Nitzschia frustulum var. *perminuta*				3
Nitzschia graciliformis			x	
Nitzschia gracilis				2
Nitzschia heufleriana				2
Nitzschia incognita			x	2
Nitzschia inconspicua		x	x	2
Nitzschia intermedia			x	3
Nitzschia lancettula				
Nitzschia linearis		x	x	2
Nitzschia microcephala			x	1
Nitzschia montanestris				
Nitzschia palea		x	x	1
Nitzschia paleacea		x	x	2
Nitzschia perminuta		x		3
Nitzschia pura				
Nitzschia pusilla			x	2

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Nitzschia recta			x	2
Nitzschia sigma		x	x	
Nitzschia sigmoidea		x	x	3
Nitzschia sinuata		x		3
Nitzschia sinuata var. *tabellaria*				
Nitzschia sociabilis			x	
Nitzschia sp.				
Nitzschia subinflata				
Nitzschia sublinearis				
Nitzschia supralitorea			x	1.5
Nitzschia tryblionella		x	x	
Nitzschia tryblionella var. *levidensis*				
Nitzschia tryblionella var. *victoriae*				
Nitzschia vermicularis			x	2
Tryblionella calida (*Nitzschia calida*)				
Cymbellales				
Gomphonemataceae				
Reimeria sinuata		x		2
Anomoeoneidaceae				
Anomoeoneis brachysira	x			3
Anomoeoneis serians var. *acuta*				
Anomoeoneis vitrea		x		2
Cymbellaceae				
Cymbella affinis			x	3
Cymbella aspera			x	3
Cymbella caespitosa (*Encyonema caespitosum*)		x		2
Cymbella cistula		x	x	3
Cymbella delicatula				3
Cymbella excisa				
Cymbella gracilis	x			3
Cymbella helvetica				3
Cymbella lunata				
Cymbella mexicana				3
Cymbella microcephala		x	x	2
Cymbella minuta (*Encyonema minutum*)		x		2
Cymbella minuta var. *silesiaca*				3
Cymbella muelleri				2
Cymbella naviculiformis			x	3
Cymbella norvegica	x			
Cymbella prostrata			x	3
Cymbella prostrata (*Encyonema prostratum*)				
Cymbella prostrata var. *auerswaldii*				2
Cymbella proxima				
Cymbella reichardtii				3
Cymbella silesiaca (*Encyonema silesiacum*)			x	3
Cymbella stauroneiformis				

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Cymbella subcuspidata				
Cymbella subhelvetica				
Cymbella subturgidula				
Cymbella triangulum				3
Cymbella tumida		x	x	1.5
Cymbella tumidula				
Cymbella turgidula				3
Gomphonemataceae				
Gomphoneis minutum				3
Gomphonema acuminatum		x	x	2
Gomphonema affine				
Gomphonema affine var. *insigne*				
Gomphonema angustatum				2
Gomphonema angustatum var. *productum*				2
Gomphonema augur var. *turris*				
Gomphonema clavatum				2
Gomphonema gracile				2
Gomphonema hedinii				3
Gomphonema intricatum				3
Gomphonema kobayasii				1.5
Gomphonema minutum			x	2
Gomphonema olivaceoides				3
Gomphonema olivaceum			x	3
Gomphonema parvulum			x	1
Gomphonema productum		x		1.5
Gomphonema pumilum		x		3
Gomphonema sphaerophorum				
Gomphonema subclavatum				2
Gomphonema subclavatum var. *mexicanum*				2
Gomphonema truncatum			x	2
Gomphonema truncatum var. *capitatum*				3
Rhoicospheniaceae				
Rhoicosphenia curvata		x	x	2
Eunotiales				
Eunotiaceae				
Eunotia bilunaris			x	2
Eunotia curvata				
Eunotia diadon	x			3
Eunotia exigua	x	x		3
Eunotia fallax				
Eunotia flexuosa				
Eunotia formica	x			3
Eunotia incisa	x			3
Eunotia implicata	x			3
Eunotia maior				
Eunotia monodon (*monodontiforma*)	x			3

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Eunotia monodon var. *bidens*				
Eunotia naegelii				
Eunotia pectinalis				
Eunotia pectinalis var. *minor*	x			3
Eunotia pectinalis var. *ventricosa*				
Eunotia perpusilla				
Eunotia septentrionalis				
Eunotia tenella				
Eunotia vanheurckii var. *intermedia*				
Mastogloiales				
Mastogloiaceae				
Mastogloia elliptica var. *dansei*		x		2
Mastogloia smithii		x		2
Naviculales				
Amphipleuraceae				
Frustulia rhomboides	**x**			3
Frustulia rhomboides et var. *amphipleuroides*	x			3
Frustulia rhomboides var. *capitata*				3
Frustulia rhomboides var. *saxonica*	x			3
Frustulia vulgaris			x	2
Frustulia vulgaris var. *capitata*				2
Frustulia weinholdii				3
Amphipleura pellucida		x		2
Brachysiraceae				
Brachysira neoexilis				
Diploneidaceae				
Diploneis elliptica				3
Diploneis smithii				2
Diploneis smithii var. *dilatata*				
Naviculaceae				
Capartogramma crucicula		x		
Geissleria punctifera				
Gregaria decussis				
Navicula accomoda			x	1
Navicula amphiceropsis			??	
Navicula anglica				
Navicula anglica var. *subsalsa*				
Navicula angusta	x			3
Navicula arenaria				
Navicula arvensis				2
Navicula atomus			x	1
Navicula aurora				3
Navicula bacillum				3
Navicula bicephala				3

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Navicula biconica				
Navicula canalis				
Navicula capitata		x	x	1.5
Navicula capitata var. *capitata*				
Navicula capitata var. *hungarica*				2
Navicula capitatoradiata		x	x	2
Navicula cari		x		2
Navicula cincta			x	2
Navicula confervacea		x	x	2
Navicula cryptocephala		x		1.5
Navicula cryptocephala var. *exilis*		x		2
Navicula cryptotenella		x		2
Navicula cuspidata			x	2
Navicula decussis			x	3
Navicula dicephala				
Navicula dithmarsica				
Navicula elginensis			x	3
Navicula erifuga		x	x	2
Navicula exigua			x	
Navicula goeppertiana			x	
Navicula gregaria		x	x	1.5
Navicula gysingensis				
Navicula hambergii	x			
Navicula hintzii				
Navicula hustedtii	x			
Navicula integra		x	x	
Navicula lacustris				
Navicula lanceolata		x	x	1.5
Navicula meniculus var. *obtusa*				
Navicula menisculus		x	x	2
Navicula menisculus var. *upsaliensis*				2
Navicula minima			x	1
Navicula mournei				
Navicula mutica		x	x	2
Navicula muticopsis				
Navicula normaloides				
Navicula notha				2
Navicula oblonga			x	2
Navicula oppugnata				
Navicula peregrina		x	x	2
Navicula perminuta				2
Navicula phyllepta				2
Navicula phylleptosoma				
Navicula placentula		x	x	2
Navicula protracta			x	2
Navicula pseudoscutiformis				

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Navicula pupula				2
Navicula pupula var. *elliptica*				2
Navicula pupula var. *rectangularis*				2
Navicula pygmaea		x	x	2
Navicula radiosa				3
Navicula radiosa var. *parva*				
Navicula radiosa var. *tenella*				2
Navicula recens		x	x	2
Navicula reinhardtii			x	
Navicula rhynchocephala			x	2
Navicula rhynchocephala var. *germainii*				3
Navicula rostellata				
Navicula salinarium		x	x	1
Navicula schroeteri		x	x	2
Navicula secreta var. *apiculata*				2
Navicula seminulum			x	1
Navicula slesvicensis		x	x	2
Navicula sp.				
Navicula stroemii				
Navicula subminuscula			x	1
Navicula subrotundata				3
Navicula subtilissima	x			
Navicula symmetrica				2
Navicula tantula				2
Navicula tenera				1
Navicula tripunctata		x	x	2
Navicula tripunctata var. *schizonemoide*		x	x	3
Navicula trivialis		x	x	1.5
Navicula tuscula var. *angulata*				3
Navicula veneta		x	x	1
Navicula vilaplanii				
Navicula viridula			x	2
Navicula viridula var. *avenacea*				2
Navicula viridula var. *linearis*				2
Navicula viridula var. *rostellata*		x	x	2
Navicula wallacei				
Neidiaceae				
Neidium affine				
Neidium dubium				
Neidium iridis				
Pinnulariaceae				
Pinnularia abaujensis var. *lacustris*				
Pinnularia biceps				
Pinnularia brebissonii				
Pinnularia mesolepta				
Pinnularia subcapitata	x			

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Pinnularia viridis			x	
Caloneis bacillum		x	x	2
Caloneis lewisii				
Caloneis schumanniana				
Pleurosigmataceae				
Gyrosigma acuminatum		x	x	3
Gyrosigma attenuatum			x	3
Gyrosigma spencerii				2
Pleurosigma delicatulum		x		2
Plagiotropidaceae				
Plagiotropis lepidotera var. *proboscidea*				2
Sellaphoraceae				
Sellaphora pupula (*Navicula pupula*)			x	2
Sellaphora pupula et var. *capitata*		x	x	2
Stauroneidaceae				
Craticula cuspidata				
Stauroneis anceps				
Stauroneis nana				
Stauroneis obtusa				
Stauroneis phoenicenteron				2
Stauroneis smithii			x	
Stauroneis tackei				
Rhopalodiales				
Rhopalodiaceae				
Epithemia sorex			x	3
Epithemia turgida				3
Rhopalodia brebissonii		x		
Rhopalodia gibba			x	2
Surirellales				
Surirellaceae				
Cymatopleura elliptica		**x**	x	2
Cymatopleura solea			x	2
Surirella amphioxys		x	x	2
Surirella angusta			x	1
Surirella brebissonii		x		2
Surirella minuta			x	2
Surirella ovalis		x	x	2
Surirella ovata			x	2
Surirella ovata var. *crumena*				2
Surirella ovata var. *pinnata*				2
Surirella sp.				
Surirella tenera			x	
Surirella tenera var. *nervosa*			x	3

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Thalassiophysales				
Catenulaceae				
Amphora inariensis				3
Amphora libyca				3
Amphora ovalis			x	3
Amphora pediculus		x	x	2
Amphora perpusilla				3
Amphora submontana				3
Amphora veneta		x	x	1
Coscinodiscophyceae				
Biddulphiales				
Biddulphiaceae				
Biddulphia laevis				2
Coscinodiscales				
Coscinodiscaceae				
Coscinodiscus lacustris		x		
Coscinodiscus sp.				
Coscinodiscus subtilis				
Aulacoseirales				
Aulacoseiraceae				
Aulacoseira alpigena	**x**			3
Aulacoseira ambigua			x	2
Aulacoseira granulata			x	2
Aulacoseira granulata var. *angustissima*			x	
Aulacoseira italica			x	2
Melosirales				
Melosiraceae				
Melosira ambigua				
Melosira distans				3
Melosira varians		x	x	2
Thalassiosirales				
Stephanodiscaceae				
Cyclotella bodanica				3
Cyclotella comensis				
Cyclotella comta				2
Cyclotella distinguenda				2
Cyclotella glomerata				3
Cyclotella kuetzingiana var. *schumannii*				2
Cyclotella meneghiniana		x	x	1.5
Cyclotella ocellata			x	2
Cyclotella pseudostelligera			x	1.5
Cyclotella stelligera				3
Cyclotella tripartita				
Cyclotella woltereckii				
Stephanodiscus astraea				3
Stephanodiscus hantzschii			x	1.5

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Stephanodiscus niagarae				3
Stephanodiscus subtilis			x	2
Stephanodiscus parvus			x	2
Fragilariophyceae				
Fragilariales				
Fragilariaceae				
Asterionella formosa			**x**	2
Diatoma anceps				3
Diatoma hiemale				3
Diatoma hiemale var. *mesodon*				3
Diatoma hiemalis				
Diatoma mesodon (*Diatoma hiemale*)				3
Diatoma moniliformis				
Diatoma tenue var. *elongatum*				2
Diatoma vulgare		x	x	1.5
Diatoma vulgare var. *breve*				3
Fragilaria brevistriata var. *inflata*			x	
Fragilaria capucina				
Fragilaria capucina var. *gracilis*				3
Fragilaria capucina var. *mesolepta*		x		2
Fragilaria capucina var. *rumpens* (*Synedra rumpens*)		x		2
Fragilaria capucina var. *vaucheriae*		x	x	2
Fragilaria construens		x	x	3
Fragilaria construens var. *binodis*			x	3
Fragilaria construens var. *venter*			x	2
Fragilaria crotonensis		x		2
Fragilaria delicatissima (*Synedra delicatissima*)		x		
Fragilaria famelica		x		3
Fragilaria leptostauron				
Fragilaria leptostauron (*Staurosirella leptostauron*)				
Fragilaria nanana				3
Fragilaria pinnata		x	x	2
Fragilaria pinnata var. *lancettula*				
Fragilaria vaucheriae				
Fragilaria vaucheriae var. *capitellata*				
Fragilaria virescens				3
Fragilaria virescens var. *capitata*				
Hannaea arcus				
Meridion circulare			x	
Meridion circulare var. *constrictum*		x	x	2.5
Synedra acus		x	x	2
Synedra fasciculata				
Synedra goulardi				
Synedra incisa				
Synedra parasitica		x	x	2

Phylogenetic group/ Genus species	Acido-philous	Salinity	Trophy	Pollution Class
Synedra parasitica et var. *subconstricta*			x	1.5
Synedra pulchella		x	x	1.5
Synedra rumpens				
Synedra rumpens var. *familiaris*				
Synedra tenera				
Synedra ulna				
Synedra ulna et var. *acus*				2
Synedra ulna var. *biceps*				
Synedra ulna var. *chaseana*				
Synedra ulna var. *contracta*				
Synedra ulna var. *impressa*		x		2
Tabellariales				
Tabellariaceae				
Tabellaria fenestrata	x			2.5
Tabellaria flocculosa	x	x		3

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18.14 EFFECTS OF LAKE OUTLETS AND IMPOUNDMENTS ON AQUATIC INVERTEBRATE COMMUNITIES

Lakes, ponds, and impoundments have pronounced effects on the invertebrate faunas of their outflows. Although each outflow is dependent on the characteristics of the lake, most outflows share the following traits:

Species richness is nearly always lower below lake outlets. Due primarily to the lack of upstream communities to provide a resource for colonization and drift, lake outlet communities often have only about 60% of the number of species found in comparable non-impacted segments. EPT richness is often only 30% of that found at non-impacted sites. Biotic index values and percent model affinity values are also depressed (see below).

Several types of invertebrate communities are found downstream of impoundments. Invertebrates which are commonly numerous below lake outlets include Simulium (black fly larvae), Cheumatopsyche or Hydropsyche (filter-feeding caddisflies), Nais (worms), Gammarus (crustacean), Rheotanytarsus (midges), Stenelmis (riffle beetles) Sphaerium (fingernail clams), or Platyhelminthes (flatworms). To date, 8 community types have been identified from streams in New York State.

A marked succession of species often occurs over a short distance. Productivity may be initially high below the lake, but usually decreases a short distance downstream. Plankton carried downstream from the lake increases the biomass immediately downstream, primarily of organisms which feed by filtering plankton, such as certain caddisflies, black flies, and midges. This enriching effect does not persist very far downstream, as the plankton is diminished, and communities below this may have very low productivity.

Lakes with cold-water hypolimnion releases limit the fauna additionally by interference with life cycles of aquatic insects such as mayflies, stoneflies, and caddisflies. Because the temperature of hypolimnetic releases is usually very cold, the downstream communities are often limited to midges, worms, black flies, snails, and sowbugs.

Water quality assessment:
Impoundment-affected sites usually indicate slight or moderate impact. Of 25 lake-affected stream sites across New York State, the following index means and ranges were obtained: species richness: 17 (7-24); EPT richness: 4 (0-12); Hilsenhoff biotic index: 5.83 (4.48-8.22); Percent Model Affinity: 45 (24-67). Correct interpretation of these assessments should reflect that although the resident fauna is affected, the impact is usually not a pollutional impairment. However, faunal effects caused by hypolimnion releases should be considered temperature-related and anthropogenic.

Corrective action:
Data judged to be affected by lake outlets is the adjustment of the water quality assessment up one category (e.g., slightly impacted to non-impacted) to reflect genuine water quality.

18.15 CHARACTERISTICS OF HEADWATER STREAM SITES

Headwater stream sites are defined as first or second-order locations close to the source, usually less than three miles. Natural characteristics of headwaters sometimes result in erroneous assessment of water quality.

The following are typical characteristics of headwater sites:

- Reduced upstream community recruitment populations reduce drift colonization, and may reduce species richness.

- Usually nutrient-poor, lower in food resources, and less productive.

- A few intolerant species may be very abundant, due to reduced, simplified fauna. For a 100- organism subsample, this can affect species richness, EPT richness, and percent model affinity. The dominant species averages 37% of the total fauna, and is an intolerant species of either mayfly (e.g., Epeorus, Paraleptophlebia, Stenonema), stonefly (e.g., Leuctridae or Capniidae), caddisfly (e.g., Brachycentrus, Dolophilodes, or Chimarra), or riffle beetle (e.g., Optioservus or Promoresia).

- Many community indices are low, even though invertebrate communities are dominated by intolerant species. Average index values are: species richness - 19, EPT richness - 8, Hilsenhoff biotic index - 3.05, and percent model affinity - 57 (based on headwaters of a number of New York State streams).

Corrective action:
To adjust for non-representative indices from headwater sites, *A correction factor of 1.5 may be applied to species richness, EPT richness, and percent model affinity.* Criteria for the use of the correction factor are: a headwater location as described above; a community dominated by an intolerant species, and species richness, EPT richness, and percent model affinity are judged to be non-representative of actual water quality. *Alternatively, index values may be maintained, and the overall assessment may be adjusted up to non-impacted if the above criteria are met.*