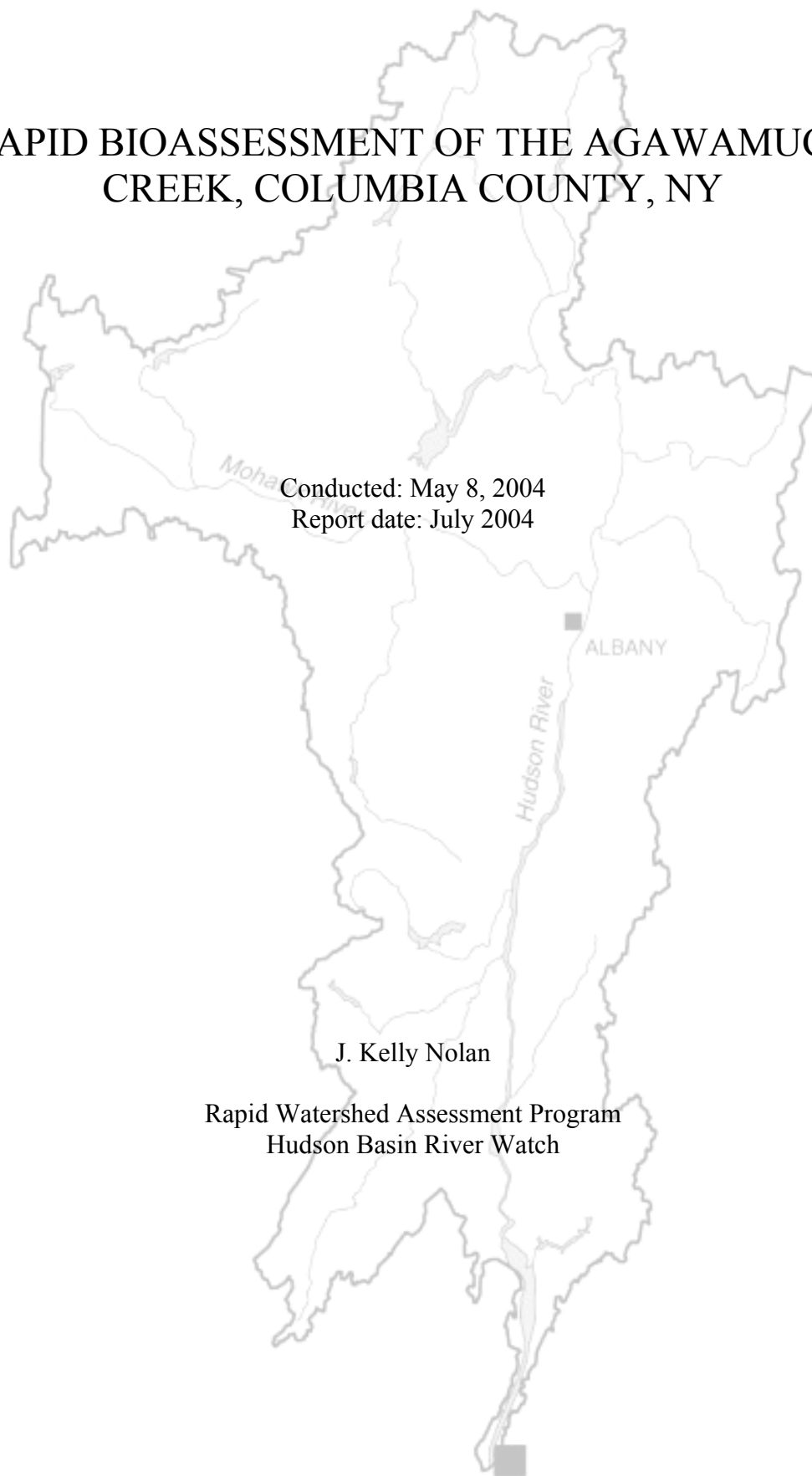# RAPID BIOASSESSMENT OF THE AGAWAMUCK CREEK, COLUMBIA COUNTY, NY
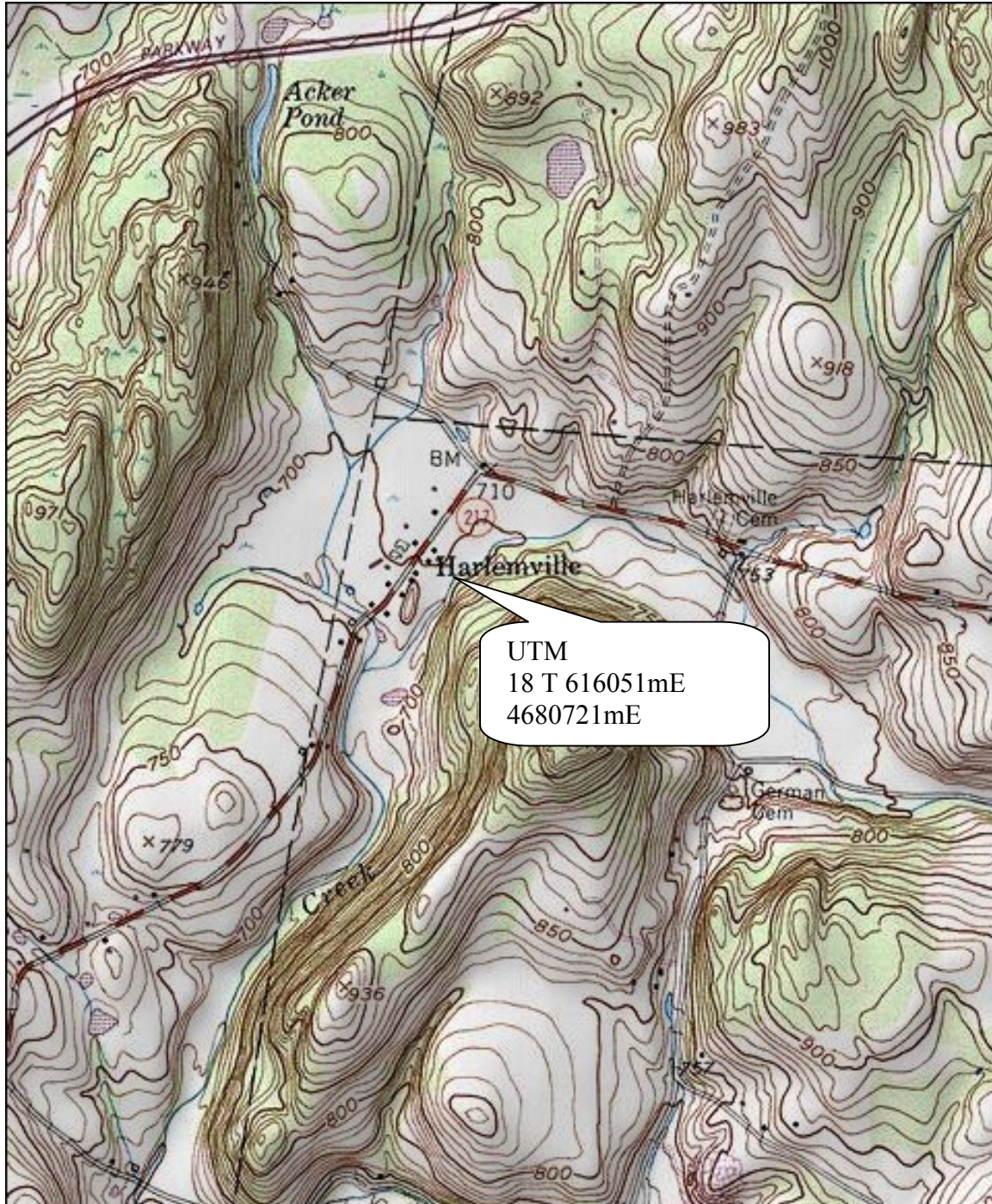
Conducted: May 8, 2004
Report date: July 2004

J. Kelly Nolan

Rapid Watershed Assessment Program
Hudson Basin River Watch

UTM
18 T 616051mE
4680721mE

Agawamuck Creek, Columbia County, NY

Contents

SUMMARY

In May 2004, Hudson Basin River Watch (HBRW) performed a rapid bioassessment on the Agawamuck Creek, in Columbia County, NY. Physical, chemical, bacteriological, and biological data were collected once at one site along the Creek. The assessment was conducted as a stream monitoring training workshop for community members, HBRW coordinators, and staff with the Hawthorne Valley Farm. Results from this water quality assessment include elevated phosphorus and nitrate nitrogen levels and a slightly altered biological community structure.

BACKGROUND

Potential threats to the watershed include runoff from agricultural land use and residential septic systems. The surveyed site of the Agawamuck Creek is classified as class C waters with water quality standards of TS. (see appendix V).

OVERVIEW OF PHYSICAL AND CHEMICAL DATA

[Explanation of the methods used to collect and evaluate the data obtained in this study can be found in the section on Rationale of Data Collected and Methods pages 6—9. For complete physical, chemical, and biological data see appendix I—III. A map of site locations is located inside the front cover.

The Hudson Basin River Watch Rapid Bioassessment Program Quality Assurance Quality Control (QAQC) was developed and written following the EPA guidelines for volunteer stream monitoring programs and outlines in detail the study's organization, objectives, volunteer training requirements, methods of data collection, documentation, analysis, and quality control. The QAQC is available from the author.]

Physical site assessment, chemical analysis, bacteriological analysis and collection of macroinvertebrates were performed once at one site on May 8, 2004.

The overall habitat assessment rating was excellent to good, with a current speed of 0.6 meters/second, stream depth of 0.8 meters, and stream width of 6.5 meters. The pH was 7.1, alkalinity was 54 mg/l, turbidity was 2 FAU, conductivity was 110 µS/cm, nitrate-nitrogen (NO3-N) was 4 mg/l, phosphate (P) was 0.07 mg/l, dissolved oxygen was 10.8 mg/l, water temperature was 11 degree Celsius, and the dissolved oxygen percent saturation was 97 percent (see appendix II).

DISCUSSION OF PHYSICAL, CHEMICAL, AND BIOLOGICAL DATA

During the physical assessment, anthropogenic alterations were evident at the testing site and had the potential for adverse affects on the Agawamuck's ability to maintain a healthy benthic macroinvertebrate community (Cooper, 1993; Dance and Hynes, 1980; Meyer and Wallace, 2001; and Wang, et al., 1997). Alterations included poorly constructed stream embankment and a riparian area of cut grasses (see appendix I for the physical assessment surveys). An algae bloom, as reported by workshop participants, had occurred upstream a few weeks prior to this workshop. Increases in nutrients, particularly in conjunction with abundant sunlight, can promote excessive growth of algae (Stevenson, et. at., 1996).

Alkalinity, pH, turbidity, water temperature, conductivity, dissolved oxygen, and percent oxygen saturation were all within NYS DEC water quality standards or biologically acceptable parameters. However, some of these parameters, such as dissolved oxygen, water temperature, and conductivity exhibit diel and seasonal variations (Christensen, et. al., 1990; Hessen, et. al., 1996; Isenhart, et. al., 1989; Kobayashi, et. al., 1990; and Stevenson, et al., 1996), which were not examined during this study. In particular, the data may not reflect the site's lowest dissolved oxygen readings.

Readings for phosphorus and nitrate-nitrogen exceeded background levels. Because of diel variations in

nitrate levels, nocturnal levels of nitrates may be higher than levels during daylight hours (Christensen, *et. al*., 1990; Hessen, *et. al*., 1996; Isenhart, *et. al*., 1989). Total nitrogen levels exceeding background levels have been shown to have a deleterious effect on macroinvertebrates and fish communities, and, in fact, might influence the fish community as much as overall water quality does (Miltner and Rankin 1998). Spawning redds are frequently located at ground water upwelling zones where, in agricultural areas, concentrations of nitrogen may be several times higher than elsewhere. These pools of concentrated nitrogen significantly increase mortality in brook trout embryos and reduce growth or biomass of brook trout in long-term exposures (Crunkilton, 2000).

The number of *E. coli* colonies collected during this survey were well below the recommended number suggested by the US Environmental Protection Agency for single sample analysis.

The Biological Assessment Profile (BAP) indicates slightly-impacted water quality (Graph, page 4). Even though the preferred time for kick sampling, in assessing water quality within the NYS DEC four-tiered assessment system, is July—September (Novak and Bode, 1992) the individual metrics that comprise the BAP indicate an altered, although slightly, benthic macroinvertebrate community.

The findings from this survey indicate that the Agawamuck Creek may be stressed from excessive nutrients which may be adversely affecting the aquatic biota, though the extent and duration of the problem are not evident by this study.

CONCLUSIONS AND RECOMMENDATIONS

1. There is evidence that nutrients levels are high enough to be altering the chemical and biological profile of the stream reach tested.
2. Longitudinal study, including pre-dawn chemical analysis and the inclusion of additional survey sites within the watershed will help determine the degree of any changes in the creek's water quality and its intended uses.
3. Bacterial testing should be expanded to include a full set of data analysis as outlined in the NYS DEC water quality standards manual.

Biological Assessment Profile
Agawamuck Creek, Columbia County, NY
May 8, 2004

Site Number   1

Water Quality Scale

10

7.5

5

2.5

0

Water Quality Impact

Non-
slight
moderate
severe

■ Family   ◆ EPT   ✳ FBI   ▲ PMA   ─○─ Mean
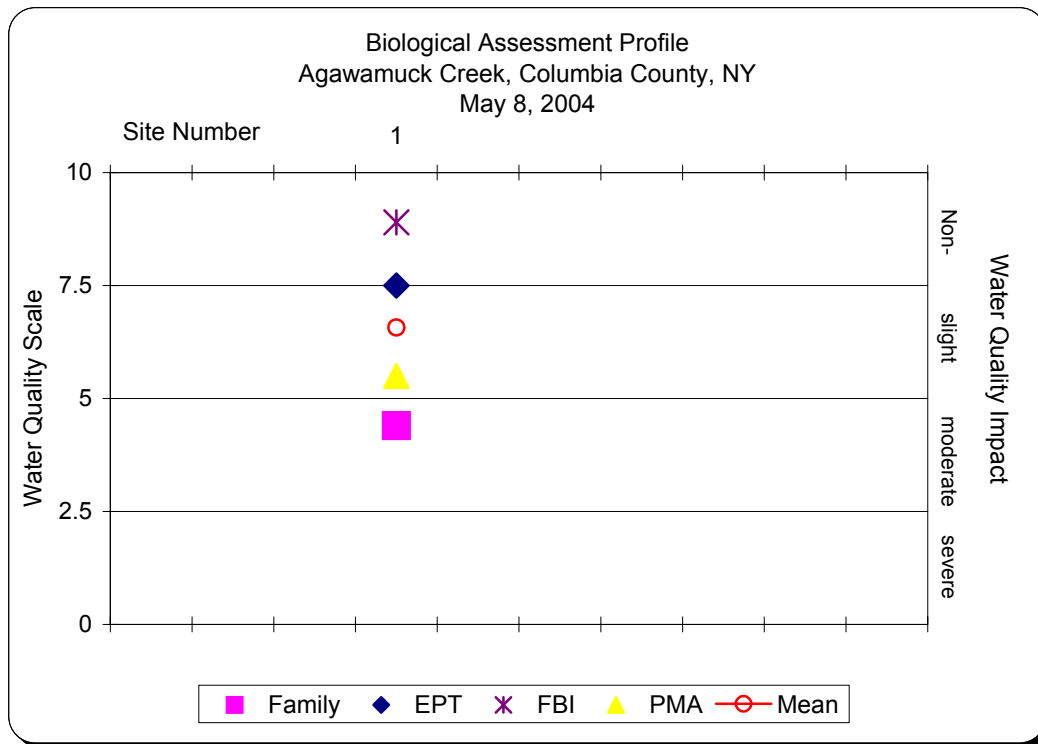
The biological assessment profile is comprised of four contributory indices that are determined from a sub sample of
macroinvertebrates collected from each site (see appendix VI).

Glossary

Anthropogenic: caused by man

Assessment: a diagnosis or evaluation of water quality

Benthic: located on the bottom of a body of water or in the bottom sediments or pertaining to bottom-dwelling organisms

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

Biomonitoring: the use of biological indicators to measure water quality

Diel cycle: referring to the 24 hr day

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

Non point source: diffuse pollution sources (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet)

Periphyton: are algae that grow on a variety of submerged substrates, such as rocks, plants or debris, in lakes or streams

Point source: a stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, e.g., a pipe, ditch, ship, ore pit, factory smokestack

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

Station: a sampling site on a waterbody

Stenotherms: organisms having a very narrow thermal tolerance and preferring cooler temperatures

Survey: a set of sampling conducted in succession along a stretch of stream

Tolerant: able to survive poor water quality

RATIONALE OF DATA COLLECTED AND METHODS

Physical

The *physical survey* is essential to a stream study because aquatic fauna often have specific habitat requirements independent of water composition, and alterations in these conditions affect the overall quality of a water body (Giller and Malmqvist, 1998). Additionally, the physical characteristics of a stream affect stream flow, volume of water within the channel, water temperature, and absorbed radiant energy from the sun.

Testing sites are evaluated for: stream size and gradient; surrounding land use; presence/absence of upstream dams; algal or weed growth; presence/absence of oily film, grease globules, or unusual odor or color; riffle size; substrate size; presence/absence of shelter for fish; flow pattern; channel alteration; stream bank cover and stability; disruption of the riparian bank cover; width of the riparian vegetation zone; and the presence of litter. Habitat condition was scored as excellent, good, fair, or poor. (See physical survey/habitat assessment data sheets for scoring parameters). Site photos were taken of the upstream and downstream area and are included in the attached physical survey/habitat assessment sheets.

W*ater temperature* directly affects both the nature of aquatic fauna and species diversity; temperature tolerance is organism specific, and the reproductive cycle (including timing of insect emergence and annual productivity) will vary within different temperature ranges. Temperature can also affect organisms indirectly as a consequence of oxygen saturation levels. As water temperature rises, the metabolism of aquatic organisms increases, with an attendant increase in their oxygen requirements. At higher water temperatures, however, the oxygen carrying capacity of water decreases because of a diminished affinity of the water for oxygen.

Optimal water temperature ranges and lethal limits of water temperature vary among different organisms. The ratio of Plecoptera to Ephemeroptera (individuals and numbers of species) has been found to drop as the annual range of temperature increases (Hynes, 1970). The optimal temperature range for Brook trout is 11-16 ^{0} Celsius with an upper lethal limit of 24^0 Celsius (Hynes, 1970). NYS DEC does not have a water quality standard for water temperature.

Temperature was recorded by grab samples with a glass thermometer.

Turbidity, or the cloudiness of water, is caused by multiple factors such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton, and other microscopic organisms. Because the ability of trout to sight feed is restricted at turbidity levels above 50 Nephelometric Turbidity Units (NTU), salmonid displacement will occur above this level. A turbidity of less than 10 NTU is recommended for trout propagation (Watersheds, 1994).

The Hach 890 colorimeter was used in this study, which measures turbidity in Formazin Attenuation Units (FAU) (The equivalency ratio is 1FAU/1NTU).

NYS DEC does not have a numeric standard for turbidity.

Percent cobble embeddedness, the degree to which gravel-sized and larger particles are surrounded by sand-sized and smaller particles, is an indicator of a stream's ability to support trout survival and propagation. If deposition of sediment occurs in spawning areas, it can be detrimental to trout reproduction. Trout eggs require a well-oxygenated environment; the eggs are laid in permeable gravel beds with many open spaces to allow continuous bathing of the eggs with cool, oxygenated water. Sediment deposition destroys this environment by clogging these open spaces, leading to oxygen deprivation and buildup of metabolic waste. When cobble embeddedness reaches 50-60%, a stream loses its salmonid fry. Furthermore, although habitat quality is still considered fair for trout survival (though not propagation) at 50-75% embeddedness, changes in the bethnic macroinvertebrate fauna population, on which trout feed; begin to occur (Harvey, 1989).

Velocity was calculated at the time of macroinvertebrate collection because an optimal macroinvertebrate collection site has a velocity between 0.45 and 0.75 meter/second. Velocity was determined by averaging the time it takes a float to travel a marked distance midstream and near each bank, and dividing the distance of the course by the average time.

<u>Chemical</u>

Dissolved Oxygen (DO) level is a function of water turbulence, diffusion, and plant respiration. The EPA recommends that dissolved oxygen levels remain above 11 mg/l during embryonic and larval stages of salmonid production and above 8 mg/l during other life stages (EPA, 1987). The NYS DEC standard for dissolved oxygen for class C(T) and C(TS) stream is 6 mg/L and 7 mg/L respectively.

A significant drop in DO concentration can occur over a 24-hour period, particularly if a waterbody contains a large amount of plant growth. Oxygen is released into the water as a result of plant photosynthesis during daylight; dense plant growth within a stream can therefore elevate the DO level significantly. At night photosynthesis ceases and DO may drop to levels maintained by diffusion and turbulence. A pre-dawn DO level will, in this case, reflect the lowest DO concentration in a 24 hour period and thus provide important data on the overall health of the system.

DO was measured using the modified Winkler titration with microburet method.

It is also important to consider *percent oxygen saturation*, since dissolved oxygen levels vary inversely with water temperature. Percent saturation is the maximum level of dissolved oxygen that would be present in the water at a specific temperature in the absence of other influences, and is determined by calculating the ratio of measured dissolved oxygen to maximum dissolved oxygen for a given temperature. (The calculation is also standardized to altitude or barometric pressure.) Percent oxygen saturation falls when something other than temperature, such as dissolved solids or bacterial decomposition, affects oxygen levels.

A healthy stream contains near 100 percent oxygen saturation at any given temperature (Hynes, 1970). Trout are particularly sensitive to even a slight drop in oxygen saturation and will migrate away from streams when oxygen saturation falls. Similarly, certain macroinvertebrates are sensitive to varying saturation levels and because the ability of these organisms to migrate away from the changing conditions is limited a drop in saturation can be lethal. NYS DEC has not adopted percent oxygen saturation as a water quality standard. The assessment was included in this study because of our belief that it is vital to the complete evaluation of the health of a stream.

Conductivity is a measure of the ability of an electrical current to pass through a stream; it is dependent on both the concentration of dissolved electrolytes within the water and water temperature. When inorganic ions are dissolved in water, conductivity increases. Organic ions, such as phenols, oil, alcohol and sugar, can decrease conductivity (EPA, 1997). Warmer water is also more conductive and, therefore, conductivity is reported for a standardized water temperature of 25 degrees Celsius. Measurements are reported in microsiemens per centimeter (μS/cm).

In the United States, freshwater stream conductivity readings vary greatly from 50-1,500μS/cm. The conductivity of most streams remains relatively constant, however, unless an extraneous source of contamination is present. A failing septic system would raise conductivity because of its chloride, phosphate, and nitrate content, while an oil spill would lower conductivity.

Conductivity between 150 and 500μS/cm is considered a good mixed-fisheries range (EPA, 1997). A Corning conductivity meter was used to measure conductivity. NYS DEC does not have a standard for conductivity.

The *pH* and *alkalinity* are measures of a stream's acidity and its buffering capacity, or ability to neutralize acidic influences and resist changes in pH. A desirable pH for salmonid is 6.5-8.5. An alkalinity of greater than 20 ppm helps to protect a stream from pH altering influences (such as acid rain). An Oakton pHtestr meter and the Lamotte alkalinity test kit direct reading titrator method were used to obtain pH and alkalinity, respectively. The NYS DEC standard for pH is 6.5-8.5.   No standard has been established for alkalinity.

In most fresh water streams, *nitrates and phosphates* are in short supply and are therefore the nutrients that limit plant growth. Because of this, even small excess amounts of these substances can significantly impact a stream. Typically, natural background levels of nitrate nitrogen (NO_3 –N) are <1.0 mg/l. Phosphorus (P) levels of >0.05 mg/l indicate that impact is likely; at levels of >0.1 mg/l impact is certain. Increased levels of these nutrients often indicate that sewage, animal manure, fertilizer, and other types of contamination from commercial

sites, residential homes, or farms are entering the system.

These nutrients affect aquatic organisms indirectly when elevated levels increase plant proliferation and, ultimately, decaying plant material in the stream. Bacteria that decompose this material require oxygen, depleting the dissolved oxygen. Excessive plant growth also physically changes the substrate on which macroinvertebrates live, altering the diversity of macroinvertebrate community on which trout feed.

It has been documented that nitrate levels are highest just before dawn due to plant inactivity (Stevenson et al., 1996). Plant uptake of nitrates during daylight due to plant metabolism can lower the levels in the water column; at night when plant activity ceases nitrate levels increase. Pre-dawn nitrate levels will therefore indicate maximum nitrate present in a 24-hour period.

Nitrates (NO_3 –N) and Phosphorus (P) were measured using the Hach DR 890 colorimeter by chromotropic acid method and ascorbic acid reduction method, respectively. NYS DEC does not have a numeric standard for nitrates or phosphates.

Biological

Macroinvertebrates are collected by kick net as described by Bode *et. al.* (2002) and the specimens are preserved. Pollution-sensitive *macroinvertebrates*, a food source for trout, require similar chemical parameters as trout. The relative numbers of different macroinvertebrate groups indicate the overall health of an ecosystem. Perhaps more importantly, macroinvertebrate data demonstrate the effects of problems that may not be detected by chemical testing.

The NYS DEC Stream Biomonitoring Unit has utilized stream biological monitoring and water quality analysis since 1972 but the biological profiles and water quality assessments are not a part of the state's standards. They serve as a "decision threshold" to determine the need for further studies.

The Environmental Protection Agency recommends that states and tribes with biomonitoring experience adopt biological criteria into water quality standards to provide a quantitative assessment of a waterway's designated and supportive use. Currently only five states have done so; NY is not one of these states. Biological assessment was included in this study because of our belief that it is vital to the complete evaluation of the health of a stream.

The four family indices, or metrics, that are recommended by the NYS DEC Biomonitoring Unit to provide a biological profile and overall stream water quality assessment are listed below. Family level identification using the four family indices has a prediction placement rate for proper water quality impact assessment within the NYS DEC four tier level of impact assessment of 92% (Smith and Bode, unpublished).

1. Family Richness: The total number of families found in the sample.
2. EPT richness: The number of families in the three most pollution sensitive orders – Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies)- that are present.
3. Biotic index: The product of the quantity of a particular macroinvertebrate found and its assigned biotic value (pollution tolerance value).
4. Percent model affinity, PMA: A comparison of the number of identified macroinvertebrates to a New York model "non-impacted" community, based on percent abundance in seven major groups.

A Biological Assessment Profile, as outlined by the DEC, is obtained from the four metrics by converting each metrics score to a 0-10 water quality scale and calculating their mean. The mean score identifies the water quality impact as: non-, slightly, moderately, or severely impacted. [For definitions of each category, see appendix VI]. The DEC surmises the ability of each of the above water qualities to support fish and their propagation, but a particular family or species of fish is not identified. This is significant because trout are sensitive to small amounts of pollutants and slight ecological changes, whereas bass or carp, having a higher tolerance to pollutants and ecological changes, are not.

It is prudent to remember that an index is a means to convey information about the status of a water body, but should not be used exclusive of its component metrics and data (EPA, 1999).

The HBRW Rapid Biological Assessment includes the above indices and:
1. Organism Density Per Sample: An estimate of the total number of individuals in the sample.
2. EPT/EPT + Chironomidae: A measure of the ratio of the intolerant EPT orders to the generally tolerant

Diptera family Chironomidae.

3. <u>Percent Contribution of Dominant Family</u>: The percentage of the sample made up of the most abundant family.

4. <u>Percent Composition of Major Groups</u>: The percent of the sample comprised of selected major groups.

[For complete definitions of indices see appendix VII]

Extended Bibliography:

Allan, J. David 1995. *Stream Ecology Structure and function of running waters*. Dordrecht, The Netherlands, Kluwer Academic Publishers.

Barbour, Michael T. Gerritsen, Jeroen Snyder, Blaine D. Stribling, James B. 1999. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers*. Washington, D.C.: Office of Water. July.

Barbour, M.T., Diamond, J.M., Yoder, C.O. 1996. Biological assessment strategies: Applications and Limitations. Pages 245-270 in D.R. Grothe, K.L. Dickson, and D.K. Reed-Judkins (editors). *Whole effluent toxicity testing: An evaluation of methods and prediction of receiving system impacts*, SETAC Press, Pensacola, Florida.

Barton, David. 1996. *The use of Percent Model Affinity to assess the effects of agriculture on benthic invertebrate communities in headwater streams of southern Ontario, Canada*. Fershwater Biology Vol. 36. Pp. 397-410.

Behar, Sharon. 1997. *Testing the Waters: Chemical and Physical Vital Signs of a River*. Dubuque, Iowa: Kendall/ Hunt.

Bode, Robert. W., and Simpson, Karl W. 1984. *Battenkill Biological Assessment*. NYS DEC technical report.

Bode, Robert W., Novak, Margaret A; L.E. Abele, and D.L. Heitzman. 1999. *Battenkill Biological Assessment*. NYS DEC technical report.

Bode, R. W., M.A. Novak, L.E. Abele, D.L. Heitzman, and A.J. Smith. 2002. *Quality Assurance work plan for biological stream monitoring in New York State*. NYS DEC technical report.

Caduto, Michael J. 1990. *Pond and Brook: A Guide to Nature in Freshwater Environments*. Hanover, New Hampshire: University Press of New England.

Christensen, Peter Bondo; Nielsen, Lars Peter; Sorensen, Jan and Revsbech, Niels Peter. 1990. *Denitrification in nitrate-rich streams: Diurnal and seasonal variation related to benthic oxygen metabolism*. Limnol. Oceanogr. Vol., 35. Pp. 640-651.

Cooper, C. M. 1993. *Biological Effects of Agriculturally Derived Surface Water Pollutants on Aquatic Systems– A Review*. Journal of Environmental Quality. Vol., 22. Pp. 402-408.

Cox, Kenneth M. 2000. *Evaluation of wild trout populations in the Batten Kill and application of a catch and release regulation*. Vermont Fish and Wildlife Department, Federal Aid in Fish Restoration F-36-R-2 Final Report, Waterbury.

Crukilton, Ronald; Point, Stevens and Johnson, Todd. 2000. *Acute and Chronic toxicity of nitrate to brook trout Salvelinus fontinalis*. Wisconsin Water Resources. Http://wri.wisc.edu/wgrmp/95dnr140.htm.

Dance, K. W. and Hynes, H. B. N. 1980. *Some Effects of Agricultural Land use on Stream Insect Communities. Environmental Pollution*. Vol., 22. Pp. 19-28.

Dates, Geoff and Byrne, Jack. 1997. *Living Waters, Using Benthic Macroinvertebrates and Habitat to Assess Your River's Health*. River Watch Network.

Davis, Wayne S. and Simon, Thomas P. 1995. *Biological Assessment and Criteria Tools for water resource Planning and decision making*. Washington, D.C. Lewis Publishers.

Dufour, A.P. 1984. *Health Effects Criteria for Fresh Recreational Waters*. Cincinnati, Ohio. USEPA. EPA-600/1-84-004

Elder, Don and Killam, Gayle and Koberstein, Paul. 1999. *The Clean Water Act: An Owner's Manual*. Portland, Oregon. River Network.

EPA, U.S. Environmental Protection Agency. 1987. *Quality Criteria for Water*. EPA Publication 440/5-86- 001. U.S. Gov. Prin. Office, Washington D.C.

EPA, Environmental Protection Agency. 1997. *Volunteer Stream Monitoring*: A Methods Manual. Washington, D. C.: Office of Wetlands, Oceans and Watersheds, Assessment and Watershed Protection Division (4503F). November.

EPA, Environmental Protection Agency. 1999. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers*. Washington, D.C.: Office of Water (4503F). July.

Giller, Paul S. and Malmqvist, Bjorn. 1998. *The Biology of Streams and Rivers*. Oxford, New York. Oxford University Press.

Gray, N. F. 1985. *Heterotrophic Slimes in Flowing Waters*. Biol. Rev. Camb. Philos. Soc. Vol. 60. Pp. 499-548.

Bibliography cont.

Harvey, G.W. 1989. *Technical Review of Sediment Criteria, for Consideration for Inclusion in Idaho Water Quality Standards*. Idaho Dept. of Health and Welfare, Water Quality Bureau, Boise, ID.

Hauer, Richard F. and Lamberti, Gary A. 1996. *Methods in Stream Ecology*. New York, New York. Academic Press.

Hessen, Dag O.; Henriksen, Arne and Smelhus, Anne M. 1996. *Seasonal Fluctuations and Diurnal Oscillations in Nitrate of a Heathland Brook*. Wat. Res. Vol. 31. Pp. 1813-1817.

Hilsenhoff, William L. 1988. *Rapid field assessment of organic pollution with a family-level biotic index*. Journal of the North American Benthological Society. 7(1): 65-68.

Hunter, Christopher J. 1991. *Better Trout Habitat, A Guide to Stream Restoration and Management*. Washington, D.C. Island Press.

Hynes, H.B.N., 1970. *The Ecology of Running Waters*. Toronto Canada. University of Toronto Press.

Hynes, H.B.N., 1974. *The Biology of Polluted Waters*. Toronto Canada. University of Toronto Press.

Isenhart, Thomas M., and Crumpton, William G., 1989. *Transformation and Loss of Nitrate in an Agricultural Stream*. Journal of Freshwater Ecology. Vol., 5. Pp. 123-129.

Kilgour, Bruce W. and Barton, David R. 1999. *Associations between stream fish and benthos across environmental   gradients in southern Ontario, Canada*. Freshwater Biology. Vol. 41. Pp. 553-566.

Karr, R. James and Chu, Ellen W. 1999. *Restoring Life in Running Waters, Better Biological Monitoring*. Washington, D.C. Island Press.

Karr, R. James and Chu, Ellen W. 1997. *Biological Monitoring: Essential Foundation for Ecological Risk Assessment.* Human and ecological risk assessment. Vol., 3. Pp. 993– 1004.

Kobayashi, D.; Suzuki, K. and Nomura, M. 1990. *Diurnal fluctuation in stream flow and in specific electric conductance during drought periods*. Journal Hydrology. Vol., 115. Pp. 105-114.

Lepopold, Luna B. 1997. *Water, Rivers and Creeks*. Sausalito, California. University Science Books.

Mackie, Gerald L. 2001. *Applied Aquatic Ecosystem Concepts*. Dubuque, Iowa. Kendall/Hunt Publishing.

Mason, Christopher, F., 2002. *Biology of Freshwater Pollution*. Edinburgh. Pearson Education Limited

McCafferty, Patrick W. 1981. *Aquatic Entomology, The Fishermen's and Ecologists' Illustrated Guide to Insects and Their Relatives*. Sudbury, Massachusetts. Jones and Bartlett Publishers.

Meyer, J. L. and Wallace, J. B. 2001. Ecology: *Achievement and Challenge, Lost linkages and lotic ecology rediscovering small streams*. Oxford, England. M. C. Press.

Miltner, Robert J. and Rankin, Edward T. 1998. *Primary nutrients and the biotic integrity of rivers and streams*. Freshwater Biology. Vol. 40. Pp. 145-158.

New York State Department of Environmental Conservation, Division of Water Quality. 1994. *Water Quality Regulations Surface Water and Groundwater Classifications and Standards*. Effective January 9, Albany, NY.

New York State Department of Environmental Conservation Division of Water, 2000. *New York State Water Quality 2000.* NYS DEC technical report, October.

Nolan, J. Kelly 2003. *A rapid bioassessment of the White Creek, Washington County, NY*. Hudson Basin River Watch, Rapid Watershed Assessment Program technical report.

Nolan, J. Kelly, Smith, Alexander J. 2001. *An expanded rapid bioassessment of the White Creek, Washington County*, NY. Hudson Basin River Watch, Rapid Watershed Assessment Program technical report.

Novak, Margaret A.; Bode, R. W., L.E. Abele. 1986. *Battenkill Biological Assessment*. NYS DEC technical report.

Novak, M. A. and Bode, R. W. 1992. *Percent model affinity: a new measure of macroinvertebrate community composition*. Journal of the North American Benthological Society. 11(1): 80-85.

Novak, M.; Bode, Robert W., L.E. Abele, D.L. Heitzman, and A.J. Smith. 2001. *Battenkill Biological Assessment*. NYS DEC technical report.

Peckarsky, Barbara L. et al. 1990. *Freshwater Macroinvertebrates of Northeastern North America*. Ithaca, NY. Cornell University Press.

Riva-Murry, Karen, Bode, Robert W., Phillips, Patrick J., and Wall, Gretchen L., 2002. Impact Source Determination with Biomonitoring data in New York State: Concordance with Environmental Data. Northeastern Naturalist. Vol., 9. Pp. 127-162.

Bibliography cont.

Rosenberg, David M. and Resh, Vincent H. 1993. *Freshwater Biomonitoring and Benthic Macroinvertebrates.* Boston, Mass. Kluwer Academic Publishers.

Simon, Thomas P. 2003. *Biological Response Signatures Indicator Patterns Using Aquatic Communities.* Washington, D.C. CRC Press.

Smith, Alexander J. and Bode, Robert W. (unpublished). *Variability in kick samples and fixed-count subsamples across a wide range of water quality.* NYS DEC

Stevenson, Jan R. Bothwell, Max L. Lowe, Rex L. 1996. *Algal Ecology.* San Diego, California: Academic Press.

Voshell, J. Reese. 2002. *A Guide to Common Freshwater Invertebrates of North America.* Virginia: McDonald and Woodward Publishing.

Water Quality Guidelines for Dissolved Gas Supersaturation. 2002. Http://wlapwww.gov.bc.ca/wat/wq/bcguidelines/tgp/tgptextonly

Wang, Lizhu; Lyons, John; Kanehl, Paul; and Gatti, Ronald. 1997. *Influences of Watershed Land Use on Habitat Quality and Biotic Integrity in Wisconsin Streams.* Fisheries. Vol., 22. Pp. 6-12.

Washington, H. G. 1982. *Diversity, Biotic and Similarity Indices; A review with special relevance to aquatic ecosystems.* Water Res. Vol. 18 No. 6. Pp. 653– 694.

Watersheds. Water, Soil, and Hydro-Environmental Decision Support System. 1994. *Aquatic Life: Rivers and Streams*, Salmonidae. http://h2osparc.wq.ncsu.edu/index.html

Weston, Deborah. 1974. *Nitrate and Nitrite Toxicity to Salmonoid Fishes.* The Progressive Fish Culturist. Vol., 36. Pp. 87-89.

Yoder, C.O. 1991. The integrated biosurvey as a tool for evaluation of aquatic life use attainment and impairment in Ohio surface waters. Pages 110-122 in George Gibson, editor. *Biological criteria; Research and regulation, proceedings of a symposium.* U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA-440-5-91-005.

Appendix I

Physical Survey / Habitat Assessment

Assess a 200 foot segment up & down stream from your sample site

Name(s) J. Kelly Nolan _____ Date 5/8/2004 Time 10:30 am

School/Group Hawthorne Valley Farms _____ Stream Agawamuck Creek ____ Site 1 _____

Weather: Today: Partly cldy _____ Past 2 days Partly cldy _____ **Temperature:** Air 24 °C _____

UTM Coordinates: 18T 616051 mE   4680721 mE _____   Water 11° C _____

Sampling Site Type (Check one from each row)								
Stream Size	Headwater Tributaries (<20 cfs)		**Creeks and Streams (20-150 cfs)** ✔			**Larger Rivers (>150 cfs)**		
Gradient	FAST (primarily riffle)		VARIED (pools and riffles) ✔			SLOW (low gradient)		
Surrounding Land Use	Forested		Agricultural		Residential		Urban	
	dense	sparse	pasture-land	crop-land	rural ✔	village	suburban	resident-ial	commercial/ industrial

Upstream Dam: ☐ Yes ☑ No   The stream is on average 6.5 meters wide and 0.10 meters deep
How far up stream: _____

Compared to the height of the stream channel, the water level seems relatively: ☐ High ☐ Low ☑ Average

Turbidity is substantially greater than natural conditions: ☐ Yes ☑ No Describe_____

Algal or weed growth: ____10____ % of bottom covered

Oily film, grease globules, or unusual odor or color present ☐ Yes ☑ No
Describe:_____

Average velocity: average time it takes to flow 3 meters: a) 3 m / _____ = v1 _____
                                                                b) 3 m / _____ = v2 _____
                                                                AVERAGE: 0.6 **m/sec**

NOTE: 0.45 – 0.75 m/sec is optimal for macroinvertebrate collection sites.

Additional Notes:

Appendix I

Assessment Factor	Excellent	Good	Fair	Poor
Riffle Size	Well-developed riffle, as wide as stream & as long as 2x stream width; ✔	Riffle as wide as stream but riffle length < 2x stream width	Riffle not as wide as stream and length < 2x stream width	Riffles or run virtually nonexistent
Substrate Size	Cobble predominates; ✔ boulders, gravel common	Cobble less abundant; boulders and gravel common	Gravel, boulders or bedrock prevalent; some cobble	Large boulders and bedrock or sand & silt prevalent; cobble lacking
Shelter for Fish	Snags, submerged logs, undercut banks, or other stable habitat are found in over 50% of the site	Snags, submerged logs, undercut banks, or other stable habitat are ✔ found in 30-50% of the site	Snags, submerged logs, undercut banks, or other stable habitat are found in 10-30% of the site	Snags, submerged logs, undercut banks, or other stable habitat are found in < 10% of the site
Embeddedness (for tier 3, use *Stream Bottom Survey*)	Rocks in stream <25% embedded; ✔ very little sand, silt, or mud	Rocks 25-50% embedded; can easily turn over rocks	Rocks 50-75% embedded and firmly stuck in sediments	Rocks >75% embedded; bottom mostly sand, silt, or mud
Flow Pattern (deep is > 2 ft)	All 4 patterns present: slow/deep, fast/shallow fast/deep, slow/shallow	Only 3 of 4 flow patterns present ✔	Only 2 of 4 flow patterns present	Dominated by 1 flow pattern
Channel Alteration	Stream straightening, dredging, artificial embankments, dams or bridge abutments absent or minimal; stream with meandering pattern	Some stream straightening, dredging, artificial embankments, or dams present, ✔ usually near bridge abutments; no recent channel alteration	Artificial embankments present to some extent on both banks; and 40-80% of stream site straightened, dredged, or otherwise altered	Banks shored with gabion or cement; over 80% of the stream site straightened and disrupted
Stream bank cover and stability *	Banks stable; no evidence of erosion; bank covered by vegetation or rock	Moderately stable; small areas of erosion; ✔ most of bank covered by vegetation or rock	Largely unstable; almost half of bank has areas of erosion or is not covered by vegetation or rock	Unstable, eroded; < half of bank covered by vegetation or rock, or rock slumping into creek
Disruption of riparian bank coverage* (land bordering stream bank)	Mature trees and vegetation; most growing naturally; no disturbance by forestry, grazing, or mowing	Trees, woody plants, soft green plants dominate; some disruption but not affecting full plant growth potential	Obvious disruption; patches of bare soil, cultivated fields or closely cropped ✔ vegetation are the norm	Not much natural vegetation left or it has been removed to 3" or less in height
Width of riparian vegetation zone*	More than 35 yards wide; human activities have not impacted zone	Zone 12-35 yards wide; marginal impact from human activities	Zone 6-12 yards wide; impact from human activities evident	Zone <6 yards; lots of nearby human activities ✔
Litter	No litter (metal or plastic) ✔ area	Very little litter; accidentally dropped	Litter fairly common; purposely dropped	Lots of litter present; obviously dumped

*if the two banks are very different, assess the worse side

Given the assessment above, how would you rate your habitat? ___Excellent-Good___

Describe how land uses / human activities may be impacting the stream:

HBRW Tiers 2 & 3

Physical Survey / Habitat Assessment

Site [1]_____ Date 5/8/2004_____

Flow

Collecting area

Flow

Flow

Collecting area

Collecting

©

Appendix II

Chemical Data Reporting Sheet

Name(s) J. Kelly Nolan

Organization/School/Agency HBRW
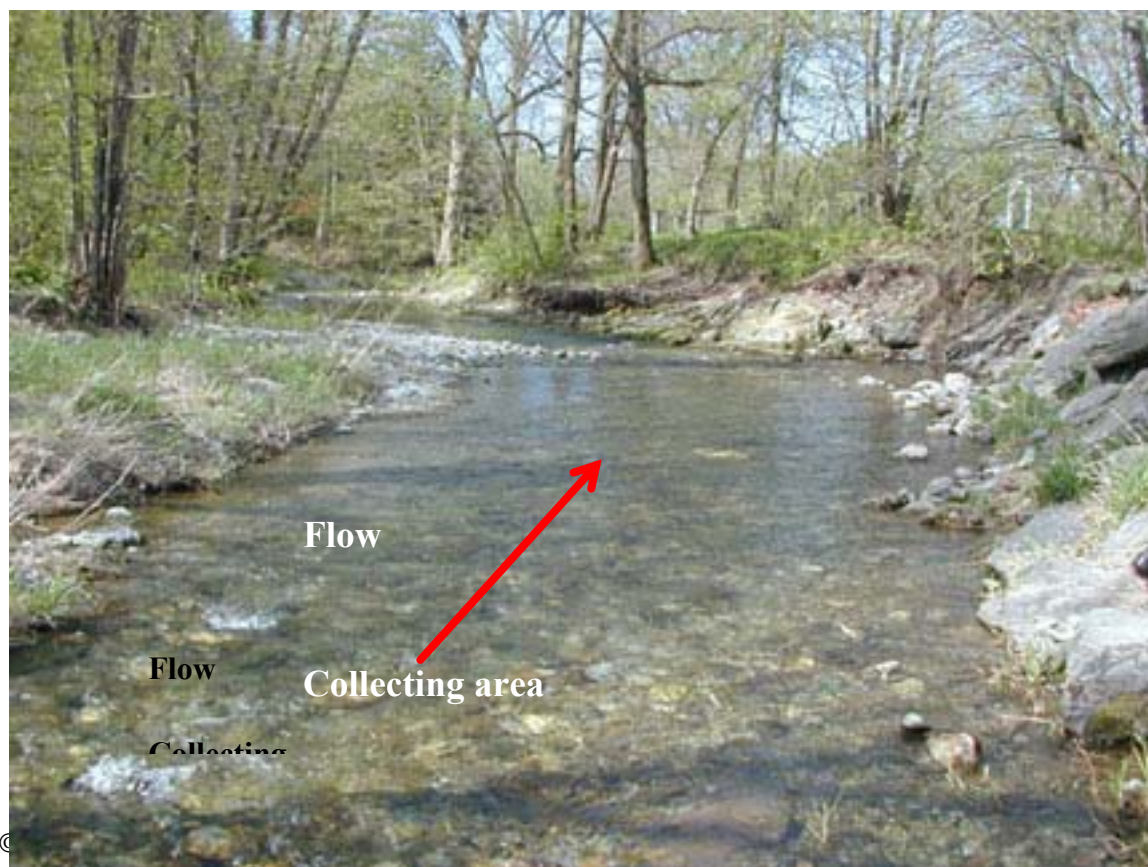
Stream/County Agawamuck Creek

Date(s) Sampled May 8, 2004   Air temp 24 C

Today's weather conditions: clear   cloudy ✓   light rain   heavy rain   Past 24 hrs: Partly cldy

Site Number	1							
pH	7.1							
Alkalinity (mg/l)	54							
Turbidity Units FAU	2							
Conductivity (µs/cm)	110							
Nitrate-Nitrogen: NO3-N (mg/l)	4							
Phosphorus (mg/l) Report as P	.07							
Dissolved Oxygen (mg/l)	10.8							
Water Temp.	11 C							
Barometric Pressure (mm)	---							
Dissolved Oxygen % saturation	97							
Other:								

Additonal Notes:

Appendix III

Site Site 1 (Behind Hawthorn Valley School) River/Stream/County: Agawamuck Creek, Columbia Co. NY

Date Sampled: May 8, 2004   Name(s) Hawthorn Valley Farms

Date of Lab Work May 9, 2004   # Squares Picked   1: 0.5   Mean: 0.5

Total # Squares in Tray Grid   12

Replicate #   1   Replicate #   1

I	II	III	IV	V	VI		I	II	III	IV	V	VI
Families in Major Groups	(1)	D (2)	D̄	x̄	% (3)		**Families in Major Groups**	T	D	D̄	x̄	%
EPHEMEROPTERA (E)							**TRICHOPTERA (T)**					
Baetidae	6	6	6	36	0.06		Brachycentridae	2	0	0	0	0
Baetiscidae	4	0	0	0	0		Glossosomatidae	1	0	0	0	0
Caenidae	6	0	0	0	0		Helicopsychidae	3	0	0	0	0
Ephemerellidae	2	0	0	0	0		Hydropsychidae	5	1	1	5	0.01
Ephemeridae	4	10	10	40	0.1		Hydroptilidae	6	0	0	0	0
Heptageniidae	3	65	65	195	0.65		Lepidostomatidae	1	0	0	0	0
Leptophlebiidae	4	0	0	0	0		Leptoceridae	4	0	0	0	0
Metretopodidae	2	0	0	0	0		Limnephilidae	4	0	0	0	0
Isonychiidae	2	1	1	2	0.01		Molannidae	6	0	0	0	0
Polymitarcyidae	2	0	0	0	0		Odontoceridae	0	0	0	0	0
Potomanthidae	4	0	0	0	0		Philopotamidae	3	0	0	0	0
Siphlonuridae	7	0	0	0	0		Phryganeidae	4	0	0	0	0
Tricorythidae	4	0	0	0	0		Polycentropodidae	6	0	0	0	0
Other		0	0	0	0		Psychomyiidae	2	0	0	0	0
		0	0	0	0		Rhyacophilidae	1	0	0	0	0
Subtotal E			82	273	0.82		Sericostomatidae	3	0	0	0	0
PLECOPTERA (P)									0	0	0	0
Capniidae	3	0	0	0	0		Other		0	0	0	0
Chloroperlidae	0	8	8	0	0.08		*Subtotal T*			1	5	0.01
Leuctridae	0	0	0	0	0		**DIPTERA (D)**					
Nemouridae	2	0	0	0	0		Athericidae	4	0	0	0	0
Peltoperlidae	0	0	0	0	0		Blephariceridae	0	0	0	0	0
Perlidae	3	0	0	0	0		Ceratopogonidae	6	0	0	0	0
Perlodidae	2	3	3	6	0.03		Chironomidae	6	3	3	18	0.03
Pteronarcyidae	0	0	0	0	0		Tipulidae	4	3	3	12	0.03
Taeniopterygidae	2	0	0	0	0		Empididae	6	0	0	0	0
		0	0	0	0		Simuliidae	5	0	0	0	0
Other		0	0	0	0		Tabanidae	5	0	0	0	0
Subtotal P			11	6	0.11				0	0	0	0
MEGALOPTERA (M)									0	0	0	0
Corydalidae	4	0	0	0	0				0	0	0	0
Sialidae	4	0	0	0	0		Other		0	0	0	0
		0	0	0	0		*Subtotal D*			6	30	0.06
Other		0	0	0	0		**ISOPODA (I)**					
Subtotal M			0	0	0		Asellidae	8	0	0	0	0
LEPIDOPTERA (L)									0	0	0	0
Pyralidae	5	0	0	0	0		Other		0	0	0	0
		0	0	0	0		*Subtotal I*			0	0	0
Other		0	0	0	0							
Subtotal L			0	0	0							

Appendix III

COLEOPTERA (C)					
Dryopidae	5	0	0	0	0
Elmidae	5	0	0	0	0
Gyrinidae	4	0	0	0	0
Haliplidae	5	0	0	0	0
Psephenidae	4	0	0	0	0
		0	0	0	0
Other		0	0	0	0
Subtotal C			0	0	0
ODONATA (O)					
Aeshnidae	5	0	0	0	0
Calopterygidae	6	0	0	0	0
Coenagrionidae	8	0	0	0	0
Cordulegastridae	3	0	0	0	0
Corduliidae	2	0	0	0	0
Gomphidae	4	0	0	0	0
Lestidae	9	0	0	0	0
Libellulidae	2	0	0	0	0
Macromiidae	2	0	0	0	0
		0	0	0	0
Other		0	0	0	0
Subtotal O			0	0	0
AMPHIPODA (A)					
Crangonyctidae	6	0	0	0	0
Gammaridae	6	0	0	0	0
Talitridae	8	0	0	0	0
		0	0	0	0
Other		0	0	0	0
Subtotal A			0	0	0

DECAPODA (I)					
Cambaridae	6	0	0	0	0
Astacidae	6	0	0	0	0
Other		0	0	0	0
Subtotal I			0	0	0
OTHER					
Oligochaeta	9	0	0	0	0
Hirudinea	7	0	0	0	0
Gastropoda	7	0	0	0	0
Pelecypoda	6	0	0	0	0
Turbellaria	6	0	0	0	0
Nemertea	8	0	0	0	0
Other		0	0	0	0
Subtotal Other			0	0	0

TOTALS			100	314	1

Organism Density/Sample Unit	2400
EPT Richness	7
Total Family Richness	9
EPT/EPT+Chironomidae Ratio	0.97
Biotic Index	3.14
% Contribution of Dominant Family	65%
% Model Affinity	52%

% COMPOSITION OF MAJOR GROUPS		
EPHEMEROPTERA		82%
PLECOPTERA		11%
TRICHOPTERA		1%
CHIRONOMIDAE		3%
OTHER DIPTERA		3%
COLEOPTERA		0%
ODONATA		0%
MEGALOPTERA		0%
LEPIDOPTERA		0%
AMPHIPODA		0%
ISOPODA		0%
OLIGOCHAETA		0%
GASTROPODA		0%
PELECYPODA		0%
OTHER		0%

EPT RICHNESS = RE+RP+RT

# Ephemeroptera Families	4
# Plecoptera Families	2
# Trichoptera Families	1
EPT Richness (Total)	7

Codes:

(1) T = Hilsenhoff pollution tolerance- NYS DEC adj

(2) D = Density

(3) % = percent composition

Total Coliform- 77/100 ml
E. Coli- 10/100 ml

NEW YORK STATE SURFACE WATER QUALITY STANDARDS CLASS C WATERS

According to the DEC Water Quality Regulation manual, the best usages of Class C waters are for fishing. Furthermore, the waters shall be suitable for fish propagation and survival and the quality shall be suitable for primary (where body may become submerged in water) and secondary (where contact with the water is minimal) contact recreation.

Parameter	Class	NYS DEC Standard
PH	C, C (TS)	Shall not be less than 6.5 nor more than 8.5.
Dissolved Oxygen	C, C (TS)	For cold waters suitable for trout spawning, the DO concentration shall not be less than 7.0 mg/L from other than natural conditions. For trout waters, the minimum daily average shall not be less than 6.0 mg/L, and at no time shall the concentration be less than 5.0 mg/L. For nontrout waters, the minimum daily average shall not be less than 5.0 mg/L, and at no time shall the DO concentration be less than 4.0 mg/L.
Temperature	C, C (TS)	No standard
Total phosphorus	C, C (TS)	None in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.
Nitrogen	C, C (TS)	None in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.
Alkalinity	C, C (TS)	No standard
Total Coliforms (number per 100 ml)	C, C (TS)	The monthly median value and more than 20 percent of the samples, from a minimum of five examinations, shall not exceed 2,400 and 5,000, respectively.
Fecal Coliforms (number per 100 ml)	C, C (TS)	The monthly geometric mean, from a minimum of five examinations, shall not exceed 200.
Turbidity	C, C (TS)	No increase that will cause a substantial visible contrast to natural conditions.
Oil or floating substances	C, C (TS)	No residue attributable to sewage, industrial wastes or other wastes, nor visible oil film nor globules of grease.

According to the unofficial version of the NYS DEC State's digital stream classification CD program the Agawamuck Creek site tested is class C with C (TS) standards.

NYS DEC FAMILY-LEVEL MACROINVERTEBRATE INDICES

1. *Family richness:* This is the total number of macroinvertebrate families found in a riffle kick sample. Expected ranges for 100-organism sub samples of kick samples in most streams in New York State are: greater than 13, non-impacted; 10-13, slightly impacted; 7-9, moderately impacted; less than 7, severely impacted.
2. *Family EPT richness:* EPT denotes the orders of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). These are considered to be mostly clean-water organisms, and their presence generally is correlated with good water quality (Lenat, 1987). The number of EPT families found in a 100-organism sub sample is used for this index. Expected ranges from most streams in New York State are: greater than 7, non-impacted; 3-7, slightly impacted; 1-3, moderately impacted; and 0, severely impacted.
3. *Family Biotic Index:* The family-level Hilsenhoff Biotic Index is a measure of the tolerance of the organisms in the sample to organic pollution (sewage inputs, animal wastes) and low dissolved oxygen levels. It is calculated by multiplying the number of individuals of each family 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). Values are listed in Hilsenhoff (1988); additional values for non-arthropods are assigned by the NYS Stream Biomonitoring Unit. The most recent values are listed in the Quality Assurance document (Bode et al., 1996). Ranges for the levels of impact are: 0-4.50, nonimpacted; 4.51-5.50, slightly impacted; 5.51-7.00, moderately impacted; and 7.01-10.00, severely impacted.
4. *Percent Model Affinity:* 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 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.

Non-impacted: Indices reflect very good water quality. The macroinvertebrate community is diverse, usually with at least 12 families in riffle habitats. Mayflies, stoneflies, and caddisflies are well represented; EPT family richness is greater than 7. 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.

Slightly impacted: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Family richness usually is 9-12. Mayflies and stoneflies may be restricted, with EPT values of 4-7. 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.

Moderately impacted: Indices reflect poor water quality. The macroinvertebrate community is altered to a large degree from the pristine state. Family richness usually is 6-8. Mayflies and stoneflies are rare or absent, and caddisflies are often restricted; EPT richness is 1-3. 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.

Severely impacted: Indices reflect very poor water quality. The macroinvertebrate community is limited to a few tolerant Families. Family richness is less than 6. Mayflies, stoneflies, and caddisflies are rare or absent; EPT richness is 0. The biotic index value is greater than 8.51. 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.

Reprinted by permission– NYS DEC (Revised January 2003)

How to Summarize and Interpret Benthic Macroinvertebrate Data
Geoff Dates and Jack Byrne: *Living Waters, Using Benthic Macroinvertebrates and Habit to Assess Your River's Health*. River Watch Network. 1997.
The following is modified to the NYS DEC Stream Biomonitoring Unit Indices

Organism Density/Per Sample:
An estimate of the total number of individuals in the sample based on the number of organisms picked from a certain number of squares.
It is calculated as follows:
1. Calculate the average density for each major group (density for each replicate divided by the number of replicates) and sum them to find the total average # of organisms picked.
2. Divide the number of squares picked by the number of squares in the grid to find the percentage of squares picked (e.g. 3 ¸ 12 = 0.25).
3. Divide the total average # of organisms picked by the percentage of squares picked. The result is the organism's density per sample.

Density varies considerably from stream to stream. It's best to compare results with a specific reference site. In general, however, density will increase with the addition of organic matter (which happens naturally in a river system as one moves downstream) and/or improvements in habitat conditions. Density will decrease with siltation, low pH, and toxic substances.

Family EPT Richness:
The number of mayfly (E), stonefly (P), and caddisfly (T) families in the sample. This is an actual count of the number of families in the sample.
EPT family richness is calculated by summing the number of mayfly, stonefly, and caddisfly families in which you found and entered at least one organism on the work sheet (including the taxa in the "Other" section).

The orders Ephemeroptera (mayflies), Plecoptera (stonefly), and Trichoptera (caddisflies) are known to contain many taxa, which are sensitive to water quality changes. Generally, the more EPT families, the better the water quality or the better the habitat. However, some pristine headwater streams may be naturally low in richness, due to a relative lack of food (quantity and different types) and generally lower abundance of organisms. In these areas, an increase in richness may mean pollution from organic material (from failing septic systems, for example).

For most sites, there should be more than 10 – 12 estimated or identified families.

However, the newly revised expected EPT Family richness index for a 100-organism sub sample in New York State provided by the NYS DEC Stream Biomonitoring Unit ranges are:
·   Greater than 7, non-impacted
·   3-7, slightly impacted
·   1-2, moderately impacted
·   0, severely impacted

Family Richness:
The number of macroinvertebrate families in the sample. It is an actual count of the number of families in the sample.

Total family richness is calculated by summing the number of families in which you found and entered at least one organism on the work sheet (including the taxa in the "Other" section).

Total family richness is a rough measure of the diversity of the macroinvertebrate community. It responds in much the same way as EPT Richness.

(Revised January 2003)

Expected ranges for 100-organism sub samples of kick samples in most streams in New York State are:

- greater than 13, non-impacted;
- 10-13, slightly impacted;
- 7-9, moderately impacted;
- less than 7, severely impacted.

EPT/EPT + Chironomidae:
EPT/EPT + Chironomidae is a measure of the ratio of the abundance of the intolerant EPT orders to the generally tolerant Diptera family Chironomidae. EPT/EPT + C is calculated by dividing the number (abundance) of animals from the orders Ephemeroptera, Trichoptera and Plecoptera, by the above plus the number of animals of the order Chironomidae in the sample.

The results now lie between 0 and 1. The closer to 1, the better:
- >0.65 = Reference condition
- >0.55 = Minimal change from reference condition
- >0.45 = Moderate change from reference condition

Family Biotic Index:
This analysis was developed by Hilsenhoff and summarizes the various pollution tolerances of the families that make up the aquatic insect community with a single value. Each family is assigned a pollution tolerance value from 0 – 10, with 0 being intolerant and 10 being the most tolerant.
The index is calculated as follows:
1. Determine the pollution tolerance values for each family.
2. For each Family, calculate the following: Average density for each Family X the Pollution Tolerance Value for Each Family.
3. Add the results for all the families and divide this by the Total average density (# of organisms picked). The result is the biotic index.

The NYS DEC Stream Biomonitoring Unit family Biotic Index is:
- 0 – 4.50, non-impacted
- 4.51 –5.50, slightly impacted
- 5.51 – 7.00, moderately impacted
- 7.01 - 10.0, severely impacted

The Biotic Index increases with pollution from sources of organic material like sewage or animal manure.

% Contribution of Dominant Family:
The percentage of the sample made up of the most abundant family.
It is calculated as follows:
1. Identify the family in the sample with the most organisms picked (average density)
2. Divide the # of organisms picked in this family by the total number picked in the sample. This is the percent contribution of the dominant family.

A sample dominated (>50%) by one family may indicate an environmental impact.

% Model Affinity:
This is a measure of the similarity of the Percent Composition of Selected Major Groups of your sample to that of a model "non-impacted" community. The Model Community for NYS is as follows:
- 40% Ephemeroptera (Mayflies)
- 5% Plecoptera (Stoneflies)
- 10% Trichoptera (Caddisflies)
- 10% Coleoptera (Beetles)

- 20% Chironomidae (Midges)
- 5% Oligochaeta (Worms)
- 10% other

The Percent Model Affinity is calculated as follows:
1. Determine the percent of the sample in each of the seven major groups (see percent composition above).
2. For each group, find the absolute difference (subtract the lower percent from the higher percent) between the model and the sample.
3. Sum these absolute differences.
4. Multiply the sum by 0.5 and subtract this number from 100. This is the percent Model Affinity.

Ranges for the levels of impact are:
- >64, non-impacted
- 50-64, slightly impacted
- 35-49, moderately impacted
- <35, severely impacted

% Composition of Major Groups:
The percent of the sample in selected major groups. These groups are Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies), Coleoptera (beetles), Chironomidae (midges), Oligochaeta (worms) and other.

It is calculated as follows:
1. Calculate the average density for each of the families (density for each replicate divided by the number of replicates) and sum them to find the total average # of organisms picked
2. Subtotal these densities for each major group.
3. Add the average densities for the major groups other than mayflies, stoneflies, caddisflies, beetles, midges and worms to find the average density for the "Other" group. Note: Chironomidae is not included in the "Other" group—though it's a family within the Order Diptera, it's a group in and of itself for this metric.
4. Apply the following formula to calculate the percent composition for each major group:

$$\frac{\text{Average Density for Each Major Group}}{\text{Total Average \# of Organisms Picked}}$$

In general, the mayflies, stoneflies, and caddisflies should be well represented. If any of these groups are absent, it indicates that there may be a problem. As a group, stoneflies are the most sensitive to pollution from sewage and other organic material. They usually make up a relatively small percentage of the sample (in NYS 5%) and are usually the first to disappear from the stream. If they are not present, stream quality may be moderately degraded. Mayflies contain many taxa that are sensitive to pollution. They make up a significant percent of the sample (in NYS 40%) and are usually the next to disappear. If neither mayflies nor stoneflies are present, the stream may be moderately to seriously degraded. Caddisflies contain many taxa that are sensitive to pollution, but also one common taxon (certain genera within the family Hydropsychidae), which is tolerant to pollution. It is very rare to find a sample with no caddisflies – usually the Hydropsychidae caddisflies will be present even in seriously degraded streams. If the sample is dominated (>50%) by worms or midges, the stream may be seriously degraded.