Appendix E
Abandoned Mine Drainage Treatment System/Receiving Streams Monitoring Project Methods

Abandoned Mine Drainage Treatment System/Receiving Streams Monitoring Project Methods

INTRODUCTION

Monitoring passive treatment systems along with the receiving stream is very important in gauging the successful treatment of abandoned mine drainage problems. An important aspect for both the operation and maintenance of these systems is acquiring water quality data from the system to ensure it is functioning properly. Receiving stream sampling for water quality, habitat and macroinvertebrate populations is essential to tracking overall improvements in a watershed. This protocol will address both treatment system and stream monitoring where passive treatment for abandoned mine drainage is present. Data will be collected to show if treatment systems are functioning and to document incremental improvements and trends of change over time within the receiving stream. The following partners are projected to use the data collected from this project.

- The Nonpoint Source (NPS) section of DEP will use the data to monitor the success of NPS-funded projects and to help decide if a stream is recovering/improving enough to be referred to staff in the Water Quality Standards Division for further study.

- Staff in DEP’s Water Quality Standards Division will look at the data to decide if the stream has improved enough to warrant sending out a biologist to re-assess stream conditions for possible delisting.

- Other DEP programs including the Bureau of Mining and Reclamation and the Bureau of Abandoned Mine Reclamation may use the data collected from treatment systems and receiving streams to follow trends of change.

- Watershed groups may use the data to make sure treatment systems are working. and to show watershed improvements.

Data will be kept by the 319 Non-point Source Program. Volunteer monitors should also keep copies of the data.

Volunteer Monitors

Many volunteer monitors, including active Pennsylvania Senior Environment Corps (PaSEC) have water monitoring field kits for pH, alkalinity, conductivity and sulfates. Most PaSEC’s are also trained on the use of a colorimeter and could monitor for iron and aluminum with the colorimeter or additional field kits. Volunteers, including PaSEC members can monitor both passive treatment systems to detect if a system is failing and receiving streams to document incremental improvements and trends of change over time with proper training and equipment.

PARAMETERS

The following are parameters tested for when trying to detect impacts from abandoned mine drainage and treatment systems as well as to determine trends of change over time from the influence of the treatment systems.

Chemical

pH – A measurement of how acidic or alkaline the water is. This number is based on the concentration of hydrogen ions (H^+). pH is measured on a scale from 0-14 with 7 being neutral. Ideally the range should be from 6.0-9.0.
Alkalinity –A measurement of the water's ability to neutralize acidity. Therefore this number should be higher than acidity.
Acidity - A measurement of the water's ability to neutralize a base. Therefore this number should be lower than alkalinity.
Conductivity – A measurement of the ability of water to conduct an electrical current. The presence of inorganic dissolved solids such as iron and aluminum increase conductivity. Treated water can also have high amounts of dissolved solids which would increase the conductivity.
Sulfates – A compound formed when pyrite is exposed to weathering. High amounts of sulfates usually indicate impacts from mining. The state standard for sulfate in drinking water is 250 mg/L.
Iron – A metal associated with mine drainage. When precipitating out as a solid, iron leaves a red to orange color on the streambed.
Aluminum - A metal that is associated with mine drainage. When precipitating out as a solid, aluminum leaves a white color on the streambed.

Physical

Temperature – This can be taken using a simple thermometer and is always taken in the field. Temperature provides clues on whether a discharge is coming from a deep mine or the surface. (Deep mine discharges maintain a constant temperature over a period of time.)
Flow - A variety of methods can be used to determine flow (float method, bucket method, meter, weir). Flow is used to calculate the loadings of pollutants in a stream.

TREATMENT SYSTEMS

General

1. Treatment systems should be monitored six times a year with field kits (HACH or other). In conjunction with the field testing, one grab sample will be taken during low flow conditions and sent to either the PADEP laboratory or designated local lab (lab details will be reviewed during the training session).

2. Samples should be taken of the raw water before it enters the treatment system and then at the outlet. If the raw water can not be sampled, data will be compared to results before system was installed.
3. Flow needs to be taken, if possible, on the raw water before it enters the treatment facility and then at the final discharge. The easiest way to accomplish this is by installing weirs, or if final discharge exits a pipe and the flow is not too great, the bucket-stopwatch methods can be used.
4. Fill out data sheets
5. Send sheets to 319 NPS Program.

Sampling Procedure

1. Observe the appearance of the water entering and exiting the treatment system (if possible) and record.
2. Observe the appearance of the substrate before and after the treatment (if possible) and record.
3. Measure flow (if possible) using a weir, bucket or estimate (last resort).
4. Using the pH meter, take a reading of the pH of both the raw water (before treatment) and the treated water.
5. Using the conductivity meter, take a reading of the conductivity of both the raw water (before treatment) and the treated water.
6. Using the thermometer, take a reading of the temperature of both the raw water (before treatment) and the treated water.
7. Take a sample of both the raw water (before treatment) and the treated water and using field kits or the colorimeter test for alkalinity, sulfates, aluminum and iron (See field kit or colorimeter directions)).
8. In conjunction with the field sampling, take a grab sample of both the raw water discharge and the treated water during low flow for lab analysis.

STREAM MONITORING

General

1. Streams need to be monitored six times a year with field kits (HACH or other). Out of the six sampling events, a grab sample will be taken at low flow (most likely August or October) and sent to either the PADEP laboratory or designated local lab (lab details will be reviewed during the training session).
2. Choose your monitoring point far enough downstream to see effects of the passive treatment system. If possible, try to set up the monitoring points close to where previous DEP assessments were completed downstream of the treatment system(s). The DEP Regional Biologist or other DEP staff knows where assessments were completed and can assist with finding these monitoring points on the stream.
3. Measure flow (if possible) using a flow meter or float method.
4. Take field chemistry.
5. Take low flow grab water samples.

6. Do a macroinvertebrate assessment (once a year in fall possibly early October).
7. Do a habitat assessment (once a year in fall with the macroinvertebrate sampling).
8. Fill out data sheets.
9. Send data sheets to 319 NPS Program.

Sampling Procedure

1. Observe the appearance of the water and record.
2. Observe the substrate and record.
3. Using the pH meter take a reading of the pH.
4. Using the conductivity meter take a reading of the conductivity.
5. Using the thermometer take a reading of the temperature.
6. Take a water sample and using field kits or colorimeter test for alkalinity, sulfates, aluminum and iron (See field kit or colorimeter instructions).
7. In conjunction with the field sampling, take a grab sample for lab analysis during low flow. The sample should be taken mid-stream, mid-depth facing upstream.

QA/QC

1. General QA/QC procedures should be followed when using the field kits/meters including calibration of meters before use and periodically using standards to test accuracy and performing duplicates to test precision of the kits. Kits should also be kept clean.
2. *One duplicate sample and one blank should be done when taking the grab sample for lab analysis. This can be done either when taking the treatment samples or when taking the stream samples.

FLOW METHODS

Weir - A weir is a small dam with an opening of known size. There must be enough room behind the dam in order for the water to be backed up. A fall of 3 to 6 inches is necessary once water passes through the weir. All water must flow through opening in the weir. Water must not be flowing around the edge or under the weir.

90° v-notch weir
1. The height of the water must be measured at the notch.
2. Using the chart in Appendix B, find measured height.
3. Find corresponding flow amount in gallons/minute (gpm).

Rectangular Weir
1. A scale must be set upstream away from influence of the water being drawn down through the notch.
2. Height of water is measured on this scale.
3. Find the correct chart in (see Weir section in back of AMD Document) that corresponds with size of weir opening.

4. Locate the measured height and the corresponding flow amount in gallons/minute (gpm).

Bucket and stopwatch

1. This can only be accomplished where all the water can be caught with a bucket.
2. Find a bucket with a known volume (gallons).
3. Time how long it takes to fill the bucket to the known volume with a stopwatch.

$$\text{Flow (gal/min)} = \frac{\text{Volume (gallons)}}{\text{Time (Sec)}} \times 60$$

Float method

1. Mark out a 30 foot section of stream that is relatively straight.
2. Drop a bobber or other floatable and record the time it takes to travel the 30 foot distance. Do this at least five times and take the average.
3. Velocity is calculated by taking distance traveled in feet and dividing by time in seconds
4. Take at least five depth measurements and at least five width measurements and determine average depth and average width of the stream in the section.
5. Discharge can be found using the following equation

Discharge (ft^3/s) = Average Stream width (ft) X Average Stream depth (ft) X Velocity (ft/s) X Constant

Constant: Multiply by 0.8 for gravel or rocky bottom streams or 0.9 for sandy or muddy bottom streams.

To convert flow to gallons per minute take the discharge and multiply by 448.8.

Flow meter

1. Follow flow meter directions.

<u>MACROINVERTEBRATE SAMPLING</u>
<u>(also refer to instructions in Chapter 4 of PaSEC manual)</u>

- Complete at same monitoring point at least once a year.
- Sampling should be done between mid-October and mid-May.
- Separate the macroinvertebrates as described in the protocol. Note how many different groups of mayflies, stoneflies, free living caddisflies, etc that you have. Different groups may indicate different families, which show a healthy stream.
- Take a digital picture of the macroinvertebrates collected in the trays so Regional Biologists will have an impression of the different taxa and overall quantity.

HABITAT ASSESSMENT

Taken from: Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Parameters to be evaluated in sampling reach are listed below. Habitat assessments should be done at least once a year at the same time the macroinvertebrates are assessed. Choose either high gradient or low gradient habitat field sheets from Appendix A.

1 EPIFAUNAL SUBSTRATE/AVAILABLE COVER

high and low gradient streams

Includes the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna. A wide variety and/or abundance of submerged structures in the stream provide macroinvertebrates and fish with a large number of niches, thus increasing habitat diversity. As variety and abundance of cover decreases, habitat structure becomes monotonous, diversity decreases, and the potential for recovery following disturbance decreases. Riffles and runs are critical for maintaining a variety and abundance of insects in most high-gradient streams and serving as spawning and feeding refugia for certain fish. The extent and quality of the riffle is an important factor in the support of a healthy biological condition in high-gradient streams. Riffles and runs offer a diversity of habitat through variety of particle size, and, in many small high-gradient streams, will provide the most stable habitat. Snags and submerged logs are among the most productive habitat structure for macroinvertebrate colonization and fish refugia in low-gradient streams. However, "new fall" will not yet be suitable for colonization.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover **(high and low gradient)**	Greater than 70% (50% for low gradient streams) 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).	40-70% (30-50% for low gradient streams) 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% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) 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

2a. EMBEDDEDNESS

high gradient streams Refers to the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud of the stream bottom. Generally, as rocks become embedded, the surface area available to macroinvertebrates and fish (shelter, spawning, and egg incubation) is decreased. Embeddedness is a result of large-scale sediment movement and deposition, and is a parameter evaluated in the riffles and runs of high-gradient streams. The rating of this parameter may be variable depending on where the observations are taken. To avoid confusion with sediment deposition (another habitat parameter), observations of embeddedness should be taken in the upstream and central portions of riffles and cobble substrate areas.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
2.a Embeddedness **(high gradient)**	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

2b POOL SUBSTRATE CHARACTERIZATION

low gradient streams Evaluates the type and condition of bottom substrates found in pools. Firmer sediment types (e.g., gravel, sand) and rooted aquatic plants support a wider variety of organisms than a pool substrate dominated by mud or bedrock and no plants. In addition, a stream that has a uniform substrate in its pools will support far fewer types of organisms than a stream that has a variety of substrate types.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
2b. Pool Substrate Characterization **(low gradient)**	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 submerged vegetation.
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

3a VELOCITY/DEPTH COMBINATIONS

high gradient streams Patterns of velocity and depth are included for high-gradient streams under this parameter as an important feature of habitat diversity. The best streams in most high-gradient regions will have all 4 patterns present: (1) slow-deep, (2) slow-shallow, (3) fast-deep, and (4) fast-shallow. The general guidelines are 0.5 m depth to separate shallow from deep, and 0.3 m/sec to separate fast from slow. The occurrence of these 4 patterns relates to the stream's ability to provide and maintain a stable aquatic environment.

Habitat Parameter	**Condition Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
3a. Velocity/ Depth Regimes **(high gradient)**	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

3b POOL VARIABILITY

low gradient streams Rates the overall mixture of pool types found in streams, according to size and depth. The 4 basic types of pools are large-shallow, large-deep, small-shallow, and small-deep. A stream with many pool types will support a wide variety of aquatic species. Rivers with low sinuosity (few bends) and monotonous pool characteristics do not have sufficient quantities and types of habitat to support a diverse aquatic community. General guidelines are any pool dimension (i.e., length, width, oblique) greater than half the cross-section of the stream for separating large from small and 1 m depth separating shallow and deep.

Habitat Parameter	**Condition Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
3b. Pool Variability **(low gradient)**	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

high and low gradient streams

Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition. Deposition occurs from large-scale movement of sediment. Sediment deposition may cause the formation of islands, point bars (areas of increased deposition usually at the beginning of a meander that increase in size as the channel is diverted toward the outer bank) or shoals, or result in the filling of runs and pools. Usually deposition is evident in areas that are obstructed by natural or manmade debris and areas where the stream flow decreases, such as bends. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many organisms.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
4. Sediment Deposition (high and low gradient)	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

high and low gradient streams

The degree to which the channel is filled with water. The flow status will change as the channel enlarges (e.g., aggrading stream beds with actively widening channels) or as flow decreases as a result of dams and other obstructions, diversions for irrigation, or drought. When water does not cover much of the streambed, the amount of suitable substrate for aquatic organisms is limited. In high-gradient streams, riffles and cobble substrate are exposed; in low-gradient streams, the decrease in water level exposes logs and snags, thereby reducing the areas of good habitat. Channel flow is especially useful for interpreting biological condition under abnormal or lowered flow conditions. This parameter becomes important when more than one biological index period is used for surveys or the timing of sampling is inconsistent among sites or annual periodicity.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
5. Channel Flow Status (high and low gradient)	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

high and low gradient streams

Is a measure of large-scale changes in the shape of the stream channel. Many streams in urban and agricultural areas have been straightened, deepened, or diverted into concrete channels, often for flood control or irrigation purposes. Such streams have far fewer natural habitats for fish, macroinvertebrates, and plants than do naturally meandering streams. Channel alteration is present when artificial embankments, riprap, and other forms of artificial bank stabilization or structures are present; when the stream is very straight for significant distances; when dams and bridges are present; and when other such changes have occurred. Scouring is often associated with channel alteration.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration **(high and low gradient)**	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

7a FREQUENCY OF RIFFLES (OR BENDS)

high gradient streams Is a way to measure the sequence of riffles and thus the heterogeneity occurring in a stream. Riffles are a source of high-quality habitat and diverse fauna, therefore, an increased frequency of occurrence greatly enhances the diversity of the stream community. For high gradient streams where distinct riffles are uncommon, a run/bend ratio can be used as a measure of meandering or sinuosity (see 7b). A high degree of sinuosity provides for diverse habitat and fauna, and the stream is better able to handle surges when the stream fluctuates as a result of storms. The absorption of this energy by bends protects the stream from excessive erosion and flooding and provides refugia for benthic invertebrates and fish during storm events. To gain an appreciation of this parameter in some streams, a longer segment or reach than that designated for sampling should be incorporated into the evaluation. In some situations, this parameter may be rated from viewing accurate topographical maps. The "sequencing" pattern of the stream morphology is important in rating this parameter. In headwaters, riffles are usually continuous and the presence of cascades or boulders provides a form of sinuosity and enhances the structure of the stream. A stable channel is one that does not exhibit progressive changes in slope, shape, or dimensions, although short-term variations may occur during floods (Gordon et al. 1992).

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
7a. Frequency of Riffles (or bends) **(high gradient)**	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

7b CHANNEL SINUOSITY

low gradient streams Evaluates the meandering or sinuosity of the stream. A high degree of sinuosity provides for diverse habitat and fauna, and the stream is better able to handle surges when the stream fluctuates as a result of storms. The absorption of this energy by bends protects the stream from excessive erosion and flooding and provides refugia for benthic invertebrates and fish during storm events. To gain an appreciation of this parameter in low gradient streams, a longer segment or reach than that designated for sampling may be incorporated into the evaluation. In some situations, this parameter may be rated from viewing accurate topographical maps. The "sequencing" pattern of the stream morphology is important in rating this parameter. In "oxbow" streams of coastal areas and deltas, meanders are highly exaggerated and transient. Natural conditions in these streams are shifting channels and bends, and alteration is usually in the form of flow regulation and diversion. A stable channel is one that does not exhibit progressive changes in slope, shape, or dimensions, although short-term variations may occur during floods (Gordon et al. 1992).

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
7b. Channel Sinuosity **(low gradient)**	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long 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 (condition of banks)

high and low gradient streams

Measures whether the stream banks are eroded (or have the potential for erosion). Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks, and are therefore considered to be unstable. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soil. Eroded banks indicate a problem of sediment movement and deposition, and suggest a scarcity of cover and organic input to streams. Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
8. Bank Stability (score each bank) **Note: determine left or right side by facing downstream** **(high and low gradient)**	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

high and low gradient streams

Measures the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone. The root systems of plants growing on stream banks help hold soil in place, thereby reducing the amount of erosion that is likely to occur. This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients by the plants, the control of instream scouring, and stream shading. Banks that have full, natural plant growth are better for fish and macroinvertebrates than are banks without vegetative protection or those shored up with concrete or riprap. This parameter is made more effective by defining the native vegetation for the region and stream type (i.e., shrubs, trees, etc.). In some regions, the introduction of exotics has virtually replaced all native vegetation. The value of exotic vegetation to the quality of the habitat structure and contribution to the stream ecosystem must be considered in this parameter. In areas of high grazing pressure from livestock or where residential and urban development activities disrupt the riparian zone, the growth of a natural plant community is impeded and can extend to the bank vegetative protection zone. Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
9. Vegetative Protection (score each bank) **Note: determine left or right side by facing downstream** **(high and low gradient)**	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation 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

high and low gradient streams

Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, bare soil, rocks, or buildings are near the stream bank. Residential developments, urban centers, golf courses, and rangeland are the common causes of anthropogenic degradation of the riparian zone. Conversely, the presence of "old field" (i.e., a previously developed field not currently in use), paths, and walkways in an otherwise undisturbed riparian zone may be judged to be inconsequential to altering the riparian zone and may be given relatively high scores. For variable size streams, the specified width of a desirable riparian zone may also be variable and may be best determined by some multiple of stream width (e.g., 4 x wetted stream width). Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
10. Riparian Vegetative Zone Width (score each bank riparian zone) **(high and low gradient)**	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

Treatment System Monitoring Data Sheet

Date__________________________ Time__________________

Name of Group_______________________________________

Name of Collector____

Phone Number of Collector___________________________________

Email____

Name of Treatment Site________________________________

Site ID____

Name of Stream______________________________________

Latitude_______________ Longitude____________________

Raw Water (before it enters treatment system)

Appearance____

Flow__________________ Method used (circle one) Bucket Weir Estimate Float

pH - field______________ Conductivity – field______

Alkalinity - field_____ Acidity - field__________

Iron - field______ Aluminum - field ____

Sulfates - field_______ Temperature - field______

Lab sample date, time collected, sample number ____

Treated Water (water exiting treatment system)

Appearance____

Flow__________________ Method used (circle one) Bucket Weir Estimate

pH - field_______ Conductivity – field______

Alkalinity - field_____ Acidity - field__________

Iron - field_________ Aluminum – field _______

Sulfates - field_______ Temperature - field______

Lab sample date, time collected, sample number ____

Stream Monitoring Data Sheets

Date____________________ Time_____________

Name of Group____

Name of Collector________________________________

Name of Stream_________________________________

Description of monitoring site ____

Site ID_______________________________________

Latitude________________ Longitude______________

Are there other AMD sites downstream of this monitoring site?

____

Are there any other passive treatment systems downstream of this monitoring point?

____

Precipitation (circle one)

In past 24 hours:	Current:
Storm (heavy rain >2.5 cm)	Storm (heavy rain >2.5 cm)
Rain (steady rain .85 cm to 2.5 cm)	Rain (steady rain .85 cm to 2.5 cm)
Showers (intermittent rain up to .85 cm)	Showers (intermittent rain up to .85 cm)
Overcast	Overcast
Clear	Clear

Stream Monitoring Data Sheets (continued)

Water Appearance____

Flow________ Method used (circle one) Weir Float method Flow Meter Estimate

Appearance____

pH - field___________

Conductivity – field___ _____

Alkalinity - field__________________

Acidity - field_______

Iron - field__________

Aluminum - field___________

Sulfates - field_______

Temperature - field_________

Lab sample date, time collected, sample number ______________________________

Biosurvey Data Sheet

Date______________________ Time_______________

Name of Group____

Name of Collector____________________________________

Name of Stream______________________________________

Description of monitoring site____

Latitude___________________ Longitude_________________

Are there other AMD sites downstream of this monitoring site?

____

Are there any other passive treatment systems downstream of this monitoring point?

____

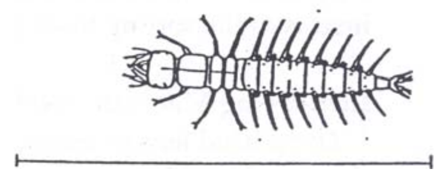
Biosurvey: Identification Chart

Bar lines next to each organism ├──────┤ indicate relative size.

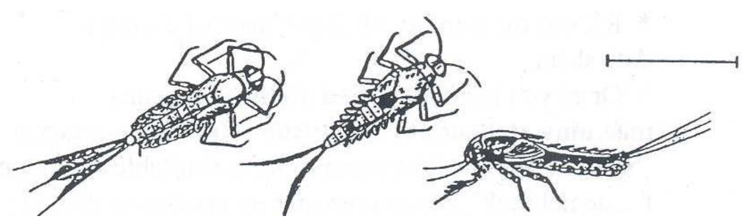
<u>Group I – sensitive</u>

Water Penny Larvae - Order Coleoptera:
4-6 mm flattened disclike forms, found clinging to rocks a dorsal plate conceals the head and 6 legs.

Dobsonfly Larva (Hellgrammite) - Order Megaloptera: 25-90 mm, dark colored, 6 legs, well developed chewing mouthparts, 2 short antennae, 8 abdominal segments each with a pair of filaments; 2 anal prolegs with hooks; has gill tufts at base of legs.

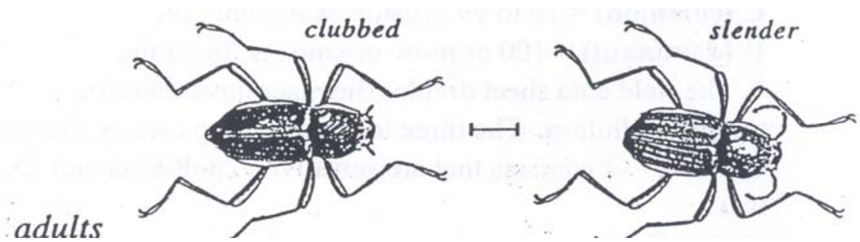


Mayfly Nymph - Order Ephemeroptera:
3-20 mm (not including tails), elongate, cylindrical to flattened form, head with slender antennae, 6 legs with one claw or no claw, wing pads present, platelike or feathery gills along abdomen, 3 long tails (sometimes 2).

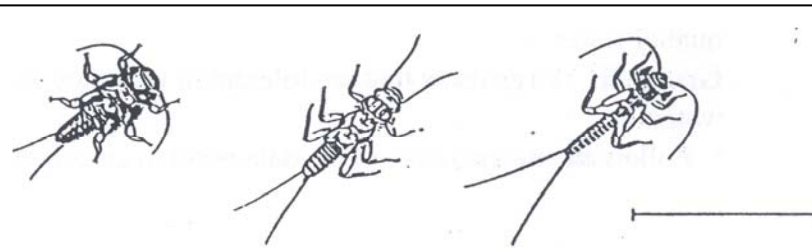


Gilled Snail - Class Gastropoda:
vary in size; a thin, horny plat, the operculum, seals the opening to the shell when the foot is retracted.

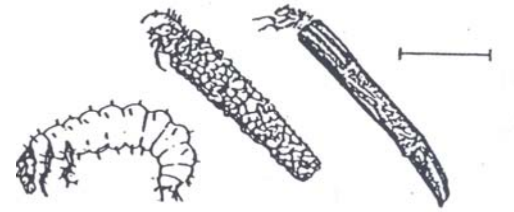
Riffle Beetle - Order Coleoptera: 1-8 mm, oval elongate body, 6 legs, crawl underwater; antennae usually slender but are sometime clubbed.



Stonefly Nymph - Order Plecoptera:
5-35 mm (not including tails), 6 legs with clawed tips, long slender antennae, 2 tails, gills might be present on mouthparts, thorax, and/or legs, gills, rarely present on abdomen, hardened thoracic segments.

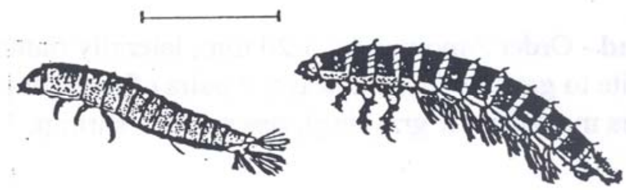


Non-Net Spinning (Case building) Caddisfly Larva – Order Trichoptera: 2-40 mm, usually found within a case attached to the bottom of rocks, case made of plant material or rock particles, long and caterpillar-like, distinct head, chewing mouthparts, antennae reduced or inconspicuous, 3 pairs of legs, no wing pads or tails, end of abdomen has prolegs each with a claw.

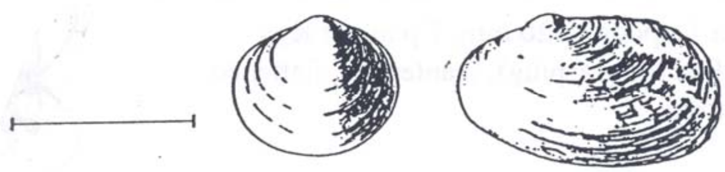


Group II - somewhat sensitive

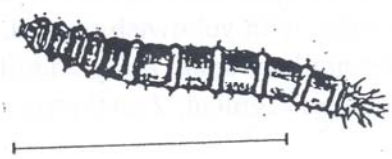
Beetle Larvae - Order Coleoptera: 2-60 mm, distinct head, 2 antennae, 6 legs, 8 to 10 segmented abdomen, might or might not have abdominal gills or lateral filaments.



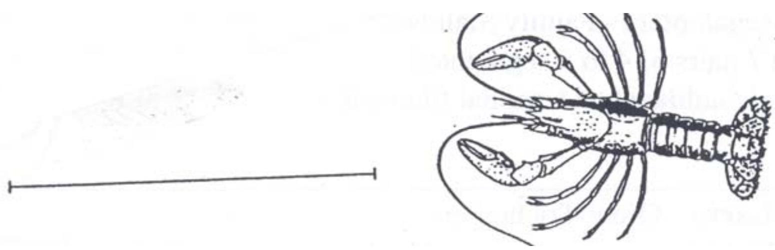
Clams - Class Pelecypoda: 2-250 mm, two-piece (bivalve) shell, commonly oval with concentric growth lines.



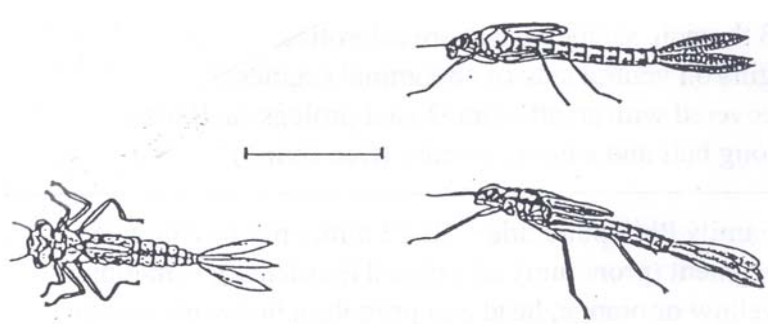
Cranefly Larva - Order Diptera - Family Tipulidae: 10 - 100 mm (sometimes larger), white, green or brown caterpillar-like body, segmented, abdomen on some kinds is bulbous and on others it ends in fleshy projections.



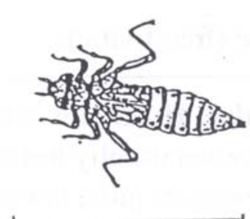
Crayfish - Order Decapoda: 10-150 mm, 2 large claws, 8 legs, 2 long antennae, resembles a tiny lobster.



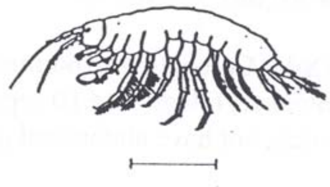
Damselfly Nymph - Order Odonata -Suborder Zygoptera: 10-30 mm, elongate and slender forms, 2 antennae, 6 legs, 2 pairs of wing pads, no gills along body, 3 leaflike "tails" (actually the gills) on end of abdomen; distinctive lower lip is large and extendable.



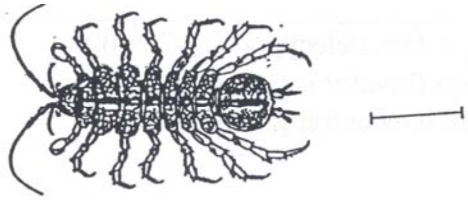
Dragonfly Nymph - Order Odonata - Suborder Anisoptera: 12-15 mm, large eyes, wide oval to round abdomen, 6 hooked legs, gills in rectum.



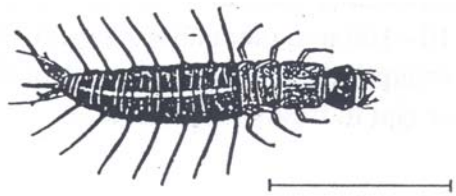
Scud - Order Amphipoda: 5-20 mm, laterally flattened, white to grey, swims sideways, 7 pairs of legs (first two pairs modified for grasping), resembles a shrimp.



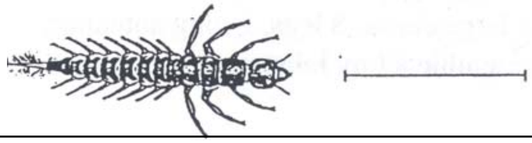
Sowbug - Order Isopoda: 5-20 mm, 7 pairs of legs (first pair modified for grasping), 2 antennae, flattened body, top to bottom.



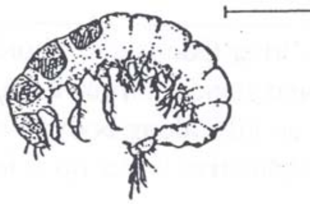
Fishfly Larva - Order Megaloptera - Family Corydalidae: 10-25 mm, reddish-tan often with yellowish streaks, no gill tufts underneath abdomen, resembles a small hellgrammite; have 2 breathing tubes on last abdominal segment; 2 anal prolegs with hooks.



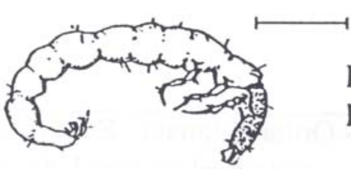
Alderfly Larva - Order Megaloptera - Family Sialidae: 10-25 mm, abdomen with 7 pairs of 4 to 5 segmented lateral filaments and a single unbranched terminal filament.



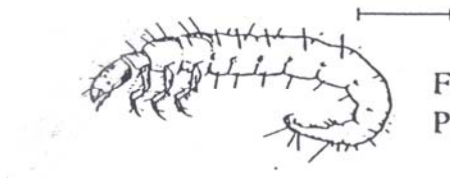
Net-Spinning Caddisfly Larva - Order Trichoptera Family Hydropsychidae: 10-16 mm, strongly curved body, 3 thoracic segments that are sclerotized (hardened), branched gills on ventral side of abdominal segments, (abdomen covered with small hairs), 2 anal prolegs each with tuft of long hair and a hook, no case (free-living).


Family Hydropsychidae

Family Philopotamidae: 10-12 mm, only first thoracic segment (pronotum) sclerotized (hardened), sometimes yellow or orange, head and pronotum brownish orange, pronotum bounded posteriorly by pronounced black line, 3 pairs of legs, no anal prolegs or abdominal gills, abdomen strongly curved, no case (free-living).


Family Philopotamidae

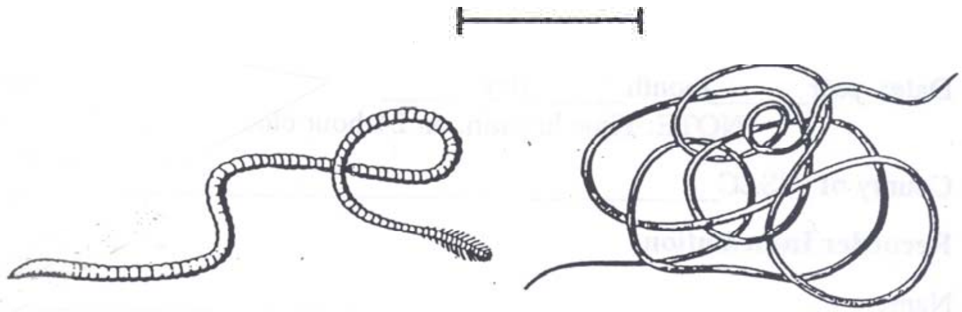
Family Polycentropodidae: 10-25 mm, whitish color tinged with purple, abdomen usually has a lateral fringe of short hairs but never possesses gills, lower end of abdomen strongly curved; 2 anal prolegs.



Family Polycentropodidae

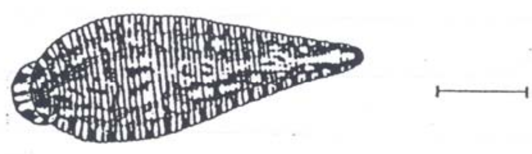
Group III - Tolerant

Aquatic Worm –
Class Oligochaeta: 1-30 mm (sometimes over 100 mm), elongate, cylindrical worms, segmented body (might be difficult to see segments), color variable.

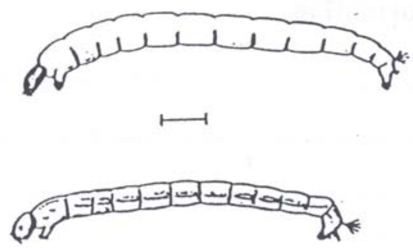


Blackfly Larva - Order Diptera - Family Simulidae: 3-12 mm, cylindrical body with one end wider, black head with fanlike mouth brushes.

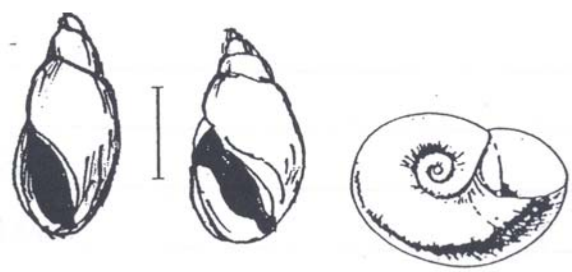
Leech - Order Hirudinea: 5-100 mm, flattened segmented body, both anterior and posterior suckers.



Midge Fly Larva - Order Diptera - Family Chironomidae: 2-20 mm, slender and cylindrical curved body, dark head with 2 prolegs on each side of the bottom of the first segment behind the head.



Other Snails - Class Gastropoda: non-gill breathing snails, do not have an operculum to close the shell opening.



Macroinvertebrate Survey Data Sheet

Type of Stream

____ Rocky-bottom ____ Muddy-bottom

Muddy-bottom Sampling Only: Record the number of jabs taken in each habitat type.

______ Vegetated Bank Margin ______ Aquatic Vegetation Beds
______ Snags and Logs ______ Silt/sand/gravel Substrate

Macroinvertebrate Count

Identify the macroinvertebrate organisms (to order) in your sample using the identification sheets. We are only concerned with organisms that appear on the identification sheets. Record the number of organisms below and then assign them letter codes based on their abundance:

R (rare) = 1-9 organisms; **C** (common) = 10-99 organisms; **D** (dominant) = 100 plus organisms.

example: _20_ (C) *Water Penny larvae*

(Enter a whole number for each, 0-999)

Group I - Sensitive

__________ (____) Water Penny larvae
__________ (____) Hellgrammites
__________ (____) Mayfly nymphs
__________ (____) Gilled snails
__________ (____) Riffle beetle adults
__________ (____) Stonefly nymphs
__________ (____) Non-net spinning caddisfly larvae

Group II - Somewhat Sensitive

__________ (____) Beetle larvae
__________ (____) Clams
__________ (____) Cranefly larvae
__________ (____) Crayfish
__________ (____) Damselfly nymphs
__________ (____) Dragonfly nymphs
__________ (____) Scuds
__________ (____) Sowbugs
__________ (____) Fishfly larvae
__________ (____) Alderfly larvae
__________ (____) Net-spinning caddisfly larvae

Group III - Tolerant

__________ (____) Aquatic worms
__________ (____) Blackfly larvae
__________ (____) Leeches
__________ (____) Midge larvae
__________ (____) Snails

Water Quality Rating

To calculate the index value, add the number of letters found in the three groups above and multiply by the indicated weighing factor.

Group I – Sensitive

(# of R's) x 5.0 = _______________
(# of C's) x 5.6 = _______________
(# of D's) x 5.3 = _______________
Sum of the Index Value for Group I = _______________

Group II – Somewhat Sensitive

(# of R's) x 3.2 = _______________
(# of C's) x 3.4 = _______________
(# of D's) x 3.0 = _______________
Sum of the Index Value for Group II = _______________

Group III – Tolerant

(# of R's) x 1.2 = _______________
(# of C's) x 1.1 = _______________
(# of D's) x 1.0 = _______________
Sum of the Index Value for Group III = _______________

To calculate the water quality score for the stream site, add together the index values for each group. The sum of these values equals the water quality score.

Water Quality Score = _______________

Compare this score to the following number ranges to determine the quality of your stream site

Good > 40 Fair 20-40 Poor < 20

Note: The tolerance groupings (Group I, II, III) and the water quality rating categories were developed for streams in the Mid-Atlantic states.

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #________ RIVERMILE________	STREAM CLASS	
LAT ____________ LONG ____________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ________ TIME ________ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are **not** new fall and **not** transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of 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 Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% 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% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. 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. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation 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

Total Score ___________

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #________ RIVERMILE________	STREAM CLASS	
LAT ____________ LONG ____________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ________ TIME ________ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category: Optimal	Condition Category: Suboptimal	Condition Category: Marginal	Condition Category: Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of 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 <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% 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 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
Parameters to be evaluated broader than sampling reach	**6. Channel Alteration**	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long 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. 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, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation 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

Total Score ________

Chart for 90° V-Notch Weir

Chart for 1 foot wide opening rectangular weir

Chart for 2 foot wide opening rectangular weir

Chart for 3 foot wide opening rectangular weir

Chart for 4 foot wide opening rectangular weir

Stream Flow Measurement Protocol

Collecting Samples for Laboratory Analysis

90° Degree V-Notch Weir

General formula: $Q=aH^b$ (Q=discharge ft^3/sec, H=Head of water above apex, a=3.052, b=2.466)

H (Inches)	H (feet)	Q (gal/min)	H (Inches)	H (feet)	Q (gal/min)
0.5	0.04167	0.54	5.8	0.48333	228.03
0.6	0.05000	0.85	5.9	0.49167	237.85
0.7	0.05833	1.24	6.0	0.50000	247.91
0.8	0.06667	1.72	6.1	0.50833	258.23
0.9	0.07500	2.30	6.2	0.51667	268.79
1.0	0.08333	2.99	6.3	0.52500	279.61
1.1	0.09167	3.78	6.4	0.53333	290.68
1.2	0.10000	4.68	6.5	0.54167	302.01
1.3	0.10833	5.71	6.6	0.55000	313.60
1.4	0.11667	6.85	6.7	0.55833	325.44
1.5	0.12500	8.12	6.8	0.56667	337.55
1.6	0.13333	9.52	6.9	0.57500	349.93
1.7	0.14167	11.06	7.0	0.58333	362.57
1.8	0.15000	12.73	7.1	0.59167	375.47
1.9	0.15833	14.55	7.2	0.60000	388.65
2.0	0.16667	16.51	7.3	0.60833	402.10
2.1	0.17500	18.62	7.4	0.61667	415.82
2.2	0.18333	20.88	7.5	0.62500	429.81
2.3	0.19167	23.30	7.6	0.63333	444.08
2.4	0.20000	25.88	7.7	0.64167	458.63
2.5	0.20833	28.62	7.8	0.65000	473.46
2.6	0.21667	31.53	7.9	0.65833	488.57
2.7	0.22500	34.6	8.0	0.66667	503.96
2.8	0.23333	37.85	8.1	0.67500	519.64
2.9	0.24167	41.27	8.2	0.68333	535.60
3.0	0.25000	44.87	8.3	0.69167	551.85
3.1	0.25833	48.65	8.4	0.70000	568.39
3.2	0.26667	52.61	8.5	0.70833	585.23
3.3	0.27500	56.76	8.6	0.71667	602.35
3.4	0.28333	61.09	8.7	0.72500	619.77
3.5	0.29167	65.62	8.8	0.73333	637.49
3.6	0.30000	70.34	8.9	0.74167	655.50
3.7	0.30833	75.26	9.0	0.75000	673.81
3.8	0.31667	80.38	9.1	0.75833	692.42
3.9	0.32500	85.69	9.2	0.76667	711.34
4.0	0.33333	91.21	9.3	0.77500	730.56
4.1	0.34167	96.94	9.4	0.78333	750.08
4.2	0.35000	102.87	9.5	0.79167	769.92
4.3	0.35833	109.02	9.6	0.80000	790.05
4.4	0.36667	115.38	9.7	0.80833	810.50
4.5	0.37500	121.95	9.8	0.81667	831.27
4.6	0.38333	128.75	9.9	0.82500	852.34
4.7	0.39167	135.76	10.0	0.83333	873.73
4.8	0.40000	142.99	10.1	0.84167	895.43
4.9	0.40833	150.45	10.2	0.85000	917.45
5.0	0.41667	158.14	10.3	0.85833	939.79
5.1	0.42500	166.05	10.4	0.86667	962.46
5.2	0.43333	174.20	10.5	0.87500	985.44
5.3	0.44167	182.57	10.6	0.88333	1008.74
5.4	0.45000	191.19	10.7	0.89167	1032.37
5.5	0.45833	200.04	10.8	0.90000	1056.33
5.6	0.46667	209.13	10.9	0.90833	1080.61
5.7	0.47500	218.46	11.0	0.91667	1105.23

One foot Rectangular Weir

General Formula: $Q=3.33(L-0.2H)H^{1.5}$ (Q=Discharge ft^3/sec, L=length of weir opening in feet, H=head on weir in feet)

H (Inches)	H (feet)	Q (gal/min)	H (Inches)	H (feet)	Q (gal/min)
0.5	0.04	12.61	3.9	0.33	258.90
0.6	0.06	16.54	4.0	0.33	268.44
0.7	0.06	20.81	4.1	0.34	279.07
0.8	0.07	25.38	4.2	0.35	287.79
0.9	0.08	30.24	4.3	0.36	297.60
1.0	0.08	35.35	4.4	0.37	307.49
1.1	0.09	40.72	4.5	0.38	317.46
1.2	0.10	46.32	4.6	0.38	327.51
1.3	0.11	52.13	4.7	0.39	337.63
1.4	0.12	58.17	4.8	0.40	347.84
1.5	0.13	64.40	4.9	0.41	358.11
1.6	0.13	70.82	5.0	0.42	368.46
1.7	0.14	77.43	5.1	0.43	378.86
1.8	0.15	84.22	5.2	0.43	389.37
1.9	0.16	91.18	5.3	0.44	399.92
2.0	0.17	96.30	5.4	0.45	410.54
2.1	0.18	105.58	5.5	0.46	421.23
2.2	0.18	113.01	5.6	0.47	431.97
2.3	0.19	120.60	5.7	0.48	442.78
2.4	0.20	128.33	5.8	0.48	453.64
2.5	0.21	136.19	5.9	0.49	454.57
2.6	0.22	144.19	6.0	0.50	475.55
2.7	0.23	152.33	6.1	0.51	486.58
2.8	0.23	160.59	6.2	0.52	497.67
2.9	0.24	168.97	6.3	0.52	508.81
3.0	0.25	177.47	6.4	0.53	520.01
3.1	0.26	186.09	6.5	0.54	531.25
3.2	0.27	194.83	6.6	0.55	542.54
3.3	0.28	203.67	6.7	0.56	553.88
3.4	0.28	212.62	6.8	0.57	565.26
3.5	0.29	221.68	6.9	0.57	576.69
3.6	0.30	230.84	7.0	0.58	588.16
3.7	0.31	240.10			
3.8	0.32	249.45			

Two foot Rectangular Weir

General Formula: $Q=3.33(L-0.2H)H^{1.5}$ (Q=Discharge ft^3/sec, L=length of weir opening in feet, H=head on weir in feet)

H (Inches)	H (feet)	Q (gal/min)	H (Inches)	H (feet)	Q (gal/min)
0.5	0.04	25.32	3.9	0.33	535.80
0.6	0.06	33.25	4.0	0.33	556.06
0.7	0.06	41.87	4.1	0.34	576.54
0.8	0.07	51.11	4.2	0.35	597.25
0.9	0.08	60.93	4.3	0.36	618.17
1.0	0.08	71.31	4.4	0.37	639.31
1.1	0.09	82.19	4.5	0.38	660.65
1.2	0.10	93.58	4.6	0.38	682.21
1.3	0.11	105.42	4.7	0.39	703.96
1.4	0.12	117.72	4.8	0.40	725.92
1.5	0.13	130.45	4.9	0.41	748.07
1.6	0.13	143.58	5.0	0.42	770.42
1.7	0.14	157.12	5.1	0.43	792.96
1.8	0.15	171.04	5.2	0.43	815.68
1.9	0.16	185.33	5.3	0.44	838.59
2.0	0.17	199.99	5.4	0.45	861.69
2.1	0.18	214.99	5.5	0.46	884.96
2.2	0.18	230.33	5.6	0.47	906.41
2.3	0.19	246.00	5.7	0.48	932.04
2.4	0.20	262.00	5.8	0.48	955.83
2.5	0.21	278.31	5.9	0.49	979.80
2.6	0.22	294.92	6.0	0.50	1003.94
2.7	0.23	311.83	6.1	0.51	1028.24
2.8	0.23	329.03	6.2	0.52	1052.70
2.9	0.24	346.52	6.3	0.52	1077.32
3.0	0.25	364.29	6.4	0.53	1102.10
3.1	0.26	382.32	6.5	0.54	1127.04
3.2	0.27	400.83	6.6	0.55	1152.13
3.3	0.28	419.19	6.7	0.56	1177.38
3.4	0.28	438.02	6.8	0.57	1202.77
3.5	0.29	457.09	6.9	0.57	1228.32
3.6	0.30	476.41	7.0	0.58	1254.01
3.7	0.31	495.97			
3.8	0.32	515.77			

Three foot Rectangular Weir

General Formula: $Q=3.33(L-0.2H)H^{1.5}$ (Q=Discharge ft^3/sec, L=length of weir opening in feet, H=head on weir in feet)

H (Inches)	H (feet)	Q (gal/min)	H (Inches)	H (feet)	Q (gal/min)
0.5	0.04	38.03	3.9	0.33	812.70
0.6	0.06	49.96	4.0	0.33	843.68
0.7	0.06	62.92	4.1	0.34	875.02
0.8	0.07	76.83	4.2	0.35	906.72
0.9	0.08	91.63	4.3	0.36	938.75
1.0	0.08	107.26	4.4	0.37	971.13
1.1	0.09	123.07	4.5	0.38	1003.85
1.2	0.10	140.84	4.6	0.38	1036.91
1.3	0.11	158.71	4.7	0.39	1070.29
1.4	0.12	177.27	4.8	0.40	1104.00
1.5	0.13	196.49	4.9	0.41	1138.03
1.6	0.13	216.35	5.0	0.42	1172.38
1.7	0.14	236.81	5.1	0.43	1207.03
1.8	0.15	257.86	5.2	0.43	1242.00
1.9	0.16	279.49	5.3	0.44	1277.26
2.0	0.17	301.67	5.4	0.45	1312.83
2.1	0.18	324.40	5.5	0.46	1348.69
2.2	0.18	347.65	5.6	0.47	1384.85
2.3	0.19	371.41	5.7	0.48	1421.29
2.4	0.20	395.67	5.8	0.48	1458.02
2.5	0.21	420.42	5.9	0.49	1496.03
2.6	0.22	445.64	6.0	0.50	1532.32
2.7	0.23	471.33	6.1	0.51	1569.89
2.8	0.23	497.48	6.2	0.52	1607.72
2.9	0.24	524.07	6.3	0.52	1645.83
3.0	0.25	551.10	6.4	0.53	1684.20
3.1	0.26	578.55	6.5	0.54	1722.83
3.2	0.27	606.43	6.6	0.55	1761.73
3.3	0.28	634.72	6.7	0.56	1800.88
3.4	0.28	663.41	6.8	0.57	1840.29
3.5	0.29	692.50	6.9	0.57	1879.94
3.6	0.30	721.98	7.0	0.58	1919.85
3.7	0.31	751.85			
3.8	0.32	782.09			

Four foot Rectangular Weir

General Formula: $Q=3.33(L-0.2H)H^{1.5}$ (Q=Discharge ft^3/sec, L=length of weir opening in feet, H=head on weir in feet)

H (Inches)	H (feet)	Q (gal/min)	H (Inches)	H (feet)	Q (gal/min)
0.5	0.04	50.74	3.9	0.33	1089.60
0.6	0.06	66.67	4.0	0.33	1131.30
0.7	0.06	83.98	4.1	0.34	1173.49
0.8	0.07	102.56	4.2	0.35	1216.16
0.9	0.08	122.33	4.3	0.36	1259.32
1.0	0.08	143.21	4.4	0.37	1302.95
1.1	0.09	165.15	4.5	0.38	1347.05
1.2	0.10	188.10	4.6	0.38	1391.61
1.3	0.11	212.00	4.7	0.39	1436.62
1.4	0.12	236.83	4.8	0.40	1482.09
1.5	0.13	262.54	4.9	0.41	1527.99
1.6	0.13	289.11	5.0	0.42	1574.33
1.7	0.14	316.50	5.1	0.43	1621.11
1.8	0.15	344.69	5.2	0.43	1668.31
1.9	0.16	373.65	5.3	0.44	1715.94
2.0	0.17	403.36	5.4	0.45	1763.98
2.1	0.18	433.81	5.5	0.46	1812.43
2.2	0.18	464.96	5.6	0.47	1861.29
2.3	0.19	496.82	5.7	0.48	1910.55
2.4	0.20	529.34	5.8	0.48	1960.21
2.5	0.21	562.53	5.9	0.49	2010.27
2.6	0.22	596.37	6.0	0.50	2060.71
2.7	0.23	630.84	6.1	0.51	2111.54
2.8	0.23	655.93	6.2	0.52	2162.75
2.9	0.24	701.62	6.3	0.52	2214.34
3.0	0.25	737.91	6.4	0.53	2266.30
3.1	0.26	774.79	6.5	0.54	2318.63
3.2	0.27	812.23	6.6	0.55	2371.32
3.3	0.28	850.24	6.7	0.56	2424.38
3.4	0.28	888.81	6.8	0.57	2477.80
3.5	0.29	927.91	6.9	0.57	2531.57
3.6	0.30	967.55	7.0	0.58	2585.69
3.7	0.31	1007.72			
3.8	0.32	1048.41			

STREAM FLOW MEASUREMENT PROTOCOL
FOR INSTREAM DISCHARGE (Q) CALCULATION

The estimate of stream discharge (Q) requires careful field measurements during variable flow conditions. Since stream discharge is a volume estimate, three dimensions must be measured. Stream width (W) and stream depth (D) are simple measurements equivalent to the cubical width and height. Since streams are flowing, the cubical length equivalent becomes a distance/time dimension (velocity, or V).

The following protocol provides guidelines outlining procedures designed to assure that W, D, and V are measured as accurately and consistently as possible. This protocol follows a "6/10th" depth method similar to that described in USGS field methodology manuals and other sources.

1. Equipment needs:

(a) Flow meter (This protocol is written for "electromagnetic probe" type flow meters similar to Marsh-McBirney models.)

(b) Standard wading rod

(c) 100' cloth tape measure (English/metric in 1/10ths)

(d) two rods/stakes for anchoring measuring tape

(e) clip board & data entry form or field data book

(f) pencils and spare meter batteries

(g) flow calculation program

(h) proper wading gear (hip or chest waders (preferred) ***Rubber-soled boots are better than felt soled boots; however, if using felt soles make sure to clean and disinfect the boots and soles before entering other steams in order to prevent the spread of aquatic invasive species.)***

2. Stream reach selection and site conditions

(a) Select stream reach location that properly reflects the cumulative flow from upstream study area.

(i) Avoid sampling immediately downstream from road crossings, road drainage ditches, tributary "plumes" (in the mixing zone - before the "zone of complete mix").

(ii) Be sure to sample or place the transect far enough downstream to reflect upstream discharges: point sources, nonpoint sources, and tributaries.

(b) Be sure flow conditions are measurable (water is moving) and wadeable (<1 meter deep & <1m/sec).

3. Transect Placement - Open channel/flow considerations

(a) Strive for the “ideal transect” - stretch your tape across the stream; perpendicular to the direction of mid-channel flow, where you find the best combination of the following “ideal” conditions:

(i) Straight channel - try to find a stream section with a straight distance that is 2X the stream width. For stream widths > 10’, straight distances <2X width can be considered IF there are no (or very few) obstacles, large vortices, or mid-channel flow diversions.

(ii) Laminar flow - the channel bottom should be as smooth as possible.

(iii) No obstacles - avoid sections where there are protruding boulders, sandbars, deflecting structures (logs, brush, debris, etc.).

(iv) Uniform depth -“U-shaped” channel with steady, gradual, tapering depths. Avoid abrupt, almost vertical changes in depth.

(v) No backwater flow.

(b) In many cases, instream conditions may be altered to reduce the overall inaccuracy by moving some submerged materials and obstacles that deflect flow or cause associated turbulence.

4. Meter and wading rod preparation

(a) Check batteries.

(b) Calibrate meter according to manufacturer’s specifications.

(c) Attach meter probe to wading rod so that the signal wire exits from the top and is parallel to the wading rod’s vertical shaft.

5. Velocity measurements

Once the tape transect has been positioned, flow measurements may begin following these guidelines:

(a) Meter operation - (This protocol is written for “electromagnetic probe” type flow meters similar to Marsh-McBirney models. If other models are used, follow the manufacturer’s instructions to render a velocity reading.)

(i) Meter is “readied” (turn on and set scale to “ft/sec”).

(ii) Meter is set for any “time constant.”

(iii) Velocity is read once it has stabilized.

(b) Wading rod placement and operation ("6/10th depth" method)

(i) With the operator standing downstream from the tape, the wading rod is held behind the tape at straight-arm length, aligned at the first width increment, and rested on the stream bottom in a perpendicular position.

(ii) Measure depth and adjust meter probe to proper depth setting by depressing the sliding rod lock and sliding it up to align with the "tenth scale" depth. The sliding rod is calibrated with single lines in 1.0 foot increments. The appropriate foot marker on the sliding rod is aligned with its corresponding "1/10th" foot reading. For example, the depth was measured to be 2.3 feet. The "2" foot marker on the sliding rod is aligned with the "3" line on the "tenth scale". Because of the wading rod's construction, the meter's probe depth is now properly positioned at "6/10ths of the total depth" from the surface.

(iii) After each velocity reading, move the rod to the next width increment, reset the meter probe depth and measure the velocity.

(iv) Repeat until all required width increments have been measured.

6. Cross-section measurements ("Mid-section" Method)

Cross-section measurements are taken to provide the "W" and "D" dimensions for Q calculations. Since the stream depth and velocities vary widely across any given transect, the cross-section will be divided into many smaller sub-sections (at least 20); each with its own W, D, and V measurements. This is to assure that no more than 5 percent of the total transect Q flows through any one sub-section and that inaccuracies introduced by widely variable depths and velocities are minimized.

(a) Anchor tape to both stream banks and measure width.

(b) Record W, D, and V entries on a flow data sheet for each width increment. It is more convenient for data recording to measure width increments in ascending order across the transect. The first depth and velocity entries should begin at the shoreline and be recorded as "0" and "0", respectively.

(c) Repeat, measuring at least 20 subsections. The final W, D, V readings recorded should be measured at the water's edge on the opposite bank and, again be entered as "0" and "0", respectively.

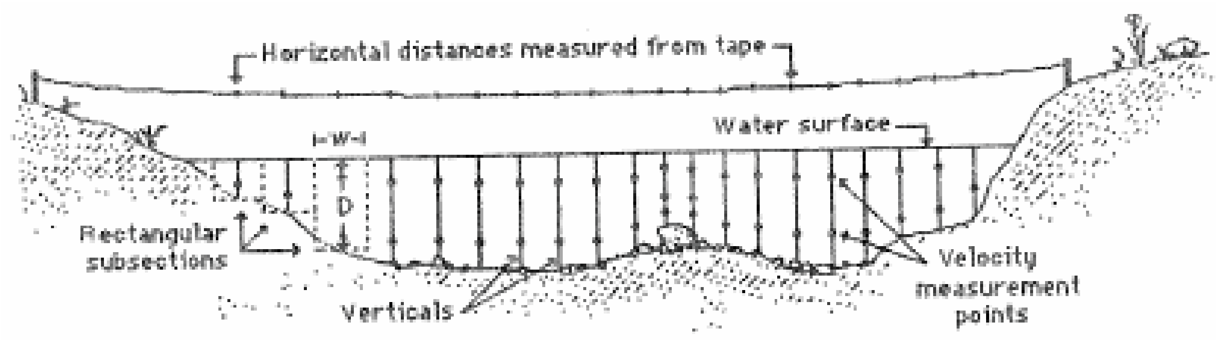
(d) Special conditions or situations to consider:

(i) For meter operation, probe must be completely submerged (approx. 3" depth).

(ii) Sub-section increments must be shortened significantly whenever velocities or depths change dramatically. Measuring smaller width increments may increase the number of sub-sections in any given transect.

(iii) Avoid placing transects in areas where backflow occurs.

Figure 1



Flow Meter Datasheet

Stream:				
Station:				
Date:				
Stream Width:				
Collectors:				
Discharge (Q) in gallons/minute = Sum of flow rates (Column 5 total) * 448.8				
Column 1 Tape (feet) (Where measurements are taken)	Column 2 Interval (Feet) (Distance on tape from one reading to next)	Column 3 Depth (feet)	Column 4 Velocity (feet/sec)	Column 5 Flow rate (ft^3/sec) (Col. 2 * Col. 3 * Col. 4)
				Total Sum of flow rates:

Collecting Samples for Laboratory Analysis

1. At each sample location, the volunteer will have a 500 ml and 125 ml bottle.

2. Each bottle should be labeled with site ID, date, Collector's number, sequence number and location. The smaller bottle will be additionally labeled with "Fixed by HNO_3".

3. The stream sample should be taken in the center of the stream (when safe to do so). For the discharge, the sample needs to be taken as close to the source as possible. For the treatment system, the sample should be taken at final outlet.

4. Bottles are rinsed with sample water, 3 times, each time pouring the water downstream of the sample location.

5. The 500 ml bottle is filled with sample water. In the stream, care should be taken to collect water from the entire water column of the stream. Push the bottle from the stream surface toward the stream bottom, making sure not to touch the stream bottom. Bring the bottle toward the stream surface, pointing the bottle upstream. Bottle should be filled to the shoulder. If the discharge and final treatment flow is like a stream, then this same method should be used. If water comes out of a pipe, bottle is placed under the pipe and allowed to fill.

6. Same procedure is followed for 125 ml bottle. Then nitric acid (HNO_3) is added to the 125 ml bottle starting with 1-2 drops. Check the pH of the sample by shaking the sample bottle and pouring a small amount of sample in the bottle lid. Check this small amount with pH paper to make sure the sample is acidified to a pH of <2.0. If pH is not < 2.0 then add another drop of HNO_3 and repeat the check of the sample with pH paper. If pH is still not <2.0 add another drop of HNO_3 and continue checking the sample and adding HNO_3 until pH <2.0.

7. All bottles are then placed in a cooler with ice.

8. The samples are taken to a courier location where samples for the PADEP lab are picked up or taken to the local lab.