ABOUT THE DATA

The following is taken directly from the Monroe County Water Quality Study in 2003, and provides information about surface water quality parameters, as well as information regarding Monroe County's macroinvertebrate survey, habitat analysis, and pebble count methodology. For sampling and analytical protocols for field and laboratory chemical data for the Paradise Creek Study, see the Sampling and Analysis Plan developed during Phase I of the study. The Sampling and Analysis Plan can be found under Phase I of Study Results.

SURFACE WATER PARAMETERS

STREAM CLASSIFICATION CODE (TITLE 25, PA CODE)

EV	Exceptional Value Waters
HQ	High Quality Waters
CWF	Cold Water Fishes - Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.
WWF	Warm Water Fishes - Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
MF	Migratory Fishes - Passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which ascend to flowing waters to complete their life cycle.
TSF	Trout Stocking - Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.

Volume of Flow - Flow is essential in determining the dilution factor for any potential discharge. It is also an indicator of recent weather patterns. Volumes of flow would be higher than normal after a period of heavy precipitation. This is important because during a test period which may occur after heavy rains, the quality of the stream may appear degraded due to non-point source run off. It is also important that the testing period occur during a low flow since pollutants would have the most damaging effect during low flow.

Temperature - Temperature is essential in determining if acceptable standards exist for a particular stream classification. Elevated temperatures from heated water discharges may have a significant ecological effect. It is also important in determining what the direct effect on fish and other aquatic life will be as a result of temperature fluctuation. Maximum temperatures for streams during the month

of August are as follows:

CWF and HQ-CWF		18.9 C (66 F)
WWF and HQ-TSF		30.6 C (87 F)
TSF and HQ-WWF	August 1-15	26.7 C (80 F)
	August 16-30	30.6 C (87 F)
EV	Must maintain Existing Quality	

Dissolved Oxygen - Oxygen dissolved in water is measured as D.O. Different levels of D.O. are necessary to support various types of aquatic life. D.O. levels in natural and wastewaters are dependent on the physical, chemical and biochemical activities prevailing in the water body. Many fishing waters average a D.O. of 9.0 mg/l and above. The minimum daily averages for D.O. are as follows:

CWF	5.0 mg/l
WWF and TSF	4.0 mg/l

pH - Measurement of pH is one of the most important and frequently used tests in water chemistry. The pH of a solution is a measure of its hydrogen ion activity and ranges from 0 (acid) to 14 (base). The pH value of most natural waters falls within the range of 4 to 9. The majority of waters are slightly basic because of the presence of carbonates and bicarbonates. A departure from the normal pH for a particular body of water can be caused by the influx of acid or alkaline industrial wastes (acid deposition in the form of rain or snow). It is a common practice for water treatment plants to adjust the pH. Most fish can tolerate pH values from 5.0 to 9.0, however the best fishing waters fall within the range 6.5 to 8.2.

Specific Conductance - Conductivity is a numerical expression of an aqueous ability to carry an electrical current. It is an indication of the dissolved inorganic solids in the water. The higher the specific conductance, the more impurities are in the water. Freshly distilled water has a conductivity of 0.5 to 2.0 micromhos/cm. The conductivity of the drinking water in the U.S. generally ranges from 50 to 1,500 micromhos/cm.

Total Hardness - Hardness is defined as the total amount of calcium and magnesium salts that are present in the water. Water can be defined by its total hardness as follows:

Soft Water	0 - 60 mg/l
Moderately Hard Water	60 - 120 mg/l
Hard Water	120 - 180 mg/l
Very Hard Water	180 mg/l and up

Total Alkalinity - Alkalinity measures the water's ability to buffer acid. It indicates the water's ability to protect fish and other aquatic life against sudden changes in pH. The best fishing waters are those with alkalinity of 100 - 120 mg/l. The minimum level of total alkalinity for aquatic life is 20 mg/l except where natural conditions are less.

Nitrogen - Nitrate plus nitrite as nitrogen. The maximum recommended level of nitrate plus nitrite for water supply is 10 mg/l as Nitrogen.

Nitrate (NO3) - Nitrate is found only in small amounts in domestic wastewater and is a major ingredient in farm fertilizer. During precipitation, varying amounts of this chemical wash from farmland into nearby waterways. Nitrates stimulate the growth of plankton on water weeds which provide food for fish. This may cause an increase in the fish population, however, if algae grows too quickly, oxygen levels in the water will be reduced and the fish may die.

Nitrite (NO2) - Nitrite is the intermediate stage between nitrate and ammonia. It is relatively short-lived because it is quickly converted to nitrates by bacteria. However, nitrites produce a serious illness in fish even though they don't exist for very long in the environment. Nitrite concentrations in drinking water seldom exceed 0.1 mg/l. It can be expected that levels below 0.2 mg/l are representative of normal conditions.

Ammonia (NH3) - Ammonia is naturally present in surface and ground water and in wastewater. Pure ammonia is strong smelling and colorless. It is manufactured synthetically from nitrogen and hydrogen or it is produced from coal gas. In nature ammonia is formed by the action of bacteria on proteins and urea. Ammonia concentrations of 0.06 mg/l can cause gill damage in fish; 0.1 mg/l may indicate domestic or agricultural wastes and 0.2 mg/l and above is lethal to trout.

Total Phosphorous - Phosphorous occurs in natural waters and waste waters almost solely in the form of phosphate. Phosphates enter waterways from human and animal wastes, phosphate rich rocks, waste from laundries, cleaning and industrial processes and from fertilizer. Phosphorous is essential to the growth of organisms and it can be the nutrient that limits the productivity of a body of water. If phosphates are present in high concentrations in streams the algae and water weeds grow more rapidly, choking the waterways and using up large amounts of oxygen. The recommended maximum level is 0.1 mg/l for rivers and streams.

Chlorides - Chlorides are salts that contain chlorine and metal. Common chlorides are sodium chloride, calcium chloride and magnesium chloride. Most good fishing waters have a chloride concentration of less than 170 mg/l. The recommended maximum chloride levels are 150 mg/l for special protection waters and 250 mg/l for water supply.

Total Acidity - Acidity can be defined as a solution's ability to neutralize bases. Acidity of water is significant because acids contribute to corrosiveness and influence certain biological processes. Measuring acidity can also reflect changes in the quality of the source water.

Solids - The term solids or residue refers to the matter suspended or dissolved in water. Residue may affect water and effluent quality in many different ways. It can affect the palatability of drinking water or the aesthetic quality of bathing waters. For these reasons wastewater treatment processes remove solids from the discharge.

T.D.S. - Total dissolved solids (T.D.S.), also termed total filterable residue refers to the portion of residue that passes through a filter of a particular size. The maximum recommended value for T.D.S. is 750 mg/l.

T.S.S. - Total suspended solids (T.S.S.), also termed total non-filterable residue refers to the portion of residue that cannot pass through a filter of a particular size.

Fecal Coliform - Coliform bacteria are common in the intestines of both warm and cold-blooded animals and aid in the digestion of food. Some of these coliform bacteria pass out of the body with the stool. Fecal coliform counts of 200/100 mls or less are desirable.

B.O.D. - Biochemical oxygen demand is a parameter measured in the laboratory to determine relative oxygen requirements of wastewaters, effluents and potentially polluted waters. It gives an indication of the amount of biodegradable waste in a water sample. If water contains a large amount of biodegradable waste, it probably contains numerous bacteria, which utilize oxygen resulting in low D.O. levels. B.O.D. levels indicate the following:

1.0 - 2.0 mg/l	Very clean water
3.0 - 5.0 mg/l	Moderately clean water
5.0 + mg/l	Potential pollution problem

The effects of metals in water and wastewater range from beneficial through troublesome to dangerously toxic. Some metals are essential to plant and animal growth while others may adversely affect water consumers, wastewater treatment systems, and receiving waters. The benefit versus toxicity of some metals depends on their concentrations in waters. The heavy metals descriptions were obtained from the EPA Office of Water web site. The contaminant levels indicated are from the safe drinking water toxicity lists.

Arsenic, Dissolved - Arsenic is an element that occurs naturally in rocks and soil, water, air, plants, and animals. Volcanic activity, the erosion of rocks and minerals, and forest fires are natural sources that can release arsenic into the environment. Although about 90 percent of the arsenic used by industry in the United States is currently used for wood preservative purposes, arsenic is also used in paints, drugs, dyes, soaps, metals and semi-conductors. Agricultural applications, mining, and smelting also contribute to arsenic releases.

Arsenic is nonessential for plants but is an essential trace element in several animal species. Studies have linked long-term exposure to arsenic in drinking water to cancer of the bladder, lungs, skin, kidneys, nasal passages, liver, and prostate. Non-cancer effects of ingesting arsenic include cardiovascular, pulmonary, immunological, neurological, and endocrine (e.g., diabetes) effects. Short-term exposure to high doses of arsenic can cause other adverse health effects, but such effects are unlikely to occur from U.S. public water supplies that are in compliance with the existing arsenic standard of 50 ppb.

Maximum Contaminant Level (MCL) .01 mg/l (proposed for 2001)
Maximum Contaminant Level Goal (MCLG) of zero for arsenic in drinking water

Cadmium, Dissolved - Cadmium occurs naturally in zinc, lead and copper ores, in coal and other fossil fuels, shales and is released during volcanic action. These deposits can serve as sources to ground and surface waters, especially in contact with soft, acidic waters. Major industrial releases of cadmium are due to waste streams and leaching of landfills, and from a variety of operations that involve cadmium or zinc.

Cadmium is nonessential for plants and animals. It is extremely toxic and accumulates in the kidneys and liver. Cadmium has the potential to cause kidney, liver, bone and blood damage from long-term exposure at levels above the MCL.

MCL: 0.005 mg/l
MCLG: 0.005 mg/l

Copper, Dissolved - Although Copper rarely occurs in source water, the following natural sources have been identified. Copper is widely distributed in nature in the elemental state, in sulfides, arsenites, chlorides, and carbonates. In the sedimentary cycle, copper is concentrated in the clay mineral fractions (sandstones contain 10-40 ppm, shales 30-150 ppm, and marine black shales 20-300 ppm) with a slight enrichment in those clays rich in organic material. Smelting operations and municipal incineration may also produce copper. Copper is considered an essential trace element for plants and animals. At high doses however it has been shown to cause stomach and intestinal distress, liver and kidney damage, and anemia.

Action Level: 1.3 mg/l
MCLG: 1.3 mg/l

Iron - MCL: 0.3 mg/l as dissolved iron.

Lead, Dissolved - Lead may enter the environment during its mining, ore processing, smelting, refining use, recycling or disposal. It enters water from atmospheric fallout, runoff or wastewater; little is transferred from natural ores.

Lead is nonessential for plants and animals. It is toxic by ingestion and is a cumulative poison which can cause a variety of adverse health effects in humans. At relatively low levels of exposure, these effects may include interference with red blood cell chemistry, delays in normal physical and mental development in babies and young children, slight deficits in the attention span, hearing, and learning abilities of children, and slight increases in the blood pressure of some adults. It appears that some of these effects, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold. Chronic exposure to lead has been linked to cerebrovascular and kidney disease in humans.

Action Level: > 0.015 mg/l in more than 10 percent of tap water samples
MCLG: zero

Nickel, Dissolved - Nickel is found in many ores as sulfides, arsenides, antimonides & oxides or silicates; chief sources include chalcopyrite; others are pyrrhotite, pentlandite, garnierite, niccolite, millerite. The principal natural form of nickel oxide occurs in admixture with nickel sulfides in varying proportions in weathered ore. Nickel carbonate, found as the mineral zaratite, is a potential atmospheric and surface water pollutant.

From 1987 to 1993, according to the Toxics Release Inventory nickel releases to land and water totaled nearly 27 million lbs., of which most was to land. These releases were primarily from nickel smelting/refining and steelworks industries. The largest releases occurred in Oregon and Arkansas. The largest direct releases to water occurred in Maryland and Georgia.

MCL: 0.1 mg/l
MCLG: 0.1 mg/l

Zinc, Dissolved - Zinc has many commercial uses as coatings to prevent rust, in dry cell batteries, and mixed with other metals to make alloys like brass and bronze.

Zinc is an essential growth element for plants and animals. Too little zinc can cause health problems, but at elevated levels it is can also be harmful. At high doses it can cause anemia and pancreas damage.

MCL: 5 mg/l

HABITAT ANALYSIS

Both the quality and quantity of available habitat affects the macroinvertebrate community. A healthy biological community not only requires good water quality, but also a supporting habitat. By assessing habitat condition, impacts to the biological community can be attributed to water quality, where habitat is favorable to robust aquatic communities.

Beginning with the 1993 study, each sampling station's habitat has been rated. There are two types of rating systems. One is for a riffle/run prevalent stream, like most of the streams in Monroe County. The other is for glide/pool prevalence. Only a few stations in this study were rated using the latter system. The rating system incorporates three categories for a total of twelve parameters. The following is an explanation of the habitat parameters:

Habitat Parameter Descriptions

RIFFLE/RUN COMMUNITY

Substrate/Instream Cover

1. **Instream Cover:**
   This is a measure of quantity and variety of natural structures in the stream that will provide a habitat for fish. This would include fallen trees, logs, and branches, undercut banks and large rocks. A wide variety of substrate will support greater diversity.

2. **Substrate for Benthic Macroinvertebrates:**
   This measures the amount of hard substrate available for insects and snail habitat. Many insect larvae attach themselves to submerged substrate. Areas with rocky bottoms are critical for maintaining a healthy variety of insects.

3. **Embeddedness:**
   This refers to the degree to which rocks are covered or sunken into the silt, sand or mud. As substrate becomes embedded in the stream bottom, the amount of surface space for insects to attach themselves decreases. As substrate becomes embedded, the quantity and quality of the macroinvertebrate community will decrease.

4. **Velocity/Depth Regime:**
   There are four basic velocity/depth combinations:
   (1) Slow-deep
   (2) Slow-shallow
   (3) Fast-deep
   (4) Fast-shallow
   General guidelines are as follows: 0.5m separates deep from shallow: 0.3m/s separates fast from slow. Streams that contain all four regimes are considered optimal.

Channel Morphology (form and structure)

5. **Channel Alteration:**
This parameter is a measure of human induced changes to the shape of the stream channel. Streams that run through agricultural or urban areas may have been altered many times. When streams have been changed in any way (i.e., straightened, deepened, diverted, concrete channelized, artificial embankments or stabilization, dams or bridges) it can affect the macroinvertebrate community. Streams that have been altered have fewer natural habitats for fish, macroinvertebrates and plants.

6. **Sediment Deposition:**
This parameter measures the sediment, which has accumulated on the stream bottom as a result of deposition. Deposition occurs as a result of large-scale movement of sediment caused by watershed erosion. This deposition may cause the formation of islands or point bars in the stream, which decreases the available habitat for macroinvertebrates.

7. **Frequency of Riffles:**
This parameter assumes that a stream with riffles or bends provides more diverse habitat than any straight or uniform depth stream. The ratio is calculated by dividing the average distance between riffles or bends by the average depth. The smaller ratio is an indicator of good habitat.

8. **Channel Flow Status:**
This is a measure of the degree to which the channel is filled with water. When the water reaches the base of both banks and a minimal amount of channel substrate is exposed, optimal conditions exist.

Riparian and Bank Structures

9. **Condition of Banks:**
This parameter addresses stream bank erosion (or potential for erosion). Steep banks are generally more subject to erosion and failure. Signs of erosion include crumbling and unvegetated banks and exposed tree roots and soil.

10. **Bank Vegetative Protection:**

This measures the amount of stream bank, which is covered by vegetation. Plant root systems on stream banks help to hold the soil in place. This reduces the stream bank erosion. This parameter also provides information such as stream shading and nutrient uptake. Banks with full natural plant growth are better for macroinvertebrates and fish.

11. **Grazing Disruptive Pressure:**
This parameter measures the impact to the riparian zone due to livestock grazing or human activities such as urbanization, golf courses and residential development.

12. **Riparian Zone Width:**
This is a measure of the width of the natural vegetation from the edge of the stream bank. This zone serves as a buffer to pollutants entering the stream from run off and erosion. It also provides nutrients to the stream. An undisturbed riparian zone is reflective of a healthy stream, while a narrow riparian zone is not as healthy for a stream. Roads, parking lots, fields, lawns, rocks, bare soil or buildings near a stream bank have a detrimental effect on habitat.

GLIDE/POOL COMMUNITY

Substrate/Instream Cover

1. **Instream cover:**
This is a measure of quantity and variety of natural structures of the stream that provides a habitat for fish. This would include fallen trees, logs and branches, undercut banks, and large rocks. A wide variety of substrate will support greater diversity.

2. **Substrate for Macroinvertebrates:**
The substrate in muddy bottom streams consists mostly of submerged logs, snags and aquatic vegetation.

3. **Pool Substrate Composition:**
This is an evaluation of the type and condition of bottom substrates found in pools. Firm sediment types such as gravel and sand as well as rooted aquatic plants support a wider variety of organisms. A pool substrate dominated by mud or bedrock will not support a diverse community. A variety of substrate is needed for a diverse community.

4. **Pool Variability:**
This parameter rates the overall mixture of pool types found in the streams. The four basic types of pools are:

(1) Large-shallow
(2) Large-deep
(3) Small-shallow
(4) Small-deep

General guidelines are as follows: greater than one half the cross-section to separate large from small and one meter separating shallow and deep.

Channel Morphology (form and structure)

5. **Channel Alteration:**
This parameter is a measure of human induced changes to the shape of the stream channel. Streams that run through agricultural or urban areas may have been altered many times. When streams have been changed in any way (i.e., straightened, deepened, diverted, concrete channelized, artificial embankments or stabilization, dams or bridges) it can affect the macroinvertebrate community. Streams that have been altered have fewer natural habitats for fish, macroinvertebrates and plants.

6. **Sediment Deposition:**
   This parameter measures the sediment, which has accumulated on the bottom as a result of deposition. Deposition occurs as a result of large-scale movement of sediment caused by watershed erosion. This deposition may cause the formation of islands or point bars in the stream, which decreases the available habitat for macroinvertebrates.

7. **Channel Sinuosity:**
   This is an evaluation of the frequency of bends in a stream. Streams that meander provide a variety of habitat for macroinvertebrates. Straight stream segments provide for monotonous habitats and are prone to flooding. The bends in the stream also protect the banks from erosion.

8. **Channel Flow Status:**
   This is a determination of the percent of the channel that is filled with water. The flow status changes as the channel enlarges or as flow is decreased as a result of dams or obstructions, diversions for irrigation, or drought. When water does not cover as much of the streambed the available habitat is decreased.

Riparian and Bank Structure

9. **Condition of Bank:**
   Refer to riffle/run definition.

10. **Bank Vegetative Protection:**
    Refer to riffle/run definition.

11. **Grazing Disruptive Pressure:**
    Refer to riffle/run definition.

12. **Riparian Vegetative Zone Width:**
    Refer to riffle/run definition.

Each sampling station's habitat is rated using the previously discussed parameters. Each parameter is scored from 0-20 as follows:

Score	Category
0-5	Poor
6-10	Marginal
11-15	Suboptimal
16-20	Optimal

Each parameter is added for a final habitat score for a particular station.

Score	Category
0-60	Poor
72-120	Marginal
132-180	Suboptimal
192-240	Optimal

The habitat is a major factor in determining the potential of the aquatic community. A marginal or poor habitat is not expected to support the quantity and quality of macroinvertebrates that an optimal habitat will.

Similar streams may have differing aquatic communities due to differing habitat. The effect of habitat can be minimized by sampling in areas where habitats are similar. In these areas, the impacts on the aquatic community can be attributed to water quality.

PEBBLE COUNT

The pebble count is a measure of stream substrate composition. Substrate (the base on which an organism lives, in this case the stream bottom) is one of the most important factors which controls the community of macroinvertebrates. Large gravel to large cobble are the ideal substrates for macroinvertebrates, giving them places to live and reproduce. The worst substrate is that dominated by silt and sand because these substrates do not provide pockets between particles for the insects to live. Over a period of time, the natural substrate may be greatly altered by the discharge of organic matter. The location and expanse of various substrate types may also change due to normal variations in hydraulic factors such as volume of flow.

Substrate types

Silt/Clay – any particle less than .062 mm across

Sand – any particle .062 mm to 2.0 mm across

Gravel – any particle 2.0 mm to 64 mm across

Cobble – any particle 64 mm to 256 mm across

Boulder – any particle 256 mm to 2048 mm across

Bedrock – any particle greater than 2048 mm across

BENTHIC MACROINVERTEBRATES

In addition to the standard chemical and physical parameters used as water quality indicators, samples of benthic macroinvertebrates were also collected whenever possible. Aquatic macroinvertebrates are animals that are large enough to be seen by the unaided eye and live at least part of their life cycles within or upon available substrates in a body of water or water transport system. These include insects such as mayflies, annelids, mollusks, flatworms, roundworms, and crustaceans. The samples collected allow for a detailed analysis of the aquatic community. A brief explanation of these factors is offered to enable the reader to understand the importance of measuring the relative stability of the aquatic community.

The sampling technique is a standard kick sample format using a 500 micron mesh size, 1meter x 1meter seine net. Normally one sample (one square meter of substrate) is taken from a riffle in the stream and one sample (one square meter of substrate) is taken from a run. The entire sample is taken to the Monroe County Conservation District office where it is subsampled. A minimum subsample of 100 organisms is desired for a valid analysis.

The following are the metrics used for the macroinvertebrate analysis. Metrics are the various counts, indexes, and ratios computed from the results of the subsamples as described above. Different metrics convey different types of information about the macroinvertebrate community. For example, taxa richness is an index of diversity and the Hilsenhoff Biotic Index measures pollution tolerance. By using a set of metrics that measures multiple aspects of the macroinvertebrate community, a complete picture of a community can be obtained.

Total Individuals is the actual number of macroinvertebrates collected.

Total Taxa (Species richness) is a measure of the variety of taxa (total number of species) present. This generally increases with increasing water quality or habitat. In some situations, organic enrichment may also result in an increase in the number of taxa.

Percent Contribution of Dominant Taxa gives an indication of the balance in the community. A community dominated by relatively few species would indicate environmental stress. An even distribution of all taxa (preferably sensitive species) is more desirable.

Percent Noninsects gives an indication of the balance in the community. Noninsects are generally tolerant species. A community dominated by noninsects would be an indication of environmental stress. An even distribution of all taxa (preferably sensitive species) is more desirable.

Modified Hilsenhoff Biotic Index (HBI) is a ranking based on pollution tolerance to organic sources values. These values range from 0-10 increasing as water quality decreases. The Biotic Index is an average of tolerance values for all individuals collected from a site.

The following demonstrates the range for Biotic Index:

0.00-3.75	Excellent
3.76-4.25	Very Good
4.26-5.00	Good
5.01-5.75	Fair
5.76-6.50	Fairly Poor
6.51-7.25	Poor
7.26-10.0	Very Poor

EPT Index is a measure of the total number of distinct taxa within the orders of Ephemeroptera, Plecoptera and Trichoptera. This summarizes the taxa richness within the insect orders that are generally sensitive to pollution. The EPT Index generally increases with increasing water quality.

Percent Intolerant Taxa gives an indication of the balance in the community. Intolerant organisms are usually not found associated with organic contaminants and are generally intolerant of even moderate reductions in dissolved oxygen. Intolerant organisms are indicators of clean water only.

The Ratio of Shredders to the Total Number of Insects uses the relative abundance of shredders as an indication of the dominant food or energy source in a small watershed. Shredders are insects that shred coarse particulate detritus for feeding. Shredders represent a distinct functional feeding group that is found predominantly in watersheds less than 10 square miles in size where the primary energy source in the stream is derived from leaf litter and similar detritus entering the watercourse. Shredders should become less abundant as the stream width increases and the canopy cover opens and photosynthesis becomes the primary energy source in the stream.

Scoring Schemes

The County identifies all organisms collected to the family level and all the calculations are performed using family level identifications. The family level of identification was chosen to make data sharing both easier and faster (both the EPA and DEP identify their macroinvertebrate samples to the family level). Identification of macroinvertebrates to the family is easier to perform and yields results that are suitable for our purposes. Another reason for choosing this level of identification was the interest of local watershed groups in performing macroinvertebrate sampling. For these groups genus level identification would be too difficult and time consuming. In order for the County to accept their data, however, the identifier would have to pass a quality assurance program established by the County.

The EPA conducted the statistical analysis needed to determine the metrics and scoring schemes that are used for streams located in the Pocono Plateau and Low Pocono subecoregions. The County with the assistance of the EPA completed the analysis work for the remaining subecoregions and scoring schemes in the County. The metrics employed were selected because of their accuracy in detecting impairment.

A simple process was used to develop the reference conditions for the different stream classes. Within each stream class, minimally impaired reference sites were sampled. Descriptive statistics for each metric were calculated from a group of similar candidate reference sites. Only the candidate reference sites with optimal habitat and intact benthic macroinvertebrate communities were included in the reference condition. Test sites, or sites thought to be impaired, were not used in the development of reference conditions. Thresholds for optimal, slightly to moderately impaired and severely impaired categories were developed for each metric. The data from each metric was compiled and ranked. If a metric increases with impact (HBI for example), the 75^{th} percentile of the reference condition is used as the threshold for the optimal category. The remaining range between that value and the maximum value obtainable for that metric was halved to provide two more ranges for scoring the slightly to moderately impaired and severely impaired categories. If the metric value decreases with impact (taxa richness for example), the 25^{th} percentile of the reference condition is used as the threshold for the optimal category. The remaining range between that value and the minimum value was halved to provide two more ranges for scoring the slightly to moderately impaired and severely impaired categories. For some metrics, this may result in somewhat insensitive scoring. For percent noninsects, for example, the maximum possible is 100%. However, 25% was the maximum encountered in the severely impacted sites for the Pocono Plateau / Glide Pool subecoregion. The scoring was adjusted to reflect the values of that metric generally encountered in impacted streams for this subecoregion, in order to make the scoring for that metric more sensitive.

All candidate reference sites were scored using the scoring scheme for that stream classification. These scores were then ranked. The lower 25^{th} percentile was used to define the lower range of the optimal category. The remaining range between that value and the minimum possible total score was bisected to define two more ranges for the slightly to moderately impaired and severely impaired categories for the total scores.

The following are tables for the scoring schemes.

Pocono Plateau, Riffle / Run < 10 square miles

Samples from Keiper Run, Beaver Creek, Cross Keys Run, Frame Cabin Run and Tripup Run were used to develop the reference condition.

Resulting scoring scheme for the reference condition for the Pocono Plateau, Riffle / Run < 10 square miles

Score Assigned →→→→ Metric	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Total Taxa	> = 15	14 - 8	7 - 0
EPT Taxa	> = 8	7 - 4	3 - 0
HBI	< = 5.4	5.5 - 7.7	7.8 - 10
% Intolerant Taxa	> = 35.3	35.2 - 17.7	17.6 - 0
% Noninsect	< = 2.0	2.1 - 25.0	25.1 - 100
Shredders / Total	> = 0.02	0.019 - 0.01	0.009 - 0

The reference sites were all scored using this scoring scheme. The lower 25th percentile of the reference site scores represents the lower threshold for the "optimal" category. The 25th percentile of the reference scores is 26. The range 25 - 16 will be the slightly to moderately impaired category, and any site with a total score of less than 16 will be considered severely impaired.

Pocono Plateau, Riffle / Run > 10 square miles

Samples collected from Tunkhannock Creek and Tobyhanna Creek were used to develop a reference condition for the larger streams on the plateau. Descriptive statistics for the metrics at these two sites were calculated and the resulting scoring scheme was developed as described previously. The scoring scheme for the larger streams is shown in the following table.

Resulting scoring scheme for the reference condition for the Pocono Plateau, Riffle / Run > 10 square miles

Score Assigned →→→→ Metric	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Total Taxa	> = 15	14 - 8	7 - 0
EPT Taxa	> = 8	7 - 4	3 - 0
HBI	< = 5.7	5.8 - 7.9	8.0 - 10
% Intolerant Taxa	> = 39.3	39.2 - 19.7	19.6 - 0
% Noninsect	< = 3.6	3.7 - 25.0	25.1 - 100
Shredders / Total	> = 0.003	0.0029 - 0.0015	0.0014 - 0

The reference sites were all scored using this scoring scheme. The 25th percentile of the reference scores is 26. The range 25 - 16 will be the slightly to moderately impaired category, and any site with a total score of less than 16 will be considered severely impaired.

Pocono Plateau, Glide / Pool

Samples collected from Tunkhannock Creek were used to develop a reference condition for the glide pool streams found in the Long Pond area. Descriptive statistics for the metrics at these sites were calculated and the resulting scoring scheme was developed as described previously. The scoring scheme for the glide pool streams is shown in the following table.

Resulting scoring scheme for the reference condition for the Pocono Plateau, Glide / Pool

Score Assigned →→→→ Metric	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Total Taxa	> = 15	14 - 8	7 - 0
EPT Taxa	> = 6	5 - 3	2 - 0
HBI	< = 5.5	5.6 - 7.8	7.9 - 10
% Intolerant Taxa	> = 26.7	26.6 - 13.4	13.3 - 0
% Noninsect	0	>0 - 25.0	25.1
Shredders / Total	> = 0.01	0.009 - 0.005	0.0049 - 0

The reference sites were all scored using this scoring scheme. The lower 25th percentile of the reference site scores represents the lower threshold for the "optimal" category. The 25th percentile of the reference scores is 28. The range 27 - 17 will be the slightly to moderately impaired category, and any site with a total score of less than 17 will be considered severely impaired.

Low Pocono, Riffle / Run < 10 square miles

Samples from Spruce Cabin Run and Buck Hill, Rattlesnake, Mill, Poplar Run, Devils Hole, Fall, Poplar and Swiftwater Creeks were used in developing a scoring scheme for this region. Descriptive statistics for the metrics at these sites were calculated, and the resulting scoring scheme was developed as described earlier. The main difference between the metrics from the Pocono Plateau and Low Pocono subecoregions is the inclusion of the percent dominant family for the Low Pocono.

Resulting scoring scheme for the reference condition for the Low Pocono, Riffle / Run < 10 square miles

Score Assigned →→→→ Metric	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Total Taxa	> = 16	15 - 8	7 - 0
EPT Taxa	> = 11	10 - 6	5 - 0
HBI	< = 4.5	4.6 - 7.3	7.4 - 10
% Dominant Family	< = 42.6	42.7 - 71.3	71.4 - 100
% Intolerant Taxa	> = 55.6	55.5 - 27.8	27.7 - 0
% Noninsect	< = 0	0 - 25.0	25.1 - 100
Shredders / Total	> = 0.11	0.10 - 0.06	0.05 - 0

The reference sites were all scored using this scoring scheme. The 25th percentile of the reference sites scores is 31. The range 30 - 19 will be the slightly to moderately impaired category, and any site with a total score less than 19 will be considered severely impaired.

Low Pocono, Riffle / Run > 10 square miles

Samples collected from the Bushkill, McMichael, Brodhead, Paradise, and Pocono Creeks were calculated and the resulting scoring scheme was developed.

Resulting scoring scheme for the reference condition for the Low Pocono, Riffle / Run > 10 square miles

Score Assigned →→→→ Metric	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Total Taxa	> = 17	16 - 9	8 - 0
EPT Taxa	> = 10	9 - 5	4 - 0
HBI	< = 5.6	5.7 - 7.8	7.9 - 10
% Dominant Family	< = 46.3	46.4 - 73.2	73.3 - 100
% Intolerant Taxa	> = 35.7	35.6 - 17.9	17.8 - 0
% Noninsect	< = 9.6	9.7 - 25.0	25.1 - 100
Shredders / Total	> = 0.03	0.029 - 0.015	0.014 - 0

The reference sites were all scored using this scoring scheme. The 25th percentile of the reference scores is 29. The range 28 - 18 will be the slightly to moderately impaired category, and any site with a total score of less than 18 will be considered severely impaired.

Northern Shale Valleys and Slopes, Riffle / Run < 10 square miles

Samples collected from the Princess, Ross Common, and Cherry Creeks were calculated and the resulting scoring scheme was developed. This scoring scheme follows the work that has been completed for the Low Pocono subecoregions in that it also includes the percent dominant family metric.

Resulting scoring scheme for the reference condition for the Northern Shale Valleys and Slopes, Riffle / Run < 10 square miles

Score Assigned →→→→ Metric	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Total Taxa	> = 18	17 - 9	8 - 0
EPT Taxa	> = 9	8 - 4	3 - 0
HBI	< = 5.0	5.1 - 7.5	7.6 - 10
% Dominant Family	< = 34.9	35.0 - 71.4	71.5 - 100
% Intolerant Taxa	> = 26.1	26.2 - 13.0	12.9 - 0
% Noninsect	< = 5.6	5.7 - 25.0	25.1 - 100
Shredders / Total	> = 0.14	0.139 - 0.070	0.069 - 0

The reference sites were all scored using this scoring scheme. The 25^{th} percentile of the reference scores is 31. The range 30 - 18 will be the slightly to moderately impaired category, and any site with a total score of less than 18 will be considered severely impaired. It should be noted that only six sites were used in creating this scoring scheme. It will be adjusted after further studies have provided more data.

Northern Shale Valleys and Slopes, Riffle / Run > 10 square miles

Samples collected from the McMichael, Pohopoco, Aquashicola, Cherry, and Buckwha Creeks were calculated and the resulting scoring scheme was developed.

Resulting scoring scheme for the reference condition for the Northern Shale Valleys and Slopes, Riffle / Run > 10 square miles

Score Assigned →→→→ Metric	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Total Taxa	> = 19	18 - 10	9 - 0
EPT Taxa	> = 11	10 - 6	5 - 0
HBI	< = 5.1	5.2 - 7.6	7.7 - 10
% Dominant Family	< = 42.6	42.7 - 71.4	71.5 - 100
% Intolerant Taxa	> = 28.6	28.5 - 14.3	14.2 - 0
% Noninsect	< = 3.9	4.0 - 25.0	25.1 - 100
Shredders / Total	> = 0.02	0.019 - 0.009	0.008 - 0

The reference sites were all scored using this scoring scheme. The 25th percentile of the reference scores is 31. The range 30 - 18 will be the slightly to moderately impaired category, and any site with a total score of less than 18 will be considered severely impaired.

Northern Sandstone Ridges, Riffle / Run

Samples collected from the Poplar, Caledonia and Ross Common Creeks were calculated and the resulting scoring scheme was developed.

Resulting scoring scheme for the reference condition for the Northern Sandstone Ridges, Riffle / Run

Score Assigned →→→→ Metric	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Total Taxa	> = 16	15 - 8	7 - 0
EPT Taxa	> = 10	9 - 5	4 - 0
HBI	< = 3.9	4.0 - 7.0	7.1 - 10
% Dominant Family	< = 24.1	24.2 - 62.1	62.2 - 100
% Intolerant Taxa	> = 37.5	37.4 - 18.8	18.7 - 0
% Noninsect	< = 2.2	2.3 - 51.2	51.3 - 100
Shredders / Total	> = 0.09	0.089 - 0.045	0.044 - 0

The reference sites were all scored using this scoring scheme. The 25th percentile of the reference scores is 33. The range 32 - 17 will be the slightly to moderately impaired category, and any site with a total score of less than 16 will be considered severely impaired.