State of New Jersey
Jon S. Corzine, Governor

NJ Department of Environmental Protection
Lisa P. Jackson, Commissioner

STANDARD OPERATING PROCEDURES

AMBIENT BIOLOGICAL MONITORING USING BENTHIC MACROINVERTEBRATES

Field, Lab, and Assessment Methods

Water Monitoring and Standards
Bureau of Freshwater and Biological Monitoring

NJ Department of Environmental Protection

Land Use Management
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Water Monitoring and Standards
Leslie McGeorge, Administrator

Bureau of Freshwater & Biological Monitoring
Alfred L. Korndoerfer, Jr., Chief

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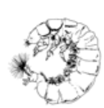
December 2007



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1.0 INTRODUCTION

Rationale for Biological Monitoring

Biological monitoring refers to the use of in-stream populations of benthic macroinvertebrates as indicators of water quality. Benthic macroinvertebrates are macroscopic invertebrate animals inhabiting aquatic habitats. In freshwater, common forms are aquatic insects, worms, snails and crustaceans. Macroinvertebrates are commonly found throughout the state's streams, fulfilling an important role in the aquatic food web. Species comprising the instream macroinvertebrate community occupy distinct niches (living spaces) governed by environmental conditions and their tolerance to pollution. Changes in environmental conditions are reflected by commensurate changes in macroinvertebrate community structure. Assessments of ambient water quality can then be based upon standardized measures of said changes in community structure.

In 1992, the Bureau of Freshwater & Biological Monitoring reactivated its **Am**bient Biomonitoring **Net**work (**AMNET**) which, at the time of its last sampling in 1988, consisted of only 18 sampling sites statewide. The old network was determined to be inadequate to support the department's 305(b) [water quality inventory report], 303(d) [list of impaired waters] and watershed programs, so bureau staff designed a new program.

The new statewide AMNET program established over 800 sampling stations throughout each of the 20 freshwater Watershed Management Areas, evaluating the health of instream benthic macroinvertebrate communities using a USEPA-developed monitoring and assessment methodology referred to as Rapid Bioassessment Protocol (RBP). Under AMNET, each of the State's five major Water Regions are sampled for benthic macroinvertebrates on a rotational schedule of once every five years. Visual observations, Stream Habitat Assessments and limited physical/chemical parameters are performed on each site.

Advantages of Using Benthic Macroinvertebrates:

1. They are good indicators of localized conditions of water quality due to their limited mobility. As such, they are well suited for the assessment of site specific pollution impacts.
2. They are sensitive to environmental impacts from both point and nonpoint sources of pollution.
3. They integrate the effects of short term environmental variations, such as oil spills and intermittent discharges.
4. Sampling is relatively easy and inexpensive.
5. They are holistic indicators of overall water quality, even for substances at lower than detectable limits.
6. They are normally abundant in New Jersey waters.
7. They serve as the primary food source for many species of fish important commercially and for recreation.
8. Unlike chemical monitoring, where impacts to the environment are by inference, not direct measurement, they are a direct measure of water quality degradation in a manner closely aligned with the goals of the Clean Water Act.
9. They can be used to assess non-chemical impacts to the benthic habitat, such as by thermal pollution or excessive sediment loading (siltation).
10. To the general public, impacts to resident benthic macroinvertebrate communities are more tangible measurements of water quality than more complex listings of chemical analysis results.
11. When used together with chemical/physical parameter monitoring, benthic macroinvertebrate monitoring can be used to identify sources of impairment.

Limitations:

Biological monitoring cannot replace chemical monitoring, toxicity testing, and other environmental measurements. Each of these tools provides the analyst with specific information only available by that procedure.

The next two pages provide an overview of the most common groups of organisms used when making biological impairment assessments.

Aquatic Organisms as Environmental Indicators

The following photos provide an overview of the major macroinvertebrate indicator groups employed in making biological water quality assessments.

Benthic Macroinvertebrates Usually Indicative of Good Water Quality

Mayfly nymphs are often abundant wherever the water is clean. They are sensitive to various types of water pollution, including low dissolved oxygen, ammonia, biocides, and metals.

Stonefly nymphs are usually found only in cool, well-oxygenated waters free of pollution. Though not usually found in the numbers characteristic of mayflies, the presence of even a few stoneflies is indicative of good water quality.

Most caddisfly larvae, many of which build portable cases of stones, sticks, sand, and other detritus, are intolerant of water pollution.

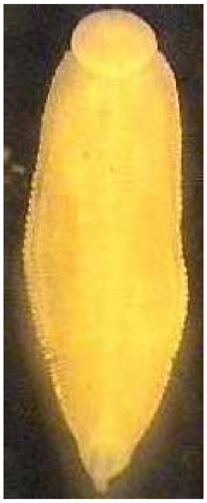
Aquatic beetles are common in well-oxygenated, swiftly running waters; many species are referred to as “riffle beetles.” They are usually indicative of clean water since they are sensitive to wetting agents (soaps and detergents) and other pollutants.

All photographs taken by D.Bryson, NJDEP

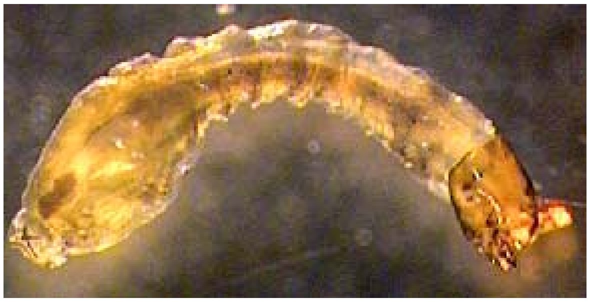
Benthic Macroinvertebrates Usually Indicative of Poor Water Quality

Midges (chironomids) are among the most common of aquatic invertebrates. They occupy a variety of aquatic habitats, including lakes, ponds, bogs, rivers, creeks, and marshes. They even exploit manmade habitats such as sewage treatment plants, water treatment plants, fish pools, irrigation ditches, and birdbaths. Many species are very tolerant of pollution.

Aquatic sowbugs, or freshwater isopods, are abundant in waters enriched with organic nutrients and low in dissolved oxygen. They are commonly observed in the recovery areas below sewage treatment plants.



Leeches and other segmented worms are very common in our lakes and streams, though not often noticed. They are tolerant of poor water quality and severe pollution.



Black fly larvae are filter feeders, capturing and ingesting plankton and bacteria from the surrounding water with specialized antennae. Some species are very tolerant of poor water quality and thus can be used as indicators of pollution.

All photographs taken by D.Bryson, NJDEP

2.0 SCOPE AND OBJECTIVES

The major goal of AMNET is to provide a cost efficient means of gauging the quality of surface water and watershed areas throughout the state. This is done through biological sampling and analysis of macroinvertebrate communities from a network of stream sites that adequately represents New Jersey's major drainage basins and NJDEP's Watershed Management Areas (WMAs). Administratively there are currently twenty-one (21) WMAs within New Jersey's five (5) major basins [Upper Delaware (aka Northwest), Lower Delaware, Northeast, Raritan, and Atlantic]. Each major basin is also known as a "Water Region". Each of the 21 WMAs are a sub-basin of a Water Region. There are an average of 165 AMNET sites in each Water Region with a statewide total of over 800 sites.

Another program goal is to monitor each Water Region's complement of stations within the optimal sampling season of April through November, giving our modelers and planners a snapshot of ambient biological conditions during that particular year.

The spatial distribution of stations is adequate to provide biological impact data on a long-term, basin-wide or statewide scale. It is likely not sufficient, however, to assess the biological impact(s) of any one point source of pollution, as this would be better served by a site-specific or intensive survey of the stream segment in question. The designated sampling interval for AMNET, of five years, reflects a realistic temporal lag between cessation of an environmental perturbation and recovery of the impacted biological community.

3.0 DATA USAGE

Data obtained is used in the generation of the biennial New Jersey Integrated Water Quality and Assessment Report [includes 305(b) and 303(d) list],which supports the development of water quality criteria to protect aquatic life and human health, the assignment of stream classifications to reflect existing and designated uses, and the promulgation of antidegradation policies to protect and maintain the quality of surface and ground waters of the State. Data is also used to support sound policy decisions in water quality/watershed management such as Category 1 (C1) designations, used in Stressor Identification (SI) investigations, and to direct regulatory or "permit" activities. The information gathered will be summarized in a final AMNET report which, following internal review, will be made generally available on the Bureau of Freshwater and Biological Monitoring website: www.state.nj.us/dep/wms/bfbm.

4.0 SITE SELECTION

As mentioned previously, the existing AMNET network contains over 800 active sites. These sites were initially selected to ensure complete and representative coverage of the State and each Water Region. Sites have been placed on “first order”, “second order”, and higher order streams as described by Strahler (see figure 1). To ensure enough flow for sampling, sites on "first-order" streams (those with no tributaries) are situated at least three miles downstream of headwaters. Since many first order streams have very little, or only intermittent flow, most sites are situated on second-order and higher waterways. All sites are located in reasonably accessible and primarily wadeable segments. Sites are located at, or upstream, of the head of tide.

AMNET site locations (latitude and longitude to nearest seconds) are determined via the Global Positioning System (GPS) using Trimble Pathfinder units and the appropriate correction sources utilized by NJDEP. This will allow field personnel to return to the exact site locations for current and future sampling. All positions are logged into the Geographical Information System (GIS).

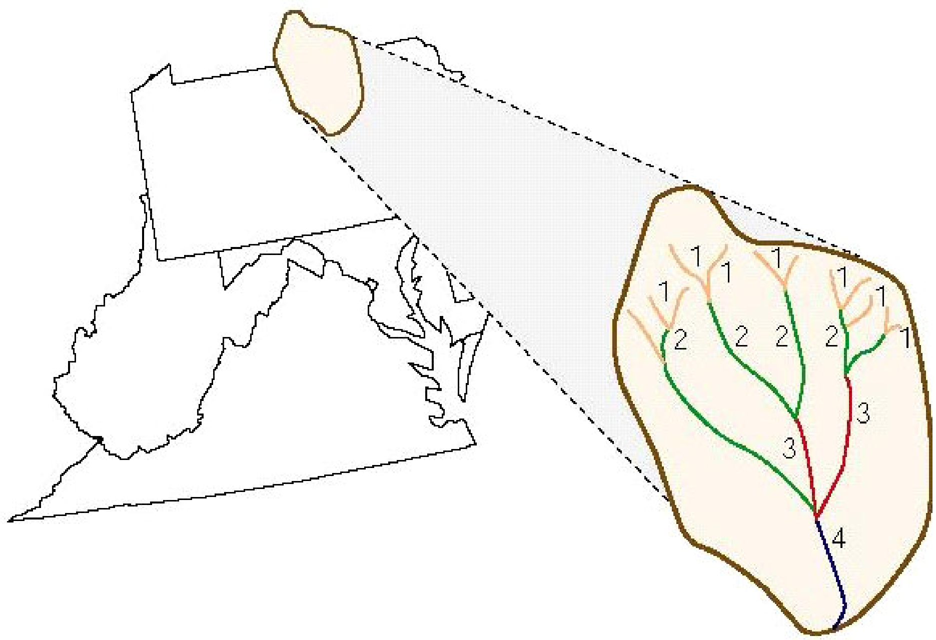


Figure 1. Strahler stream order diagram.
Stream size is categorized by Strahler stream order, demonstrated here for a watershed. The confluence (joining) of two 1st order streams forms a 2nd order stream; the confluence of two 2nd order streams forms a 3rd order stream. (USEPA, Office of Water, 2006)

5.0 METHODS

The methodology follows the Rapid Bioassessment Protocols (RBP), designed and validated under the auspices of the U. S. Environmental Protection Agency (USEPA); this is described in *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers, 2nd Edition* (Barbour et al, 1999). Data analysis and assessments were developed using the RBP multi-metric approach and are customized to New Jersey water regions.

5.1 Equipment

A complete checklist of field equipment is found in Appendix A. This checklist is filled out prior to leaving for sampling sites.

5.2 Safety

Foremost, when sampling, is to keep safety is mind. Listed below are **some** things to be aware of when sampling.

-Always sample using the "buddy system".
-Parking is frequently limited at sampling locations. Park in a safe legal location and use vehicle's hazard lights and traffic cones. Obtain permission when accessing private property
-Wear protective clothing. Hip boots or chest waders with steel shanks. Rubber gloves, especially when there is trash present or a discharger is upstream.
-Know the bottom of the stream. Look for any algae or other substances coating rocks and stream bottom. This can make movement very slippery and dangerous. Be careful of mud and silt, as you can sink several feet and get stuck even if the water depth is only a few inches.
-Look for deep pools. Use the pole of your net in front of you as a guide in deep water.
-Avoid areas where you cannot see the bottom from the surface.
-Look for any trash or glass which may be a hazard.
-Look for snags which may trip you.
-If the flow is too swift and/or too deep to manage, **do not sample**.
-Do not sample when ice is present.
-Keep car keys and valuables with your partner on the bank, or at a secure location.

5.3 Labels

Sample jars and field sheets are affixed with a pre-printed label containing the following:

1) collection date
2) watershed management area
3) station number
4) stream name \ location
5) sampler name(s)

5.4 Sample Collection

Level of effort is consistent for all sites. In the presence of road crossings, where possible, sampling is performed upstream of bridges, sufficiently removed to avoid the influence of any associated channel alterations.

5.4.1 Riffle/Run Sample

A riffle/run area is the ideal substrate in which to collect macroinvertebrates. It provides stable habitat in the form of large rocks and cobbles and is usually well oxygenated. A traveling kick method, using a D-frame net, is used in streams dominated by riffle/ run areas.

-Face downstream.
-Place the net on the stream bottom in front of you so the water flows into the net.
-Place your feet in front of the net and "kick" the stream bottom vigorously, in an area approximately the length and width of the net frame, to disturb the bottom and disengage any organisms attached to the substrate. Where substrate is too large to move with feet, rub the substrate with hands to dislodge organisms.
-Travel a few feet upstream, keeping the net in the water so the water flows into and does not release any organisms. Travel upstream from starting point, sampling in the above manner.
-Collect about 10 - 20 kicks using this method.

5.4.2 Multihabitat Sample

In slower moving low gradient streams, riffle areas are usually not present. Therefore, it will be necessary to sample with a multihabitat "jab and sweep" method, using a D-frame net. Substrates such as submerged portions of stream banks, submerged aquatic vegetation (macrophytes), gravel, snags (woody debris such as logs and branches, etc.) anything which a macroinvertebrate can cling to that serve as habitats. Remember to always sample riffle areas if they are present because they provide the ideal habitat. Unless it is the only habitat available, avoid sampling relatively low productive habitats such as leaf packs and sand.

-Face downstream
-Place net in front of the substrate you are sampling so the water flows into the net from the substrate.
-With your hands rub off the substrate so the organisms are dislodged and flow into the net. You can also kick a substrate vigorously as in the riffle method, and/ or jab and sweep with the net. Travel upstream from starting point, sampling in the above manner.
-Collect at least 10 - 20 samples in this fashion, proportionate to the habitat types present.

5.5 Sample Preservation

-Deposit contents of net into sieve bucket.
-Rinse net in the sieve bucket and use tweezers to pull off any organisms that are attached to the net. Place any organisms picked from the net directly into the sample container.
-While the sample is in the sieve bucket rinse off any large materials such as sticks, leaves, and large rocks which cannot fit into the sample jar. Make sure these are completely rinsed of organisms, then discard into the stream.
-Allow all water to flow from the sieve bucket, then place contents into the sample jar. Examine sieve for any adhering organisms; remove with tweezers and place directly into sample jar.
-Place a pre-printed AMNET label on the outside of the lid.
-Fill jar with water leaving an airspace of approximately ½ inch.
-Wearing protective eye-ware and gloves, add 30 mLs of formaldehyde to the sample. This will make an approximately 5 – 10 % solution of formaldehyde. Add 30-60 mLs more formaldehyde for samples with high organic content (algae, leaves, etc.). Place lid tightly on the jar and invert several times to mix.
-Place preserved sample in a closed cooler to prevent exposure to formaldehyde vapors.

5.6 Field Observations/ Habitat Assessment

The land surrounding the stream to be sampled can have an impact on the type of macroinvertebrates found at the site. Dischargers or non-point sources such as storm drains, agricultural run-off, septic system, golf courses, parking lots, construction sites, and many other types of runoff into the stream have an impact on water quality and habitat quality. When assessing surrounding land, note any dischargers or other activities near the site which may impact the stream. Also note the present and previous day's weather conditions as this can affect the amount of runoff.

Forested areas help prevent flooding and erosion, provide shade to keep the stream cool in the summer inhibiting oxygen depletion in the stream, and provide food when fallen leaves begin to degrade. It is important to note the amount of canopy, or trees and shrubs which overhang the stream. Note the proximity and amount of trees and shrubs along the stream bank as well as signs of flooding and erosion.

The in-stream substrate or habitat provides a place for macroinvertebrates to live. Run off and siltation from construction sites, for example, cover over existing habitats preventing organisms from establishing a place to survive. Although the water quality may still be good, noting the degradation of habitat is important in assessing what is happening to the stream. Record the types of substrate in the stream such as cobbles, snags, submerged vegetation, etc. (anything a macroinvertebrate can cling to).

Note the approximate average width, depth, and flow of a stream. Swift riffle areas provide more dissolved oxygen for organisms.

Note any other type of life, in or near the stream, such as submerged plants, excessive algae growth, fish, frogs, turtles, and waterfowl. This may offer a more complete picture as to the

health of a stream.
Physical/ Chemical Parameters are recorded while on site. Dissolved oxygen, pH, conductivity, and temperature are recorded using appropriate field meters following the respective manufacturer's instructions and in accordance with the specifications given in N.J.A.C. 7:18-8 (NJDEP, 1996) and Field Sampling Procedures Manual (NJDEP, 2005).

The *Biological Field Observations and Data Sheet* and *Habitat Assessment Sheet* are located in Appendix A. Complete all pertinent fields for each sheet while on site. Data sheets are specific for high or low gradient streams.

5.8 Sample Log

At the time samples are received in the lab, they are recorded into the AMNET log database. All fields on the log are completed. Any digital photos taken on site are downloaded at this time. Photo files are named with the AMNET number, up or downstream, and the month and year sampled; e.g. AN0123up1105.

5.9 Sample Processing

A 100 (± 10%) organism subsample is required to perform the biological assessments used in the AMNET program.

Transfer each sample to a #30 sieve and rinse gently, but thoroughly, with tap water to remove preservative, and fine sediment.

Place the washed sample in a light colored gridded pan and evenly distribute the sample.

A grid is randomly selected using a random number table. All material within the grid is scooped out using a lab spatula and placed into a Petri dish. The material in the dish is examined under low power (6.3x) using a stereo microscope. All observed organisms, in a condition well enough to allow for identification, are counted and removed with forceps to a separate Petri dish containing water. This procedure is repeated with additional grids until at least 100 organisms are obtained. To further eliminate bias, all organisms are removed from the grid in which the 100^{th} organism was found. This may result in a subsample much greater than required in the assessment methodology. In this case, all the organisms are identified. Then the identified individuals are added to a random generator program in MS Access. This program selects the required 100 organism subsample.

Record the number of grids sorted on the Macroinvertebrate Data laboratory bench sheet found in Appendix A.

If identification is delayed for more than one day, a few drops of 95% isopropyl alcohol is added to the Petri dish to prevent decay.

5.9 Taxonomic Identification

The biomonitoring laboratory utilizes updated, high-quality optical systems for macroinvertebrate identifications. Macroinvertebrates are identified using a Leica Model MZ6 stereomicroscope capable of up to 40x magnification. A compound microscope with 100x, 200x, 400x, and 1000x magnification will be used for very detailed identifying features. The biomonitoring laboratory currently uses Leica models DME and DMLS (with phase contrast) compound microscopes.

Individuals are identified to the lowest practicable taxonomic level (usually contingent on specimen condition and maturity) using the taxonomic references listed in Appendix C. Identifications are recorded on the Macroinvertebrate Data laboratory bench sheet found in Appendix A.

Morphological abnormalities are noted when observed. For chironomids, record the number of chironomids with abnormalities per the total number of chironomids identified in the subsample. For amphipods, record the total number of amphipods observed with abnormalities in the subsample.

Place identified sample in a jar containing 50% isopropyl alcohol. Attach a pre-printed AMNET sample label on the jar. Sample is retained until the data has been reviewed and verified.

6.0 DATA ENTRY/ ANALYSIS

Assessments are performed using a multimetric index, calibrated to major physiographic regions of the State, using recognized methods established by the USEPA (Barbour et al, 1999). Index scoring criteria is found in Appendix B.

The individuals identified in each sample are entered into the Bureau's Rapid Bioassessment Protocol (RBP Analysis) computer program. If more that 100 individuals are identified, enter each one, as the RBP Analysis Program will create a random, 100 individual, subsample. The RBP Analysis Program will calculate the bioassessment rating using the appropriate regional multi-metric index. Three distinct indices are used: High Gradient Macroinvertebrate Index (HGMI), Coastal Plain Macroinvertebrate Index (CPMI), and the Pinelands Macroinvertebrate Index (PMI). See Appendix B.

A data analysis sheet is printed and placed into the appropriate file, with the raw data bench sheets and field sheets attached, for data QC and verification.

Index and metric results are entered into the AMNET log.

7.0 QUALITY CONTROL

The Biomonitoring Operations Section is subject to audits and guidelines of the NJDEP Office of Quality Assurance Laboratory Certification Program as well as internal performance evaluations.

7.1 Quality Assurance Project Plan

A Quality Assurance Project Plan is prepared and submitted to the Office of Quality Assurance 30 days prior to the initiation of any project or study.

7.2 Taxonomic Identification

7.2.1 Ten percent of all macroinvertebrate samples are sent to an independent laboratory for confirmation. Eighty five percent, or better, taxonomic agreement between labs is the goal.

7.2.2 A reference collection of identified organisms is maintained in the laboratory for use in confirming identifications.

7.3 Physical/ Chemical Parameters

All equipment is calibrated, maintained, and used following manufacturer's instructions and in accordance with the specifications given in N.J.A.C. 7:18-8 (NJDEP, 1996).

8.0 REPORTS

All habitat assessments, physical/ chemical analyses, and site observations are recorded on the Bureau of Freshwater and Biological Monitoring Biological Field Observations and Data Sheet, and also recorded electronically in the AMNET log, Microsoft Access database.

All macroinvertebrate identifications are recorded on the Bureau of Freshwater and Biological Monitoring Macroinvertebrate Laboratory Data Sheet.

A draft report is issued to management approximately four months after all data is analyzed and verified, and will contain at a minimum: Index Scores and assessment ratings of all sites sampled, with an interpretive summary of these results; chemical results and GIS maps of the study area. A comparison of results to previous sampling rounds and a trends analysis will also be included.

9.0 REFERENCES

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APPENDIX A

Field and Laboratory Data Sheets

AMNET SAMPLING CHECKLIST
Date:

Sampling Equipment

- [ ] D-Frame Net
- [ ] Sieve Bucket
- [ ] Tweezers
- [ ] 1 L Sample Bottles (at least 8)
- [ ] Chem sample bottle
- [ ] Formaldehyde
- [ ] gloves - shoulder length
- [ ] gloves - wrist length
- [ ] chest waders

Meters/ Measuring

- [ ] pH meter
- [ ] D.O. Meter
- [ ] Cond. Meter
- [ ] Tape Measure
- [ ] camera

Paperwork

- [ ] Site List
- [ ] labels
- [ ] field sheets (at least 8)
- [ ] quad maps
- [ ] atlas

Safety

- [ ] goggles/ faceshield
- [ ] traffic cone
- [ ] hand wash

Other

- [ ] paper towels
- [ ] pencils
- [ ] kimwipes
- [ ] D.I. Water

Before Leaving Office

- [ ] calibrate pH meter
- [ ] calibrate cond. meter
- [ ] check D.O. probe for air bubbles
- [ ] turn on D.O. meter (calibrate in field)
- [ ] fill formaldehyde bottle

Return to Office

- [ ] download pictures
- [ ] log in samples
- [ ] place samples in cabinet
- [ ] turn off all meters
- [ ] place pH probe in storage sol'n
- [ ] make sure all sites sampled are checked on field site list

NJDEP-BFBM Biological Field Observations and Data Sheet HIGH Gradient

Date/Time: ____________________

Form Completed By: ____________

Quad: ________________________

Twp: ________________________

County: ______________________

Bridge # ______________________

Chemistries

_____ Temperature (°C)
_____ Conductivity (umhos)
_____ DO (mg/L)
_____ pH (SU units)

Water Clarity

- [ ] Clear
- [ ] Slightly Turbid
- [ ] Turbid

Color: ______________

Bank Stability

- [ ] Good
- [ ] Fair
- [ ] Poor

Stream Flow

- [ ] Slow
- [ ] Moderate
- [ ] Fast

_____ Width (ft)
_____ Depth (ft)

Substrate

- [ ] cobbles
- [ ] gravel / sand
- [ ] mud
- [ ] silt
- [ ] snags
- [ ] root mats
- [ ] undercut banks
- [ ] other: ______________

Bank Vegetation

- [ ] trees
- [ ] shrubs
- [ ] grasses
- [ ] weeds
- [ ] vines
- [ ] other: ______________

Canopy

- [ ] Open
- [ ] Mostly Open
- [ ] Partly Open
- [ ] Mostly Closed
- [ ] Closed

Land Uses

- [ ] Agriculture: Cropland
- [ ] Agriculture: Livestock
- [ ] Commercial
- [ ] Urban
- [ ] Suburban
- [ ] Rural
- [ ] Forested
- [ ] Industrial
- [ ] Other:

Point Sources

- [ ] Discharges
- [ ] Storm Sewers
- [ ] Other

- [ ] Downstream of impoundment — name: ______________ approx. distance: ______________

Comments:

____
____
____

Picture # ____Upstream ____Downstream

Sampling location: ____Upstream ____Downstream

Sampling device D-Net Surber Dredge

Present weather conditions: ____________

Previous 24 hr weather event: ____________

Other Observations: check all applicable (Record any other observations here)

- [ ] fish
- [ ] frogs
- [ ] crayfish
- [ ] turtles
- [ ] clams / Unionid mussels
- [ ] Zebra Mussels
- [ ] macrophytes
- [ ] periphytes
- [ ] filamentous algae
- [ ] water fowl
- [ ] beaver dam
- [ ] oil sheen

HABITAT ASSESSMENT FOR *HIGH* GRADIENT STREAMS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regimes	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is <0.3 m/s, deep is >0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity / depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

HABITAT SCORE

HABITAT SCORES	VALUE
OPTIMAL	160 – 200
SUB-OPTIMAL	110 – 159
MARGINAL	60 – 109
POOR	< 60

HABITAT ASSESSMENT OF *LOW* GRADIENT STREAMS

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

HABITAT SCORE

HABITAT SCORES	VALUE
OPTIMAL	160 - 200
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NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATERSHED MANAGEMENT
BUREAU OF FRESHWATER & BIOLOGICAL MONITORING
BIOMONITORING LABORATORY

Macroinvertebrate Data

Station name, Station location, Station ID #, Sample #, Program, Date collected, Sample collector(s), etc.

LABEL

	Start	Finish
Date of Analysis		

TAXA	L/N	P/A	TOTAL	TAXA	L/N	P/A	TOTAL

Total # Taxa: __________ Total # Organisms: _________ # Grids used: ________ Taxonomist(s)/Unit: ______________________

Comments: ____

APPENDIX B

Assessment Scoring Criteria

Multimetric Indices and Regulatory Thresholds For Benthic Macroinvertebrate Data In Wadeable Streams

Multimetric Index Development

New Jersey's benthic macroinvertebrate communities can be statistically grouped into three distinct structures based on geographical regions: high gradient (above the Fall Line), low gradient (Coastal Plain excluding the Pinelands), and Pinelands. To accurately assess biological conditions, a multimetric index was developed, using genus level taxonomic identifications for each distinct region using guidelines outlined in USEPA *Rapid Bioassessment Protocols(RBP) for Use in Wadeable Streams and Rivers* (see http://www.epa.gov/bioindicators/html/rbps.html). Before these three indices were developed, a single index was used statewide, the New Jersey Impairment Score (NJIS), which is based on family level taxonomic identifications. All current assessments will use the three genus level indices.

High Gradient and Low Gradient Streams

Two of the indices (see Table A1) to be employed in New Jersey, the High Gradient Macroinvertebrate Index (**HGMI**) [Jessup, 2007] and Coastal Plain Macroinvertebrate Index (**CPMI**) [Maxted, 2000] , were developed using guidelines outlined in USEPA *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers*. The resolution of index scoring thresholds was further enhanced by establishing a graphical relationship between the scores for each index and the tiers these scores represent in the context of a Biological Condition Gradient (BCG)[see summary of BCG below, and Figure(s) A2 & A3]. The final index scoring thresholds serves to assess each site from two perspectives: the condition of the macroinvertebrate community and the regulatory use attainment.

The final index scores were derived in coordination with professional staff from Water Monitoring and Standards' Bureau of Freshwater and Biological Monitoring, Water Monitoring and Standards' Bureau of Water Quality Standards and Assessment, USEPA, United States Geological Survey (USGS), and the Delaware River Basin Commission (DRBC). For each index, four descriptive categories were established at break points along the statistical distribution of scores from reference to degraded conditions, coordinated to the BCG to increase the accuracy; "Excellent", "Good", "Fair", and "Poor" (see Table A1). "Excellent" and "Good" fall into the acceptable regulatory range of fully attaining the aquatic life use. "Fair" and "Poor" fall below the acceptable regulatory range and are considered impaired, from a Federal Clean Water Act (CWA) perspective, and not attaining the use.

Pinelands Streams

The Pinelands Macroinvertebrate Index (**PMI**) was developed using the same USEPA guidelines and professional coordination as above. However, since a BCG was not developed, and not necessary from a regulatory standpoint, a graphical relationship between index scores and the BCG tiers was not generated. As with the high and low gradient indices, four descriptive categories were established at break points along the statistical distribution of scores from reference to degraded conditions "Excellent", "Good", "Fair", and "Poor" (see Table A1). For PL waters, "Excellent" and "Good" are classified as reference or natural conditions of Pineland waters and fall into the acceptable regulatory range of fully attaining the aquatic life use. "Fair" and "Poor" fall below the acceptable regulatory range and are considered impaired, from a CWA perspective, and not attaining the use.

The unique chemical, physical, and biological properties characteristic of waters contained with the Pinelands area are also present for varying distances outside this jurisdictional delineation. To assess these Pinelands-like waters outside the Pinelands area, the Department delineated a 5 kilometer buffer around the Pinelands Area and will apply the PMI to this region. Pinelands-like waters outside the jurisdictional delineation are, however, classified as FW2 and not PL. From a regulatory standpoint FW2 waters are held to a somewhat lower level of biological expectation than the Outstanding National Resource Waters (ONRW)waters contained within the PL designated Pinelands area. Because of this lower regulatory expectation for FW2 waters, the PMI category of “Fair” and above will be regarded as fully attaining the aquatic life use, i.e. biologically *nonimpaired* from a regulatory perspective. FW2 waters in this buffer region assessed as “Poor” will be regarded as *impaired* and not supporting the aquatic life use.

Coastal Plain Macroinvertebrate Index (CPMI)[1]

Study area: southern New Jersey, below the geologic fall-line; Middle Atlantic Coastal Plain ecoregion, excluding the Pinelands National Reserve. See figure A1.

Index Metrics
1. Total number of genera
2. Total number of EPT genera
3. Percent Ephemeroptera genera
4. Hilsenhoff Biotic Index
5. Percent Clinger genera

Index Metric	Score			
	6	4	2	0
Number of genera	>25	17-25	9-16	<9
Number of EPT genera	>9	7-9	4-6	<4
% of Ephemeroptera	>29	20-29	10-19	<10
Hilsenhoff Biotic Index	<4.9	4.9-6.0	6.1-7.3	>7.3
% Clingers	>51	34-51	17-33	<17

Assessment Rating	Score
Excellent	22-30
Good	12-20
Fair	10-6
Poor	< 6

Reference

J.R. Maxted, et al. Assessment framework for mid-Atlantic coastal plain streams using benthic macroinvertebrates. J.N. Am. Benthol. Soc. 2000, 19(1):128-144.

Attributes

Excellent: Minimal changes in structure of biological community and minimal changes in ecosystem function. Virtually all native taxa are maintained with some changes to biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.

Good: Some evident changes in structure of the biotic community and minimal changes in ecosystem function. Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but sensitive-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained.

Fair: **Moderate to major changes in structure of biological community and moderate changes in ecosystem function.** Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity.

Poor: Extreme changes in structure of biological community and major loss of ecosystem function. Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered.

[1] Based on 100 organism subsample, genus level taxonomy

Pinelands Macroinvertebrate Index (PMI)[1]

Study area: southern New Jersey, below the geologic fall-line within the Pinelands National Reserve and extending 5 kilometers outside the Reserve boundary. See figure A1.

Index Metrics

1. Number of Insect genera
2. Number of Non-insect genera
3. Percent Plecoptera (P) and Trichoptera (T)
4. Percent Diptera genera excluding Tanytarsini
5. Percent Mollusca and Amphipoda
6. Beck's Biotic Index
7. Percent Filterers

Assessment Rating	Score
Excellent	≥ 63
Good	< 63-56
Fair	< 56-34
Poor	< 34

Reference
Benjamin Jessup, et al. Report. Development of the New Jersey Pinelands macroinvertebrate index (PMI). TetraTech, Inc. Owings Mills, MD. March, 2005.

Attributes

Excellent: Minimal changes in structure of biological community and minimal changes in ecosystem function. Virtually all native taxa are maintained with some changes to biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.

Good: Some evident changes in structure of the biotic community and minimal changes in ecosystem function. Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but sensitive-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained.

Fair: Moderate to major changes in structure of biological community and moderate changes in ecosystem function. Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity.

Poor: Extreme changes in structure of biological community and major loss of ecosystem function. Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered.

[1] Based on 100 organism subsample, genus level taxonomy

High Gradient Benthic Index (HGMI)[1]

Study area: northern New Jersey, above the geologic fall-line including the following ecoregions: North Central Appalachians, Central Appalachian Ridges and Valleys, Northeastern Highlands, Northeastern Coastal Zone, and Northern Piedmont. See figure A1.

Index Metrics

1. Total number of genera $_{adj}$ = 26.53 + Metric – [22.776 + 4.173*log10(areasqkm)]
2. Percent of genera that are not insects
3. Percent sensitive EPT (excluding Hydropyschidae, including Diplectrona) $_{adj}$
   = 37.49 + Metric – [49.922 – 13.800*log10(areasqkm)]
4. Number of scraper genera $_{adj}$ = 5.44 + Metric – [3.889 + 1.724*log10(areasqkm)]
5. Hilsenhoff Biotic Index $_{adj}$ = 4.23 + Metric – [3.407 + 0.918*log10(areasqkm)]
6. Number of New Jersey TALU attribute 2 genera
7. Number of New Jersey TALU attribute 3 genera

ADJ (Adjusted metric value) = Mean $_{reference}$ + Metric $_{observed}$ – Metric $_{predicted}$, where predictions are based on linear regression analysis of reference metric values on catchment size.

Assessment Rating	Score
Excellent	≥ 63
Good	< 63 - 42
Fair	< 42 - 21
Poor	< 21

Reference

Benjamin Jessup, et al. Report. Development of the New Jersey high gradient macroinvertebrate index (HGMI). TetraTech, Inc. Owings Mills, MD. February, 2007.

Attributes

Excellent: Minimal changes in structure of biological community and minimal changes in ecosystem function. Virtually all native taxa are maintained with some changes to biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.

Good: Some evident changes in structure of the biotic community and minimal changes in ecosystem function. Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but sensitive-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained.

Fair: Moderate to major changes in structure of biological community and moderate changes in ecosystem function. Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity.

Poor: Extreme changes in structure of biological community and major loss of ecosystem function. Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered.

[1] Based on 100 organism subsample, genus level taxonomy

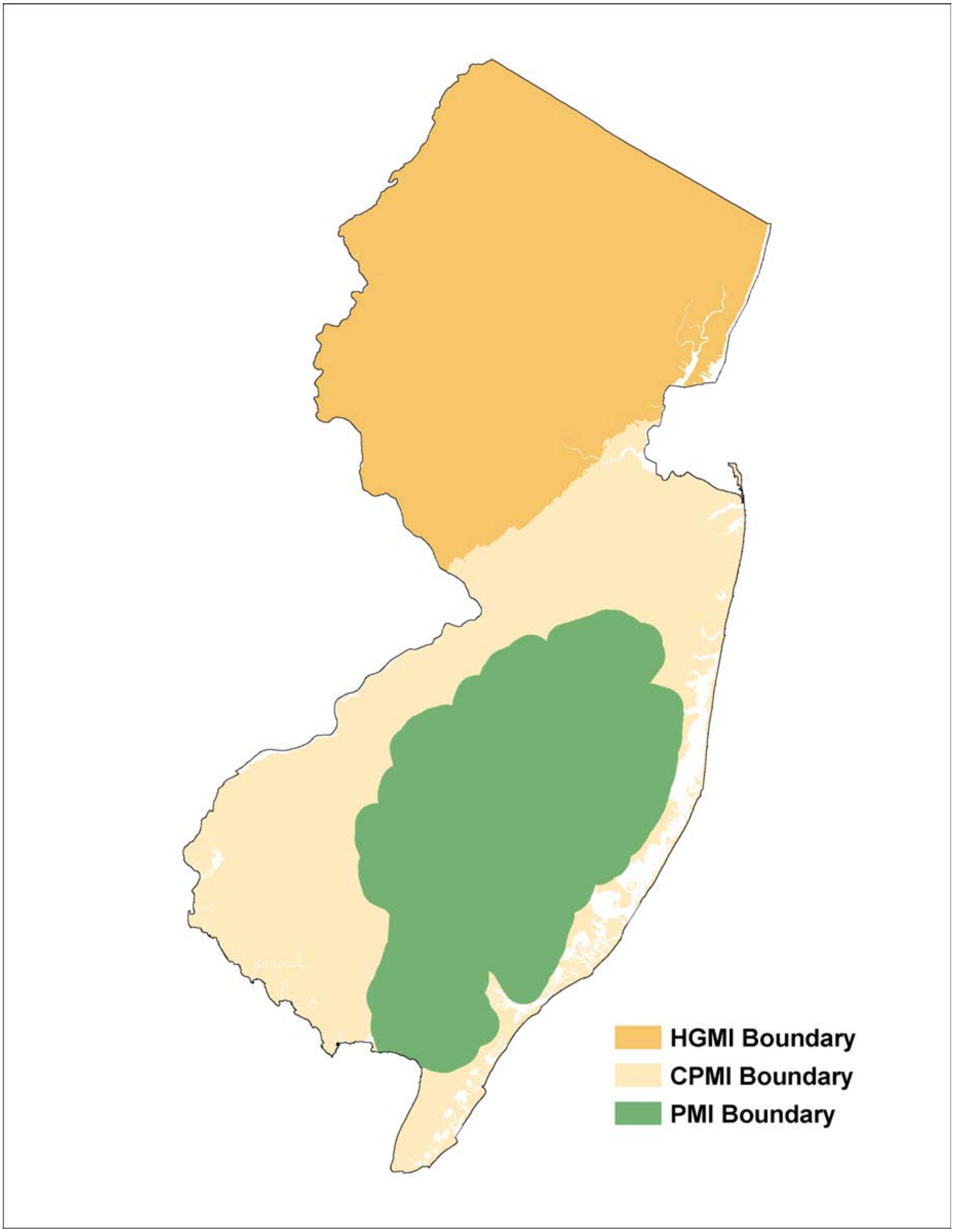


Figure A1. Boundaries for generic level index use.

Table A1: Descriptive and regulatory thresholds for Fresh Water High Gradient (Highlands, Ridge And Valley, Piedmont), Low Gradient (Coastal Plain, Excluding Pinelands Waters) and Pinelands Waters.

High Gradient Macroinvertebrate Index (HGMI) (Highlands, Ridge and Valley, Piedmont):		
Assessment category	**Index Score**	**Regulatory Threshold**
Excellent	63 - 100	Full Attainment
Good	<63-42	Full Attainment
Fair	<42-21	Non-Attainment
Poor	< 21	Non-Attainment
Coastal Plain Macroinvertebrate Index (CPMI)		
Assessment category	**Index Score**	**Regulatory Threshold**
Excellent	22 - 30	Full Attainment
Good	20 - 12	Full Attainment
Fair	10 - 6	Non-Attainment
Poor	< 6	Non-Attainment
Pinelands Macroinvertebrate Index (PMI)		
Assessment category	**Index Score**	**Regulatory Threshold**
Excellent	63 - 100	Full Attainment
Good	<63-56	Full Attainment
Fair	<56-34	Non-Attainment(PL) Full Attainment(FW2)
Poor	< 34	Non-Attainment

New Jersey Impairment Score (NJIS)[1]

Study Area: All of New Jersey. The NJIS was used for assessments in reports prior to 2007. This table can be used when referring to these historical documents.

Index metrics	6	3	0
Taxa Richness (total Families)	>10	10-5	4-0
E+P+T Index (EPT)	>5	5-3	2-0
Percent Dominance (%CDF)	<40	40-60	>60
Percent EPT[2] (%EPT)	>35	35-10	<10
Modified Family Biotic Index[3] (FBI)	<5	5-7	>7

Biological Assessment	Total Score
Non-impaired	24-30
Moderately Impaired	9-21
Severely Impaired	0-6

Reference
Kurtenbach, J. A method for rapid bioassessment of streams in New Jersey using benthic macroinvertebrates. Bull. N. Am. Benth. Soc. 8(1):129. 1991.

Attributes

Non-impaired: Benthic community comparable to other undisturbed streams within the region. A community characterized by a maximum taxa richness, balanced taxa groups and good representation of intolerant individuals.

Moderately Impaired: Macroinvertebrate richness is reduced, in particular EPT taxa. Taxa composition changes result in reduced community balance and intolerant taxa become absent.

Severely Impaired: A dramatic change in the benthic community has occurred. Macroinvertebrates are dominated by a few taxa which are very abundant. Tolerant taxa are the only individuals present.

[1] Based on 100 organism subsample, family level taxonomy. Used in previous assessments, replaced in favor of genus level indices.
[2] Including the hydropsychid family
[3] Also known as the Hilsenhoff Biotic Index

Summary of Biological Condition Gradient

A Biological Condition Gradient (BCG) defining aquatic use attainment, from a regulatory perspective, was established for wadeable streams in New Jersey by TetraTech, a USEPA contractor (Gerritsen and Leppo, 2005). A BCG establishes a conceptual framework of biological condition categories or tiers (6 in all) reflecting a gradient from pristine undisturbed biological communities to the most severe levels of anthropogenic impairment (Figure A4)(Davis and Jackson, 2006) (also see http://www.epa.gov/bioindicators/html/bcg.html for an explanation of a BCG).Theoretically, the BCG and resulting tiers can be applied consistently across broad multi-state regions or even nationally (Davis and Jackson, 2006), and they can provide a tool for states to establish consensus regarding what levels of biological condition do meet the goals of the federal Clean Water Act (CWA) and which do not. Based upon such USEPA sponsored discussions involving 23 states and one tribe, a consensus was established whereby tiers 1-4 are seen as meeting the interim goals of the CWA while tiers 5 and 6 do not (Davis and Jackson, 2006).

The effort to establish a BCG in New Jersey for macroinvertebrate data did not include the Pinelands region of the State because the region represented a unique biological system, different from the high and low gradient streams covered under the scope of the USEPA BCG contract. In addition, waters contained within the Pinelands jurisdiction (as defined under N.J.S.A. 13:18 A1-29) are classified as Outstanding National Resource Waters or ONRW (PL in the New Jersey Surface Water Quality Standards) and as such, the aquatic life designated use for PL waters requires a higher level of protection than that provided by the interim goals of the CWA. The NJ Surface Water Quality Standards delineates the aquatic life designated use in these waters as “Maintenance, migration and propagation of the natural and established biota indigenous to this unique ecological system,” hence a BCG was not necessary to establish regulatory cutoffs for benthic macroinvertebrate data. Instead, biological conditions defined within the context of the Pinelands Macroinvertebrate Index (PMI) development were used. (Jessup 2005) .

Figure A2. Comparison of HGMI Scoring Distribution and BCG Tier. (Jessup, 2007)

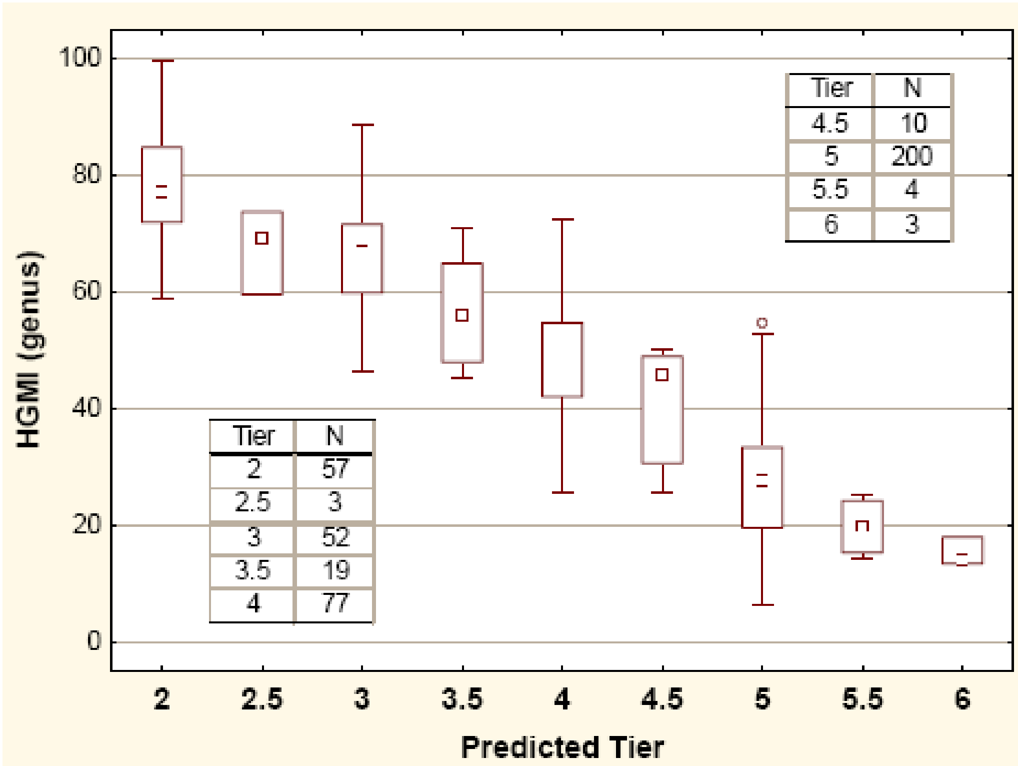


Figure A3. Comparison of CPMI Scoring Distribution and BCG Tier.

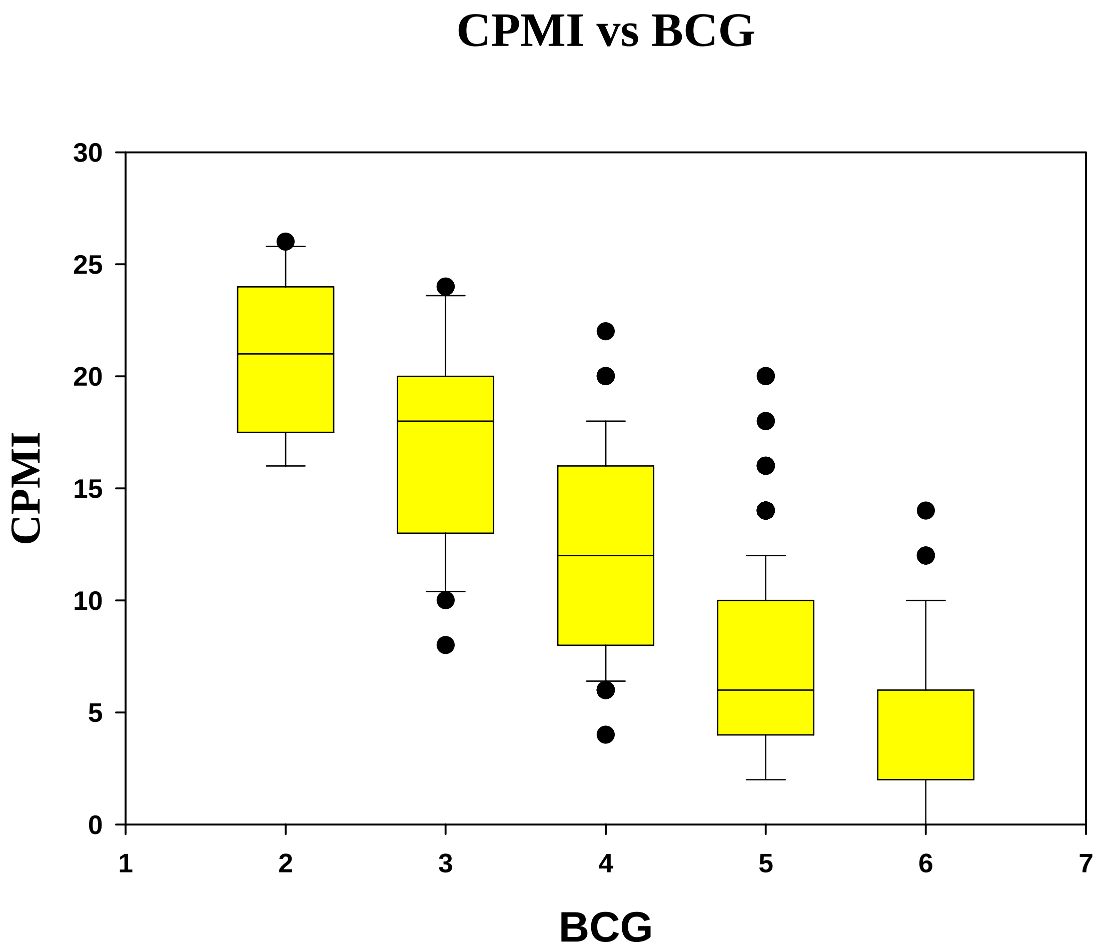
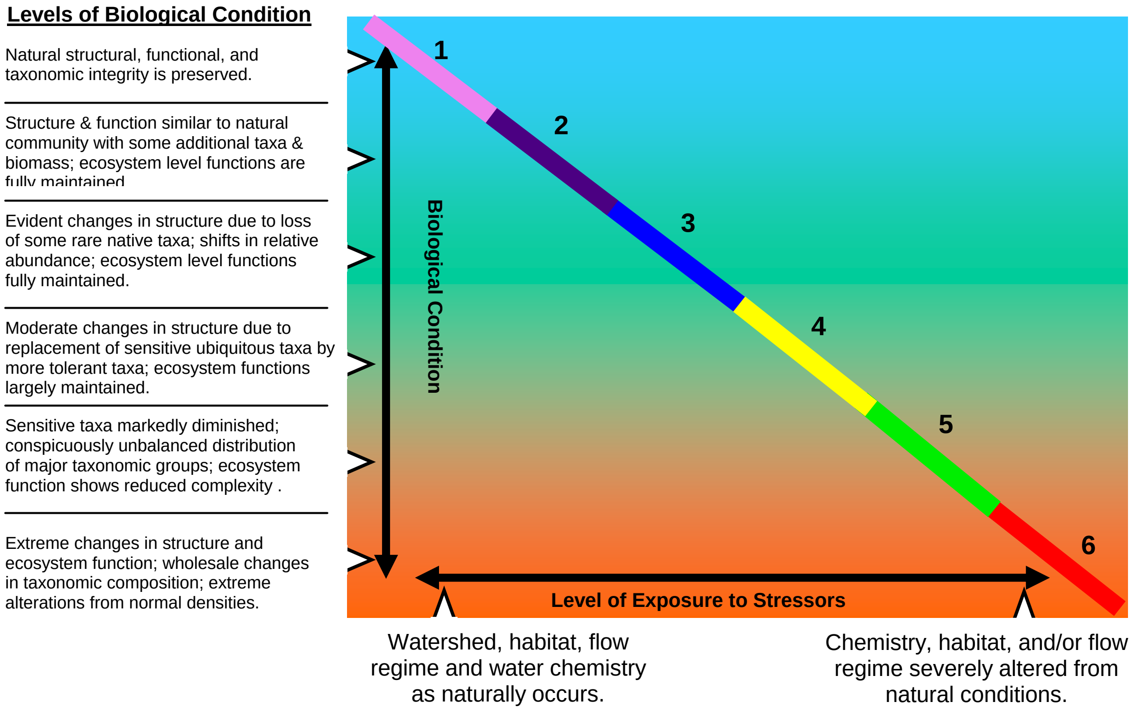


Figure A4.

The Biological Condition Gradient: Biological Response to Increasing Levels of Stress (Davies, Jackson. 2006)



APPENDIX C

List Of Taxonomic References Used by the Aquatic Biomonitoring Laboratory

General

Eddy, S. and A.C. Hodson, 1961. Taxonomic Keys to the Common Animals of the North Central States, 3rd Ed. Burgess Publishing Co., Minneapolis, MN. pp.162.

Hilsenhoff, W.L., 1975. Aquatic Insects of Wisconsin. Technical Bulletin No. 89, Wisconsin Department of Natural Resources, Madison, WI. pp.52.

Hilsenhoff, W.L., 1982. Using a Biotic Index to Evaluate Water Quality in Streams. Technical Bulletin No. 132, Wisconsin Department of Natural Resources, Madison, WI.

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