Quality Assurance Project Plan for Cluster Groups

Delaware River Watershed Initiative 2015-2016

Quality Assurance Project Plan Approval

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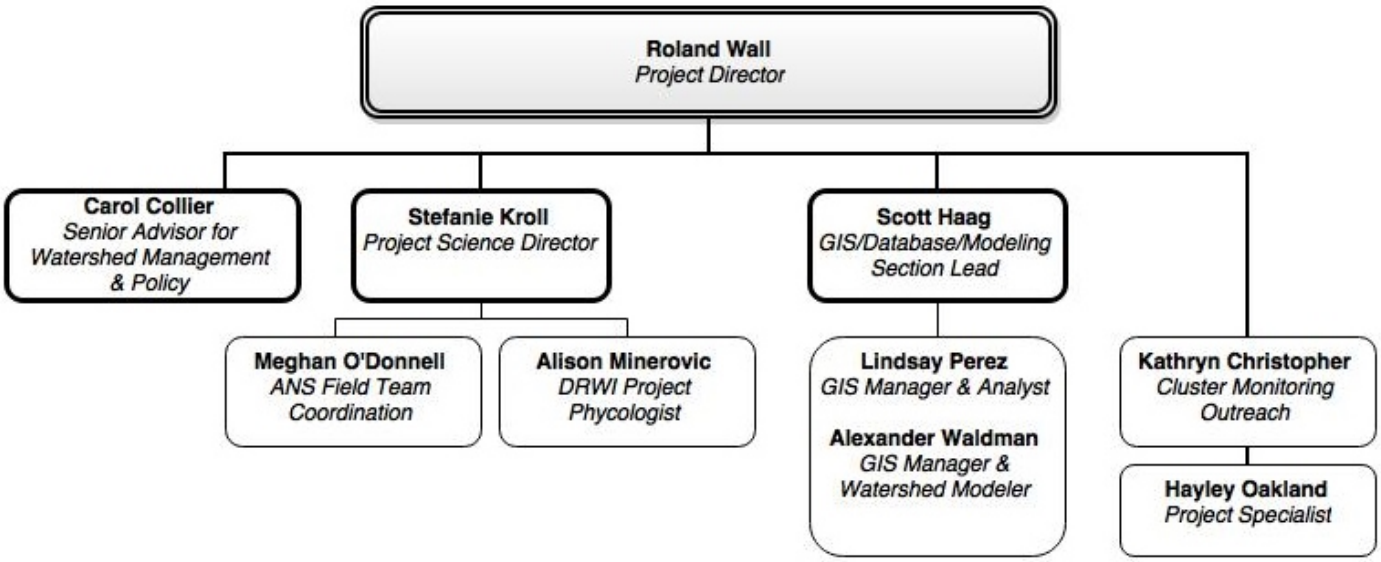

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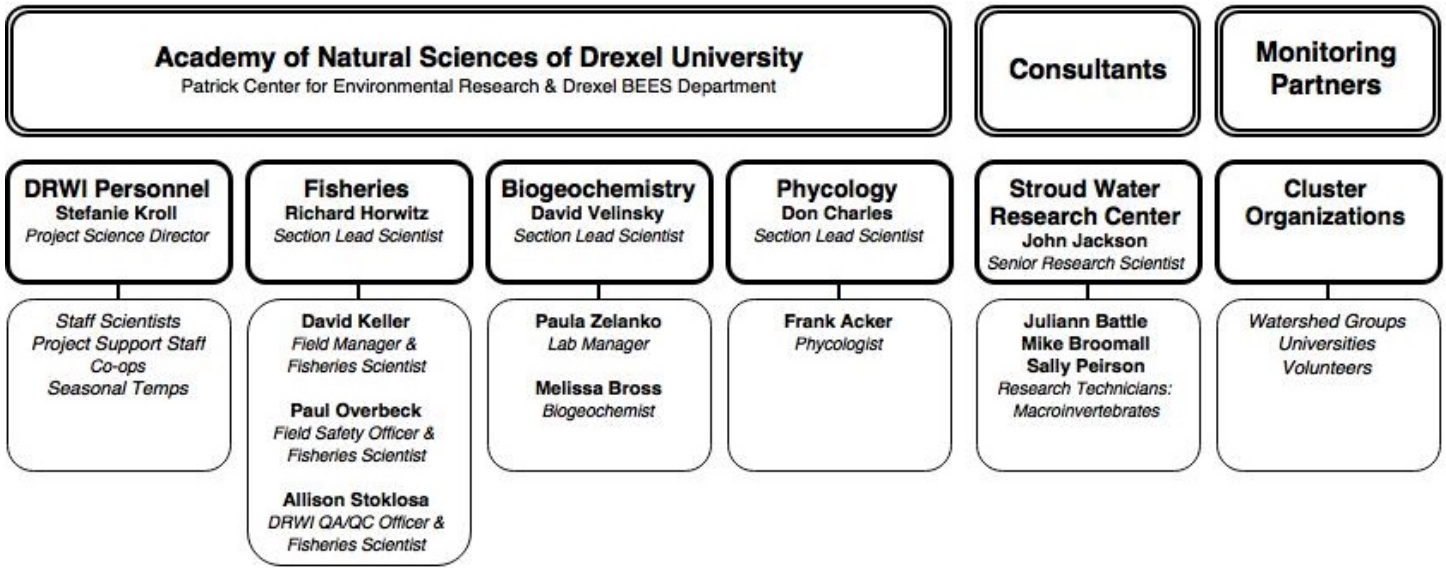

2. Introduction

As part of the Delaware River Watershed Initiative (DRWI), funded by the William Penn Foundation, biological and chemical data are collected by the Academy of Natural Sciences of Drexel University (ANS), and by partner organizations ("cluster groups").

This document is adapted from the ANS "Quality Assurance Project Plan for Watershed Protection Project 2013-2014" (the Watershed Protection Project is now known as Delaware River Watershed Initiative) and outlines procedures and protocols for sampling, data recording and laboratory analysis, specific to the cluster groups. Standard sampling, sample transport, laboratory analysis, and data management procedures comply with relevant ANS Standard Operating Procedures (SOPs; available upon request). Sampling events and data collection by the cluster groups will take place according to the following schedules, parameters and methods, and will be categorized by ANS according to the "tiers" described below. This coordinated approach to monitoring serves to produce a comprehensive, consistent data set which will be useful in showing the effects of actions taken through the DRWI. The tiers of expertise and approaches to monitoring are important for capturing useful information from working with partners with different amounts of time available for monitoring as well as varying levels of skill and capacity. All data are made public so they can be used in assessment, outreach and research by current and future DRWI partners.

3. Background and Problem Definition

In 2012, the William Penn Foundation made a strategic decision to focus its environmental investments on projects that will benefit water quality and ecological health in the Delaware River Basin. Watersheds within the Delaware Basin are the optimum scale of analysis for approaching these goals. There are several key elements to this strategy:

1.) The Foundation is committed to the use of science and, in particular, scientifically credible indicator metrics to shape strategies, guide understanding of watershed protection, and evaluate the effectiveness of funded projects.

2.) The Foundation's place-based funding strategy will target sub-watersheds and groupings of sub-watersheds to either restore degraded ecological conditions or to protect areas of ecological value. The Foundation will support projects that aim to improve conditions in the locality, are illustrative of strategies that can be applied in other locations, will address stressors that are emblematic of the watershed as a whole, and/or will have impact on cluster-scale and basin-scale problems.

3.) The Foundation recognizes that watershed protection projects, both restoration and conservation, and their ultimate results may require years to decades to evolve. Nonetheless, systematic scientific monitoring and evaluation remain the best tools for planning and implementing watershed projects, and for understanding their ultimate benefits.

4.) The Foundation is funding ANS to collect, analyze and report indicators that will reflect ecological conditions relative to the project sites, general conditions of the targeted watershed clusters, and overall conditions of the Delaware Basin. These data will be shared with the Foundation, the cluster coordinating organizations and the individual grantees, and utilized as outlined below.

5.) Each grantee will develop an internal monitoring plan to guide their projects and assess progress, as well as provide a better understanding of the role of the project in the condition of the larger watershed. The Foundation is making resources available to support planning and implementation of the plans, including ongoing interface with and guidance from ANS.

6.) Although funding for the sub-watershed level projects will focus on restoration and conservation goals at specific sites, the Foundation is committed to having an impact on the overall ecological health of the Delaware Basin. Therefore, monitoring and evaluation will be used to relate the funded projects to the conditions of the clusters and of the Basin as a whole.

7.) There is also recognition that for specific projects, the likelihood of dramatic changes in larger watershed conditions is unlikely. For that reason, more intense monitoring will take place at a granular level in the proximity of projects, while general monitoring will be used at the cluster and basin scale to set the context of the projects and determine major trends. For conservation projects, expected outcomes of the grants will focus on the commitments of the grantees (i.e., "miles of riparian zone restored") rather than firm ecological expectations.

4. Project Description

4a. Study sites and sampling design

In 2012, eight subwatershed clusters were prioritized according to landscape variables (e.g. land use, conservation easements and land trust areas) as well as organizational capacity for potential grantees of the William Penn Foundation.

Field data are collected in tributaries of the Delaware River in these clusters, where grantees of the William Penn Foundation are expected to perform restoration and conservation activities. In 2013, “integrative” sites were chosen to be representative of land use and stream conditions within subwatershed clusters and integrative of stressors or conservation areas in the drainage basin of these sites. These integrative site stream reaches are monitored over 3 to 10 years, in addition to sites that relate to where projects are developed by William Penn Foundation grantees (“project sites”).

Baseline (integrative site) sampling in 2013 provides an initial data set on the status of the ecological integrity of these streams for comparison with future samples. Project site sampling in 2014 provides “before, control-impact” sampling (within the BACI design, Stewart-Oaten et al., 1986, Bence et al., 1996). The “after, control-impact” sampling will be performed after project implementation (2015-2017) and likely in subsequent years. The baseline sites can be compared with project sample sites to rule out any local factors that may confound results. A list of the study sites is available on request.

4b. Data usage

The primary users of the biological and water chemistry data collected in this study will be ANS, the William Penn Foundation and grantees. These data will be used to monitor short- and long-term changes in water quality and ecological integrity within subwatershed clusters of the Delaware River Basin. Results will be used to compare ecological conditions at project sites and changes over time. Biological, water chemistry and in-stream habitat data will be used as indicators of stream condition. These data will be made public (with the exception of sensitive personal data) in accordance with the goals and mission of The William

Penn Foundation for the DRWI. Results will also be presented in cases wherein data sharing is legally required (e.g., as part of reporting for scientific collecting permits) or to provide landowners with information on the project.

4c. Cluster Group Tiers of Data

Data from cluster groups are of one of three tiers of integrity (Table 1). This distinction ensures that data used in scientific analysis, research and reports (Tier 1) are of a consistent level of rigor. Tier 2 data are also useful in analyses of baseline conditions and long-term trends on a coarser scale, and for outreach and community engagement. Tier 3 data are valued for their broad coverage over time and space and for their capacity to identify major trends and threats.

Table 1: Three tiers of data collected by cluster groups

Tier	Stream-side Chemistry	Laboratory Chemistry		Macroinvertebrates		QA/ QC
		Analysis	***Parameters, Detection Limits***	***Sampling***	***ID Level***	
1	YSI sonde or other probe	ANS or other designated lab*	Appendix I: Table I (Parameters) & Table II (Detection Limits)	Surber sampler	Genus level; 200-300 individuals	Field & lab: by Cluster group, ANS & Stroud
2	Chemistry kit (ex. Hach, LaMotte)	Hach kit or other chemistry kit; non-designated lab	Does not meet Appendix I: Table I (Parameters) or Table II (Detection Limits)	Kick nets	Family level; 200-300 individuals	Field & lab: ANS & Stroud
3	Chemistry kit (ex. Hach, LaMotte)	None	None	Kick nets, other	Family or Order	Other: by Cluster group

**Performance-based laboratory methods following EPA or other appropriate guidelines.*

5. Sampling Procedures

Cluster groups should include the following information on all sample containers and data sheets: site ID*, collection date and time, group or organization who performed the collection/assessment, and the names of the individuals who performed the collection/assessment. *If site codes have been assigned to cluster monitoring locations by ANS, please use that information. If locations do not yet have site codes assigned by ANS, continue to use your typical site identification information, and ANS will make the conversion upon entering data into the ANS database.

5a. Timing of sampling events

The ideal time frames for sampling different parameters for both ANS and the cluster groups are outlined in Table 2.

Table 2: Sampling timeline for ANS and cluster groups

	Spring	Summer	Fall	Winter
Water chemistry	Sampling can be done all year; timing and frequency depends on monitoring plan			
Macroinvertebrates	February – April*			February – April*
Algae		July - September		
Fish	May - October			

**May vary for northern geographies.*

5b. Water chemistry

Parameters & detection limits: Chemical Parameters for Cluster Groups can be found in Appendix I, Table I. Primary parameters are the minimum requirements for comparison of different projects. Analysis of secondary parameters is cost- and project-dependent. Detection Limits for Cluster Groups can be found in Appendix I, Table II.

5b-1. Streamside chemical parameters

Streamside chemical parameters (such as dissolved oxygen, pH, conductivity and temperature) are measured with a YSI Multi Probe or equivalent sensor(s) *in situ* 1 meter below the water surface or, in riffles, just below the water surface.

5b-2. Water column sampling

Sample Collection Bottle Cleaning: At each site, all collection equipment (the sample container and any additional sampling equipment – e.g. pitcher – if used) is rinsed three times with site water prior to collection. Between sites, sampling equipment (e.g. pitcher) is disassembled and rinsed with deionized water (DIW), then stored in a clean Zip-Loc bag. At the next site, the sampling equipment is then rinsed three times with site water prior to use. Note: sampling equipment must be rinsed with dilute HCL and DIW after sampling during the day and stored in plastic baggie.

Sample Collection: Samples should be taken at riffles upstream of bridges. Water should be collected at the downstream portion of the study reach before anyone has entered the stream. If any portion of stream reach is disturbed, samples must be taken from the top of the reach, upstream of any disturbance in the water (i.e. people walking in the water). A clean pair of latex or nitrile gloves can be put on at the beginning of each sample collection (if the water is of questionable quality). Sample containers are labeled directly on the container with permanent marker or with permanent marker on label tape, which has been wrapped all the way around to avoid peeling. Information on the label should include: DRWI, site ID, date and time of collection.

Water column samples are taken using a dip method in the middle of the water column. The sample container is submerged until approximately 80% full. If the stream is too shallow due to low flow conditions, a modified grab sample can be taken using a pre-cleaned Pyrex glass pitcher. In addition, if conditions are encountered where the above method of sample collection is considered to be dangerous (e.g., during high flow events), a modified technique is used, in which samples are composited from subsamples taken at representative depths and locations along the stream transect.

Blank and Duplicate Collection: Two types of blanks and one duplicate sample are collected during the duration of the sampling season.

1) Equipment Blank: If, in addition to the sample container, an additional bottle/pitcher is used to collect the sample, the equipment blank will be collected on the same day at a rate of 1 blank per 10 samples. After the bottle/pitcher and sample container have been cleaned and rinsed with DIW, the inside of the bottle/pitcher is rinsed with DIW into the sample container enough times to eventually fill it. The sample container is placed on ice. The label should include: "Equip. blank," DRWI, site ID, date and time of collection.

2) Field Blank: Collect 1 every 10 samples collected at the beginning of the first field day (any subsampling equipment [pitcher/bottle] had been cleaned the night before). Sample container is rinsed three times with DIW, and then the sample container is filled with DIW. The sample container is placed on ice. The label should include: "Field blank," DRWI, site ID, date and time of collection.

3) Duplicate: A second, typical stream water sample; collected at the same time as sample at a rate of 1 duplicate per 10 samples. The label should include: "Dupe," DRWI, site ID, date and time of collection.

Sample Preservation: Cubes/bottles are placed on ice, in the dark, until they can be refrigerated (must be kept in the dark at 4 degrees Celsius [± 2 degrees Celsius]). Water column samples must be shipped or hand delivered to laboratory (ANS or other lab designated to perform analysis) for analysis (filtering/processing) within 24 hours from the time of sample collection.

Alternatively, filtering for nutrient sub-samples (see "Sample Filtration" below) can be accomplished in the field. In these cases, water column samples can be preserved on ice, but nutrient sub-samples must be frozen (e.g. with dry ice) and both can then be delivered to the main laboratory within 7 days of collection.

5b-3. Nutrient sub-sampling

Sample Filtration: From the water column "grab samples," a subsample is set aside for nutrient analysis. These samples are analyzed for dissolved nutrients including nitrate+nitrite, ammonium+ammonia, and soluble reactive phosphorus (SRP). This requires two 125-mL bottles per site – one unfiltered, one filtered. Nutrient samples must be filtered within 24 hours of collection of water column sampling time and frozen immediately after filtering. Samples can be filtered in the field using 125-ml, pre-cleaned syringe filtering apparatus and 0.7-μm Whatman glass fiber filter or 25 mm x 0.45-μm syringe filters or equivalent. All material is cleaned prior to use. Bottles should be labeled before filling. Bottles are wrapped with label tape and identified using permanent marker: "DRWI", site ID, date, and Filtered ("FNUT") or Unfiltered ("UNUT"). Sample container with water column sample should be shaken before any subsample is extracted from it.

The filtrate is placed in pre-cleaned HDPE containers for storage and transported back to the laboratory. Filtered samples will fill a 125-ml blue top bottle (FNUT). Filtered: Water is extracted from the sample container using a syringe. A glass fiber filter is attached to the syringe and a small amount of the filtered water is pushed into the "FNUT" bottle, shaken to rinse, then discarded. Then the bottle is filled with the filtered water using the syringe. Unfiltered: A small amount of the water column sample is used to rinse out the inside of the 125-mL "UNUT" bottle, which is then filled with water from the cube/bottle. Nutrient sample bottles are stored in a freezer (or frozen in the field using dry ice) until they can be tested.

Sample Preservation: Water column samples must be kept in the dark at 4 degrees Celsius (± 2 degrees Celsius) after collection until received by laboratory. Nutrient sample bottles (filtered "FNUTS"/unfiltered "UNUTS" sub-samples) are filtered within 24 hours of water column sample collection, either in a laboratory freezer or in the field using dry ice, frozen immediately after filtering, and transported to the laboratory for analysis.

5c. Habitat Assessment

http://www.state.nj.us/dep/wms/bwqsa/vm/docs/visual_manual_2011.pdf

Cluster groups will follow the New Jersey Department of Environmental Protection's "Stream Monitoring Manual" in accordance with the NJDEP Volunteer Monitoring Program, and will fill out and submit the manual's Visual Assessment section. Visual stream assessments will be conducted over a 100-meter long stream reach in order to estimate substrate composition, channel morphology, canopy and riparian zone cover. The entire length of the reach must be walked prior to filling out any of the assessment forms (which should be done after sampling any fish, macroinvertebrates or algae). For the purposes of this project, the left and right banks of the stream will be determined by looking downstream, not upstream as the "Stream Monitoring Manual" indicates.

Teams (including volunteers and those who train volunteers) are trained in the field to perform the Visual Assessment. There is a video guide to the metrics (by Clean Water Team) that can be used for review after teams have undergone field training and have applied the assessment with the help of an expert. These videos are available at: https://www.youtube.com/playlist?list=PLMSa5d-iIl6OIUvw2I55DUL5QI3R8u7M9.

General Sheet. Site identification data, survey team, date, time of day and weather conditions. The assessment also entails estimates of water conditions (odor, turbidity, surface coating and stream flow) and descriptions of stream characteristics (woody debris, aquatic vegetation, algae, litter and structures). The General Assessment sheets also ask for notes on land use characteristics and general observations about flora and fauna at the site. Finally, a site sketch is drawn which includes information such as stream flow, roads, sampling locations, and photo and GPS references.

Scored Monitoring Sheet. The gradient of the stream (high- or low-gradient) is determined, and the appropriate set of Scored Monitoring Sheets is to be used. High-gradient streams have a steep slope and a rapid flow. Low-gradient streams generally have slower-moving water and a more level stream bed. The condition of several habitat parameters (epifaunal cover, embeddedness, bank stability, etc.) is graded, a score is assigned to each parameter, and the numbers are added up to make a Total Habitat Score (THS). The Total Habitat Score determines the overall habitat quality in the stream reach, categorized as Optimal (THS 160-120), Sub-Optimal (110-159), Marginal (60-109) or Poor (<60).

Pipe & Drainage Ditch Sheet. Notes are made of any pipes within the reach, as well as descriptions of size, type, location, flow and the condition of the stream both at the pipe and downstream of it.

Stream Flow Worksheet. The width and depth* of random areas throughout a 20-foot length of the stream are measured to determine an average width and depth, and then the length of time it takes an object (such as a stick, leaf or ball) to float down the 20-foot stream section is recorded. Timing is done with a digital stopwatch accurate to 0.1 second. These measurements are then used to calculate the area of the stream section in cubic feet, and then, the velocity (or flow) of the stream in cubic feet per second.

Alternatively, and when feasible, current speeds can be measured with a pre-calibrated current meter (e.g., Global Water Flow, Swoffer, Marsh-McBirney). All current meter calibration data will be recorded.

*Depth measurements are taken to estimate the undisturbed water surface (typically the downstream side of the rule), i.e., the increased depth on the upstream side of the rule will not be included. Accuracy will be to one cm.

5d. Macroinvertebrate collection

Tier 1: Macroinvertebrate Surber Sample Collection

Sampling of macroinvertebrates will involve quantitative composite sampling in riffle habitats using a Surber sampler (0.09 m^2; 250-µm mesh net). Random sampling locations are chosen based on longitudinal position (e.g., length along study reach) and position relative to the edges and center of the stream. Ideally, collection should include four riffle samples per composite sample, four composite samples per site (a total of 16 Surber samples). If sampling area is limited at a site (e.g., due to geomorphology or field safety concerns), two samples will be combined per composite sample, with four composite samples per site. In the event riffle habitat a site at a site is very limited, a minimum of four samples will be collected at the site, without compositing.

After all of the composite samples have been collected, they must be subsampled before they are preserved. The mixture of macroinvertebrates, detritus, and sediments is distributed evenly across the net-covered bottom of the subsampler, and the plastic separator is used to divide it into four equal quadrants. A spatula and scissors is used to separate one “slice” of material, which is then transferred into a labeled (WPP, site ID, date, time, collected by) sample jar filled with 95% EtOH. Within 24 hours, the ethanol in the samples will be drained and replaced with fresh 95% EtOH.

Macroinvertebrate samples can be preserved in EtOH until they are identified in the lab. See the appendix for the SOPs and full details on sampling and processing.

Sample Processing: Benthic macroinvertebrate samples are emptied into a US No. 60 mesh sieve and rinsed with tap water to remove silt and sand. In the laboratory, each composite sample will be subsampled to reduce the number of macroinvertebrates examined to 200 to 300 individuals per sample. Insects, including the Chironomidae, are identified to the lowest possible taxonomic unit (usually genus or species). Non-insect macroinvertebrates (e.g., oligochaetes, mollusks, nematodes) may be identified to higher taxonomic levels (i.e., class or order). Chironomids are mounted in CMCP-10, Hoyer's mounting medium or Euparal for identification using a compound microscope. Plastic coverslips are used for routine mounting and glass coverslips are used for permanent mounts and for CMCP-10. Chironomids are identified to

genus/species. This sampling is done prior to fish, algae, amphibian sampling and habitat assessment to ensure that early emerging insects are included in samples while they are still aquatic larvae.

Additional information can be found in Appendix II: Stroud Macroinvertebrate SOP

Tier 2: Macroinvertebrate Kick Sample Protocol

Adapted from NJ DEP Volunteer Biological Assessment Manual
http://www.state.nj.us/dep/wms/bwqsa/vm/docs/biological_manual_2013.pdf

The kick sampling protocol is used in streams that are too deep to be sampled with a Surber sampler, or streams with rocky, boulder-filled bottoms.

The kick net is placed on the substrate in the riffle or run and the user stands upstream from the net. Any large rocks should be rubbed off in the stream so that anything clinging to them will be carried by the current into the net. Some of the rubbed off rocks can be used to anchor the bottom of the net down. Remaining on the upstream side of the net, the sampler gently moves the substrate using his or her boots to kick up all the remaining substrate as thoroughly as possible within a 3 foot square area if using kick seine, or 1 foot square area if using D-Net, upstream of the net. Once the upstream area has been thoroughly disturbed the net should be rinsed off into a bucket, making sure to check the net for any remaining clinging organisms.

Sub-Sampling

The contents of the bucket are poured into a shallow tray that has been divided into squares of equal area (the area of square, in cm, is noted) and the contents are distributed evenly on the tray. The contents of one square are removed and 100 macroinvertebrates are picked out, without discriminating for size/species/etc., and placed into sample jars container filled with 75-95% ethanol. If 100 organisms are not present in the first square, a second is taken, and so on, until 100 macroinvertebrates have been counted.

5e. Fish sampling (Tier 1)

Fish communities are assessed using a quantitative depletion sampling method within a 100-m reach. Sampling is performed by qualified, trained personnel using electrofishing backpacks. Fish are identified and returned to the stream, downstream of the sampling reach, after each pass. All possible efforts are taken to keep fish alive in order to reduce the impact of sampling on the fish community. Epifaunal habitat is assessed within the same reach. See Appendix III: ANS Fish Collection SOP for details.

5f. Other Parameters

5f-1. Fecal coliforms/microbial source tracking

Cluster groups monitoring fecal coliforms or performing microbial source tracking should follow sampling procedures outlined by the laboratory that will be processing the samples. The ANS laboratory does not analyze fecal coliform or microbial samples. Sampling protocols and the laboratory's methods, reporting/detection limits and QA/QC procedures are shared with ANS.

5f-2. Additional fauna (mussels, dragonflies, etc.)

Cluster groups who wish to monitor additional insect/animal communities should consult and share monitoring protocols with ANS. These assessments will be designated Tier 2 or 3.

6. Sample Preservation Methods

80% Ethyl Alcohol (ETOH): Used in the preservation of macroinvertebrate samples. 80% ETOH is poured directly into sample bottles containing matter collected during the benthic macroinvertebrate sampling. On occasion sample preservative is replaced, by pouring off the ETOH from the initial pickling into a plastic waste container, and refilling the sampling jar with fresh ETOH. This is performed on samples containing large amounts of organic biomass.

Waste ETOH: Waste generated in the field is kept in a plastic or metal waste container and properly disposed of in the laboratory.

7. Quality Assurance/Quality Control (QA/QC)

Cluster groups will attend any sampling or data-related training sessions conducted by ANS or Stroud Water Research Center.

Field chemistry (streamside) data checking and other QA/QC procedures will be performed by the monitoring groups on their own data before transferring data to ANS.

Cluster groups sending water samples of any kind to external labs must provide ANS with the lab's detection and/or reporting limits for any parameters analyzed, and the lab's QA/QC policies.

Macroinvertebrate samples will be checked by a partner within or outside the cluster group.

Appendix I. Chemical Parameters, Detection Limits (Tier 1)

Table I: Parameter List for Delaware River Watershed Initiative (Cluster Groups Tier 1)

Primary Parameters	Sample Matrix	Method Reference	Description
Dissolved Oxygen (mg/L)	Water	360.1*	YSI Sensor
pH	Water	150.1*	YSI Sensor
Specific Conductance	Water	120.1*	YSI Sensor
Temperature	Water	170.1*	YSI Sensor
Dissolve Ammonia+ammonium (as N)	Water	350.1 Rev. 2.0 (1993)	ANS-CAS or designated Lab
Dissolved Nitrate+Nitrite-N****	Water	353.2, Rev. 2.0 (1993) ***	ANS-CAS or designated Lab
Total Nitrogen	Water	(TKN + Nitrite + Nitrate)	ANS-CAS or designated Lab
TKN	Water	351.2, Rev. 2.0 (1993) *** Semi-automated block digestor followed by: NH3-N by Automated phenate.	ANS-CAS or designated Lab
Soluble Reactive P (orthophosphate)	Water	365.1, Rev. 2.0 (1993) ***	ANS-CAS or designated Lab
Total Phosphorous	Water	365.1, Rev. 2.0 (1993) ***	ANS-CAS or designated Lab
Total Suspended Solids	Water	SM20(1998); ANSP SOP	ANS-CAS or designated Lab
Total Chloride*****	Water	SM20(1998)	ANS-CAS or designated Lab
Total Alkalinity	Water	SM20-2320 B	ANS-CAS or designated Lab
Total Hardness	Water	SM20(1998); ANSP SOP	ANS-CAS or designated Lab

Secondary Parameters	Sample Matrix	Method Reference	Description
Sulfate*****	Water	SM15(1980)	ANS-CAS or designated Lab
Barium and Strontium	Water	EPA 200.8 (1998)	Contracted to external lab
Na, Mg, Ca, K	Water	ASTM D6919-03	Contracted to external lab
Total Bromide*****	Water	Alpkem RFA Automated Colorimetric Method	ANS-CAS or designated Lab

** - As documented in EPA Methods for Chemical Analysis of Water and Wastes or ANSDU SOP*
*** - As documented in Section 7 of this work plan*
****- As documented in EPA Methods for the Determination of Inorganic Substances in Environmental Samples*
***** Dissolved nitrate (by difference)*
****** Ion chromatography may also be used, EPA Method 300*

Table II: Measurements, Methods and Target Detection Limits for Water Column Analysis (Cluster Groups Tier 1)

Ancillary Measurement	Reference Method	Detection Limit
Total Suspended Solids	SM20(1998); ANSP SOP	< 1.0 mg/L
Dissolved N and P (various forms)	US EPA (1993); ANSP SOP	< 10 µg N or P/L
Total Phosphorus	US EPA (1993); ANSP SOP	< 5 µg P/L
Total Kjeldahl nitrogen (TKN)	US EPA (1993); ANSP SOP	< 100 µg N/L
Total Hardness	SM20(1998); ANSP SOP	2.00 mg/L
Sulfate	SM15(1980); ANSP SOP	1.2 mg/L
Total Alkalinity	SM20 (1993); ANSP SOP	< 1 mg/L
Bromide	ALPKEM Method; ANSP SOP	0.128 mg/L
Chloride	SM20(1998); ANSP SOP	0.61 mg/L
Na, Mg, Ca, K	ASTM D6919-03	0.07, 0.03, 0.07, 0.16 mg/L, respectively
Barium and Strontium	EPA200.8 (1998)	In Prep.

Appendix II. Stroud Macroinvertebrate SOP

STROUD WATER RESEARCH CENTER
Procedure No. S-04-09, Rev. 0 (5/00)
Prepared By: John K. Jackson, David H. Funk, Bernard W. Sweeney
Modified for Cluster Groups by Academy of Natural Sciences, March 2014

QUANTITATIVE COMPOSITE SAMPLING OF MACROINVERTEBRATES IN RIFFLE AND/OR POOL HABITATS USING A SURBER SAMPLER

Equipment:
-Surber sampler (1 sq foot, 0.09 m2) equipped with a 250-µm mesh netting
-100 m tape measure
-steel stakes or flags for markers
-sledge hammer
-250-µm mesh sieve
-several large plastic buckets
-field sample splitter/subsampler (30 cm diameter, 250-µm mesh netting)
-spatula
-forceps
-gloves (Trappers or other type for hand protection)
-soft-bristled scrub brush
-labeled sample jars
-5% buffered formalin
-white enamel pan
-field data book
-permanent black ink pen
-folding tables
-squirt bottles

In the sample compositing technique, 2-4 samples are combined in the field to form one composite sample. The number of samples combined per composite and the number of composite samples collected depends on the study protocol and conditions at the time of sampling. This sample compositing technique has several advantages over standard (non-compositing) macroinvertebrate sampling. Compositing increases the accuracy of the desired description by increasing the number of samples collected (i.e., the area sampled) relative to the number of samples processed; for example, if four samples are combined per composite sample, the four times more samples are collected than processed. At the same time, compositing homogenizes spatial variation when these samples are combined, which generally reduces variance among samples in statistical analyses. Sample processing time is also reduced (relative to the number of samples collected) because each composite sample is subsampled in the field (taking 1/4th) and in the laboratory (the fraction examined depends on macroinvertebrate abundance and the study protocol). The use of Surber samplers in riffles and pools is described. The number of samples composited, number of composite samples collected, and microhabitats sampled depends on the project protocol and field conditions.

Technique:

(1) Sample location: The reach of stream/river to be studied is initially defined as the length of stream/river that includes representative habitat diversity (e.g., riffles and/or pools) as well as sufficient area

for the collection of samples. The length of the study reach may vary from 50-500+ m depending on the stream/river. If the sites are to be sampled repeatedly and samples from microhabitats (e.g., riffles, pools) are not to be combined, a rough map of the site that delimits the microhabitats based on their positions along the length of stream can be drawn.

(2) Random sampling locations are chosen based on their longitudinal position (e.g., along the length of the study reach) and their position relative to the stream bank. In many cases, only riffles in streams or rivers are sampled because they support a macroinvertebrate assemblage with a wide variety of species, many of which are abundant. In other cases, two or more microhabitats (e.g., riffles, pools, edges, bedrock) are sampled. Samples from multiple microhabitats can be combined or kept separate depending on the study needs outlined the project protocol. However, the basic approach can be used for single microhabitats or for multiple microhabitats that are sampled separately or together. If riffles and pools are sampled separately, or if only riffles or only pools are sampled, then the random sampling locations must pertain to an appropriate sampling location in that microhabitat. For example in a small stream, a riffle sampling location might be designated as 17-25, which would represent a sampling location in a riffle 17 m upstream from the starting point and 25% across the stream (from the right bank). If samples from riffles and pools (and other available microhabitats) are combined in the same composite sample, then it is not essential to designate microhabitat for each sample, but it could be informative in data analysis. Each sample is, a priori, assigned to a specific composite sample. Because each composite sample consists of 2-4 samples, the number of sampling locations far exceeds the number of composite samples collected. For example, if one was to collect four composite samples, each consisting of four samples from riffles, then a minimum 16 sampling locations in riffles would be chosen a priori plus 4-8 alternative locations in case some of the original sampling locations are not satisfactory (e.g., wrong habitat or impossible to sample). The choice of number of samples composited, number of composite samples collected, and microhabitat(s) sampled depends on the project protocol and field conditions.

(3) Operation of Surber Sampler: Sampling should start at the downstream end of the sampling areas and proceed in an upstream direction. The operator should identify the location of each sampling area based on the longitudinal and lateral position. The precise location of the sample within a given sub-sampling area is a subjective decision made by the operator. The center of the randomly chosen area is preferred but the presence of boulders or large woody debris may require movement off-center (laterally or longitudinally). If it is impossible to obtain a good sample from this location, an alternative sampling site should be used for this composite sample.

The operator sets the bottom of the metal frame of the net into the substrate until there is a tight seal across the bottom to prevent animals from migrating under the sampler. The operator then lays the square bottom frame out on the stream bed. This defines the sample area. Rocks that fall under the frame are included in the sample if more than half of the rock is inside the frame; if more than half of the rock is outside of the frame it is not included in the sample. Large rocks that cannot be moved are scrubbed in place. The operator picks up the larger substrate particles (> 6 cm in longest dimension) one by one, scrubbing each one with a soft bristled brush under the water (in front of the net) to remove most organisms (n.b. the water current moving through the sampler carries these dislodged organisms into the sample net). After each particle is scrubbed, it is placed in a plastic bucket or an enamel pan (held by a second person) for subsequent counting and (if done) measurements of its long and intermediate axes. The minimum substrate particle counted and/or measured is > 65 mm on the longest axis. After all particles have been scrubbed and removed, the enclosed benthic area is rapidly stirred and agitated for at least 20 seconds to swirl any residual organisms up into the water column and subsequently into the sample net. The sampler is then removed from the bottom and stream water is splashed onto the outside of the net in order to wash clinging animals into the bottom of the net. The net in inverted and the contents are washed into a plastic bucket filled with stream water designated for that composite sample. Remember, sets of four random

samples have been designated a priori for inclusion in specific composite samples.

(4) After all of the composite samples have been collected, they must be subsampled before they are preserved. Each composite sample (contents of four samples) is washed into a large sample splitter that is sitting in a large plastic barrel or trash can half filled with water. The mixture of macroinvertebrates, detritus, and sediments is homogenized and resuspended by stirring, agitating, and pushing water into the subsampler. The material is then allowed to resettle across the bottom of the subsampler by slowly drawing it out of the barrel. If the material does not appear evenly distributed, repeat the resuspension and settling process. Separate the net-covered bottom from the rest of the subsampler, and push the plastic separator into the sample material, dividing the material into four equal slices. Use the spatula and scissors to separate one slice of material and transfer that material into a labeled sample jar filled with 5% buffered formalin. One slice represents 1/4 of the composite sample.

Appendix III. ANS Fish Collection SOP

Unless specified, a 100-m reach will be sampled to assess the fish community using multiple pass depletion electrofishing (minimum of 2 passes; reach lengths other than 100 m may be used for compatibility with historical data). Each reach will be blocked at the upper and lower end using nets of 0.25-in mesh, unless natural barriers sufficient to prevent escape of fish are present. Unusual conditions such as tributaries entering the sample reach, nearby juncture of sample reaches with larger tributaries, proximity of dams, and other large in-stream obstructions will be avoided. Backpack electrofishing units will be equipped with an anode array that includes one 6-ft anode pole with a standard 14.5 x 7.75-in diamond shaped aluminum electrode. Typically, 100-300 volts will be used to output enough amps of pulsed DC (50Hz, 6 ms) to immobilize fish. To minimize fish mortality, the minimum amperage needed to immobilize fish will be used. Higher voltages will be used in streams with conductivities less than 100 µs/cm. Sampling will be done during daylight. The sampling crew will be large enough to provide efficient capture of specimens and maintain captured fish in conditions which will minimize mortality. Stunned fish will be collected using one or more dip nets (mesh size 0.125 in). The standard dip net used will have a 42 x 27-cm rectangular opening. At times, this net will be supplemented by smaller nets (e.g., aquarium dip nets) to capture small target taxa on the bottom. Polarized sunglasses will be worn to reduce sun glare and increase capture rates (sunglasses will not be worn when they decrease visibility, e.g., in dense shade). Attempts will be made to capture all fishes, lampreys, salamanders, and adult crayfishes. Notes on frogs observed or captured will be taken.

Samples will be taken under conditions where ability to see and capture stunned fish is not compromised by transient site conditions. In particular, samples will not be taken in the period immediately after precipitation if turbidity and water levels are deemed high enough to significantly impede sampling. Operationally, these levels would be determined by visual assessment of bottom visibility (sampling could be conducted if bottom substrates are visible in most riffle and run areas and in most pools (excepting deepest parts of some pools, which may be obscured even in normal conditions) and by assessment of depths (sampling would not be conducted if significant parts of pools have depth greater than 0.9 m). The decision to postpone sampling until a later date will be at the discretion of the field leader based on the level of rain and condition of the site.

Captured fish will be held in containers with ambient water. Holding containers will be managed to avoid fish stress and reduce mortality. These procedures may include holding in flow-through containers in the stream, holding fish in aerated, closed buckets, frequent water changes, and/or maintaining fish at low densities. A worker will monitor fish for signs of stress while fish are held prior processing. During processing, fish will be kept in buckets containing stream water. Larger individuals that do not fit into buckets and/or show signs of stress will be processed immediately. Remaining fish will be processed after these; fish will be enumerated, identified and condition (disease, anomalies, etc.) of individuals will be noted. The majority of fish (all, if feasible) will be identified to species on site. Staff making identifications will be skilled in identification of the regional fish fauna. Some fishes, salamanders and crayfish will be preserved (10% formalin, 95% ethanol, or dry ice, depending on eventual sample use) for laboratory identification or as voucher specimens. Collected fish will also be preserved if sample processing cannot be completed by the end of the day or if sampling needs to be terminated due to other causes.

All fish over 25 mm total length will be counted. All fish specimens will be measured, except that groups of similar-sized individuals may be sub-sampled when the number of individuals is extremely high. Length information will be taken as follows:

A. Up to 100 arbitrarily-selected specimens of each species less than 20 cm in length will be measured

(total length) or categorized as less than 3.5 cm total length (see below).
B. Fish less than 3.5 cm in length may be noted as <3.5 cm or analogous notation, and will not need to be measured precisely. These fish should be included within the 100-fish count.
C. All fish larger than 20 cm total length should be measured; these fish should not be included within the 100-fish count.
D. Where a subsample of all fish is measured, efforts will be made to avoid size-selection in measurement, including:

i. Groups of fish will be netted in groups with a net sufficient to capture a range of sizes; i.e., picking out fish singly (by hand or small dip net) will be avoided as it would likely involve unintended size bias;

ii. If a group of fish is selected for measurement, and the 100-fish count is reached before completion of measurements, the remaining fishes will also be measured, to avoid size-selection among specimens within the subsample, even though this involves measurement of over 100 total specimens.

E. Separate procedures should be followed if a size distribution is encountered which precludes arbitrary selection. For example, if a sample contains a few large fish and a large number of small fish, it would be very difficult to pick fish with an unbiased probability of measuring the larger fish. Options include:

i. Measure all fish.

ii. Measure larger fish and note that these are non-arbitrarily picked (e.g., as in the case of collection of only a few larger fish);

iii. Measure smaller fish and note that these are non-arbitrarily picked (e.g., as in the case of collection of only a few small fish).

Such procedures will be done in a way to allow reconstruction of the size distribution.

Notes will be taken on the number of diseased and anomalous individuals (excluding blackspot disease), based on external characters.

Substrate Type: visual assessments of bed composition at points along 11 transects for the entire reach

Appendix IV. Field Sheets

The following field sheets are to be used for Cluster Group Habitat Assessment, in conjunction with the NJ DEP's Volunteer Visual Assessment manual, and can be found in the "Stream Monitoring Manual" at: http://www.state.nj.us/dep/wms/bwqsa/vm/docs/visual_manual_2011.pdf.

(Note: The field sheets found at the above link include a Scored Monitoring Sheet that is suitable only with low-gradient streams. The sheets included with this document have a Scored Monitoring Sheet for both high- and low-gradient streams, to be used accordingly.)

Submission ID_____

DRWI - Visual Habitat Assessment

***Adapted from the New Jersey Department of Environmental Protection* Volunteer Monitoring Program**

General Sheet

*** Site Name/ID #:** _____ * **Watershed Management Area:** _____

*** Waterbody Name:** _____ *** County:** _____

*** Segment Identification**

Beginning at Latitude/Longitude: _____

Estimate of Segment Length (aim for 100m): _____

*** Survey Team:** _____

*** Time:** _____ * **Date:** _____

*** Today's Weather:** Clear Partly Cloudy Overcast Light Rain
(Check all that apply) Steady Rain Heavy Rain Snow Heavy Snow Melt

Rainfall:
Days since last rain: _____

Air Temperature: _____° C

Water Temperature: _____° C

Water Conditions: Circle the term that fits best for each category.

Odor:	Normal Sewage Petroleum Chemical Anaerobic (rotten eggs) Other
Turbidity:	Clear Slightly turbid Turbid
Surface Coating:	None Oily Foam Scum Other
Stream Flow:	Slow Moderate Swift Combination

Stream Characteristics: Circle the term that fits best for each category.

Stream Width:	_____, _____, _____, _____, _____			
Stream Depth:	_____, _____, _____, _____, _____			
Stream Velocity:	_____, _____, _____, _____, _____ (V=D/T)			
Canopy:	Open Mostly Open Partly Open Mostly Closed Closed			
Woody Debris:	Abundant Moderate Rare			
Woody Debris:	Free floating Attached Both			
Predominant Aquatic Vegetation:	Rooted emergent Rooted submergent Rooted floating Free floating No vegetation			
Algae Growth:	Abundant Moderate Rare			
Algae Location:	Filamentous Periphyton None			
Litter Concentration:	Present Absent			
Structures:	Bridges	Culverts	Dams	Other

Assessment Sheet

Land Use Characteristics- check the features present within viewing distance of the water

Residential	Recreational	Agricultural	Industrial
Houses	Hiking Trails	Cropland	Industrial Plants
Maintained Lawns	Parks, Campgrounds	Pasture	Mines/Quarries
Construction	Anglers	Livestock Use	Odors (from facility)
Pipes, Drains	Golfing, Resorts	Orchards	Power Plants
Dumping	Marinas	Poultry	Commercial
Roads	Trash/Litter	Feedlot	Evidence of Fire
Bridges/Causeways		Water Withdrawal	Logging
Sewage Treatment			

Comments:_____
_____
_____
_____
_____

Site Sketch: Include stream flow, roads, sampling locations, riffles, pools, runs, ditches, riprap, outfalls, photo and GPS reference #s

Low Gradient Monitoring Sheet (Page 1 of 2)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are 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 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

TOTAL HABITAT SCORE FOR THIS PAGE:

Low Gradient Monitoring Sheet (Page 2 of 2)

7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing upstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

TOTAL HABITAT SCORE

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

High Gradient Monitoring Sheet (Page 1 of 2)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regimes	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is <0.3 m/s, deep is >0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity / depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

TOTAL HABITAT SCORE FOR THIS PAGE:

High Gradient Monitoring Sheet (Page 2 of 2)

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 upstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

TOTAL HABITAT SCORE

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

Pipe & Drainage Ditch Sheet

Fill in the blanks and circle the best options for each pipe in your stream reach. Add more pages as necessary

Lat and Long	NJPDES # (if applicable	Pipe Diameter (in or ft)	Type	Pipe Material	Pipe Location	Pipe Flow:	Is stream bank at outfall eroded?	Is stream bed eroded downstream?
			Storm Drain Residential Discharge Industrial Drain Residential Discharge Combined Sewer Overflow Other	Concrete Steel Plastic Clay Other	In Water In Bank Near Water	None Trickle Intermittent Steady Heavy	Yes No	Yes No
			Storm Drain Residential Discharge Industrial Drain Residential Discharge Combined Sewer Overflow Other	Concrete Steel Plastic Clay Other	In Water In Bank Near Water	None Trickle Intermittent Steady Heavy	Yes No	Yes No
			Storm Drain Residential Discharge Industrial Drain Residential Discharge Combined Sewer Overflow Other	Concrete Steel Plastic Clay Other	In Water In Bank Near Water	None Trickle Intermittent Steady Heavy	Yes No	Yes No
			Storm Drain Residential Discharge Industrial Drain Residential Discharge Combined Sewer Overflow Other	Concrete Steel Plastic Clay Other	In Water In Bank Near Water	None Trickle Intermittent Steady Heavy	Yes No	Yes No