## APPENDIX I. BIOLOGICAL METHODS FOR KICK SAMPLING

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

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

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

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

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

Appendix II. MACROINVERTEBRATE COMMUNITY PARAMETERS

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

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

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

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

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

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

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

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

## Appendix III. LEVELS OF WATER QUALITY IMPACT IN STREAMS

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

1. Non-impacted

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

2. Slightly impacted

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

3. Moderately impacted

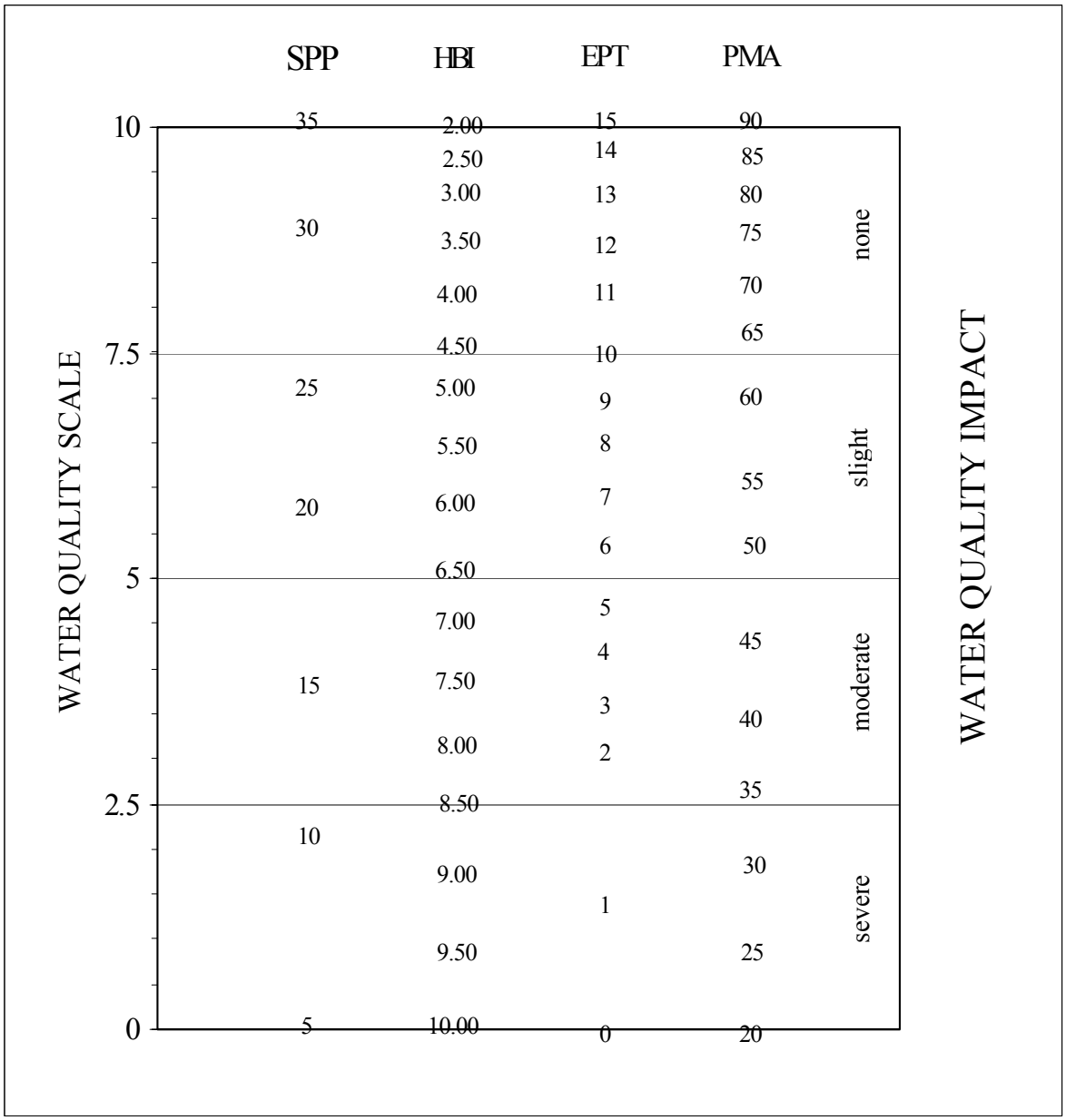
Indices reflect poor water quality. The macroinvertebrate community is altered to a large degree from the pristine state. Species richness usually is 11-18 species. Mayflies and stoneflies are rare or absent, and caddisflies are often restricted; the EPT value is 2-5. The biotic index value is 6.51-8.50.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

4. Severely impacted

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

Appendix IV. BIOLOGICAL ASSESSMENT PROFILE OF INDEX VALUES

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




To plot survey data, each site is positioned on the x-axis according to river miles from the mouth, and the scaled values for the four indices are plotted on the common scale. The mean scale value of the four indices represents the assessed impact for each site.

Appendix V.
WATER QUALITY ASSESSMENT CRITERIA
for non-navigable flowing waters

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

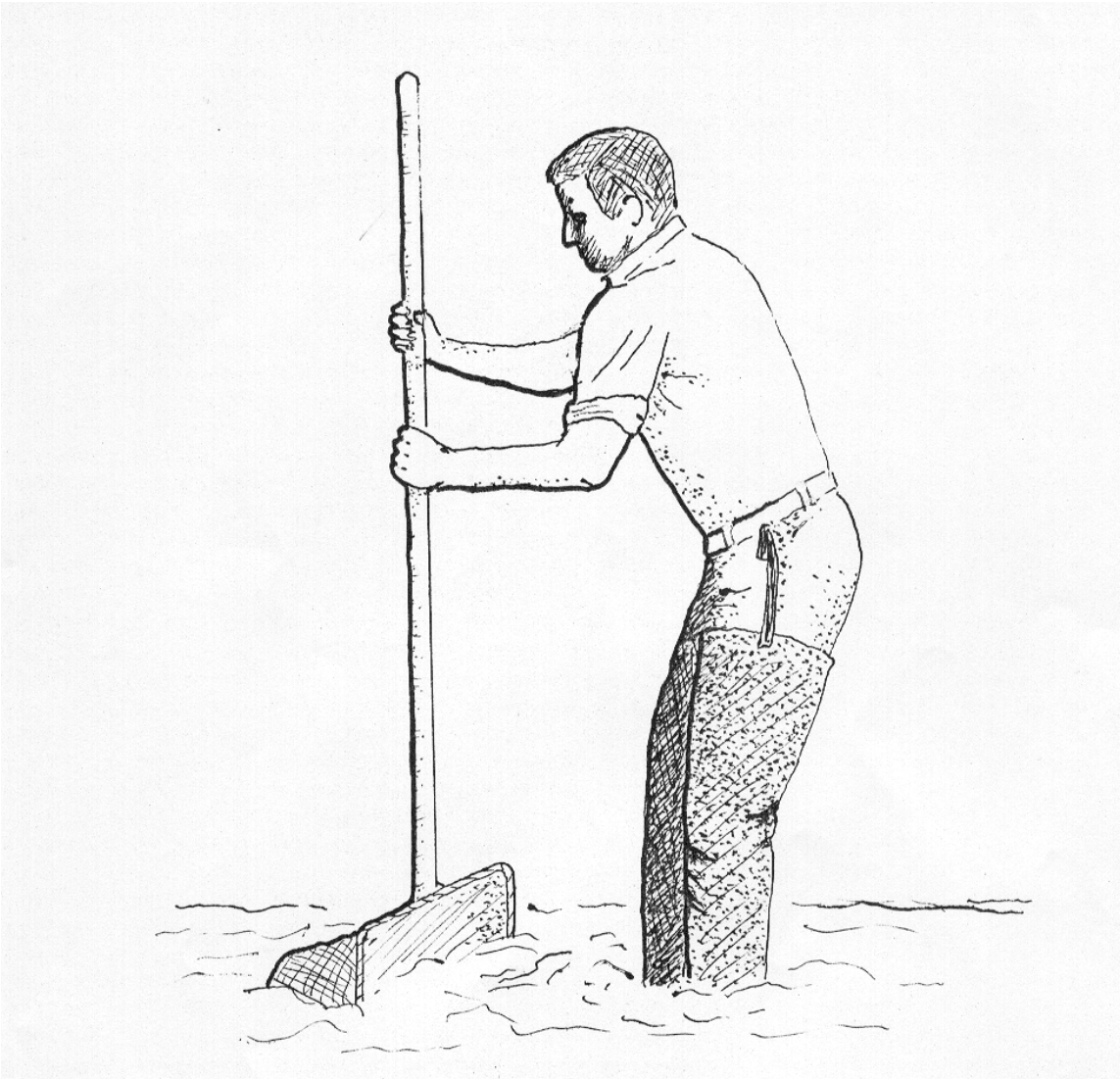
# Percent model affinity criteria are used for traveling kick samples but not for multiplate samples.
* Diversity criteria are used for multiplate samples but not for traveling kick samples.

WATER QUALITY ASSESSMENT CRITERIA
for navigable flowing waters

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

Appendix VI.

# THE TRAVELING KICK SAMPLE



← current

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.

Appendix VII. A.

# AQUATIC MACROINVERTEBRATES THAT USUALLY INDICATE GOOD WATER QUALITY

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

***MAYFLIES***

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

***STONEFLIES***

Caddisfly larvae often build a portable case of sand, stones, sticks, or other debris. Many caddisfly larvae are sensitive to pollution, although a few are tolerant. One family spins nets to catch drifting plankton, and is often numerous in nutrient-enriched stream segments.

***CADDISFLIES***

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

***BEETLES***

Appendix VII. B.

# AQUATIC MACROINVERTEBRATES THAT USUALLY INDICATE POOR WATER QUALITY

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

***MIDGES***

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

***BLACK FLIES***

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

***WORMS***

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

***SOWBUGS***

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

# APPENDIX VIII. THE RATIONALE OF BIOLOGICAL MONITORING

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

## Concept

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

Advantages of using macroinvertebrates as water quality indicators:

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

Limitations

1) Biological monitoring is not intended to replace chemical sampling, toxicity testing, or fish surveys. Each of these measurements provides information not contained in the others.
2) Substances may be present in levels exceeding ambient water quality criteria, yet have no apparent adverse community impact.
3) Macroinvertebrate sampling cannot determine if water is safe for drinking.

# APPENDIX IX. GLOSSARY

**assessment**: a diagnosis or evaluation of water quality

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

**biomonitoring**: the use of biological indicators to measure water quality

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

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

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

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

**fauna**: the animal life of a particular habitat

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

**impairment**: a detrimental effect caused by an impact

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

**intolerant**: unable to survive poor water quality

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

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

**organism**: a living individual

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

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

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

**station**: a sampling site on a waterbody

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

**tolerant**: able to survive poor water quality

## APPENDIX X. METHODS FOR IMPACT SOURCE DETERMINATION

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

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

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

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

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

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

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

SEWAGE EFFLUENT, ANIMAL WASTES

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

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

## APPENDIX XI. MACROINVERTEBRATE COMMUNITY PARAMETERS FOR SANDY STREAMS

Stream habitats dominated by slow current speeds and smaller overall sediment particle size, mostly gravel, sand, and silt, require different methods of data analysis compared to streams with rubble/gravel riffles. The criteria used to interpret the invertebrate data and assess water quality were selected to account for habitat influences in order to separate water quality influences. The following indices and scales were used:

1. Species richness. This is the total number of species or taxa found in the sample. Expected ranges for 100-specimen subsamples of kick samples are: greater than 21, non-impacted; 17-21, slightly impacted; 12-16, moderately impacted; less than 12, severely impacted.

2. EPT richness. EPT denotes the total number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) found in an average 100-organism subsample. The scale for navigable waters was also used for this index. Expected ranges are: greater than 5, non-impacted; 4-5, slightly impacted; 2-3, moderately impacted; and 0-1, severely impacted.

3. Biotic index. The Hilsenhoff Biotic Index, the average tolerance value for all the organisms in the sample, ranges from intolerant (0) to tolerant (10). The scale of expected values set for slow sandy streams is: 0-5.50, non-impacted; 5.51-7.00, slightly impacted; 7.01-8.50, moderately impacted; and 8.51-10.00, severely impacted.

4. 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. The scale used for slow sandy streams is: greater than 10, non-impacted; 6-10, slightly impacted; 2-5, moderately impacted; and 0-1, severely impacted.

These scales were developed using Long Island data in addition to data from several statewide sites with habitats similar to the Long Island streams. The scales were adjusted to make the indices corroborative, leading to accurate water quality assessments. Overall water quality is assigned by normalizing the four index values on a common ten-scale, and calculating the average of the four indices. Percent model affinity was not selected as an index, because there was no single prevailing community composition among the sites.

## APPENDIX XII. 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:

1. 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).

2. 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, 10 community types have been identified from streams in New York State.

3. 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.

4. 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.

5. Water quality assessments of 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.

6. Corrective action for 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.

APPENDIX XIII. MULTIPLATE SAMPLING FOR MACROINVERTEBRATES.

1. Rationale: Multiplates (multiple-plate samplers) are a type of artificial-substrate sampling device. They are used in flowing waters that are 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.

2. 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.

3. Sampler construction: The sampler design is 3 square hardboard plates, separated by spacers, mounted on a turnbuckle. 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. The top plates are separated by the single spacer, and the bottom plates are separated by the triple spacer. The total exposed surface area of the sampler is 0.14 square meters (1.55 square feet).

4. 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. If navigation buoys are used, samplers are suspended with plastic-coated cable attached to a suitable above-water portion of the buoy. 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. The float is anchored with a three-holed concrete block, 4 x 8 x 16 inches.

5. Sampler retrieval: Samplers are retrieved 5 weeks after placement. The sampler is removed from the water and placed in a bucket of stream water, then 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

6. Sample sorting and subsampling:. The sample with the most accumulated material is selected for processing. A quarter subsample is examined under a dissecting stereo-microscope and the organisms are removed from the debris. As they are removed, they are sorted into major groups, placed in vials containing 70% ethyl alcohol, and counted. All identified specimens are archived.

7. Organism identification: organisms are identified as for kick sampled. Chironomidae are subsampled for 100 individuals, and Oligochaeta are subsampled for 50 individuals.

8. Assessment: Four indices are used: 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 and averaged.

APPENDIX XIV. PONAR SEDIMENT SAMPLING FOR MACROINVERTEBRATES.

1. Rationale: The use of the Ponar grab sampler or Petite Ponar grab sampler 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).

2. 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.

3. 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.

4. 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.

5. 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.

6. Organism Identification: All organisms are identified to the species level whenever possible. Chironomids and oligochaetes are slide-mounted and viewed through a compound microscope; most other organisms are identified as whole specimens using a dissecting stereomicroscope. The number of individuals in each species, and the total number of individuals in the sample is recorded on a data sheet.

7. Assessment: Five indices are used: 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 and averaged.