



**DEPARTMENT OF THE ARMY  
U.S. ARMY CORPS OF ENGINEERS  
SAVANNAH DISTRICT  
100 WEST OGLETHORPE AVENUE  
SAVANNAH, GEORGIA 31401**

November 8, 2018

Regulatory Branch  
SAS-2017-00592

**PUBLIC NOTICE  
Savannah District**

The U.S. Army Corps of Engineers, Savannah District, Regulatory Branch (Corps), is proposing a new monitoring metrics and performance standards for evaluating stream and wetland compensatory mitigation pursuant to Section 404 of the Clean Water Act (33 USC 1344). This public notice is being distributed to all interested stakeholders to solicit public input for consideration in the development of these monitoring metrics and performance standards.

The Corps is soliciting written comments on the proposed "Draft Monitoring Guidelines & Performance Standards for Freshwater Wetlands and Non-Tidal Streams, U.S. Army Corps of Engineers (Corps), Savannah District", dated November 8, 2018. Once finalized, these guidelines would be incorporated into the compendium of documents that comprise the 2018 Standard Operating Procedure for Compensatory Mitigation, dated April 27, 2018, and apply to all regulatory actions requiring the evaluation of compensatory mitigation actions associated with mitigation banks, In-Lieu-Fee mitigation projects, and permittee responsible mitigation sites. The period for submittal of written comments will close 60 days from the date of this public notice.

**BACKGROUND:** The 2008 Mitigation Rule (Rule), [33 CFR 332.5 (a)], states, "The approved mitigation plan must contain performance standards that will be used to assess whether the project is achieving its objectives. Performance standards should relate to the objectives of the compensatory mitigation project, so that the project can be objectively evaluated to determine if it is developing into the desired resource type, providing the expected functions, and attaining any other applicable metrics (e.g., acres improved). In addition, the Rule states [33 CFR 332.6 (a)(1)], states, "Monitoring the compensatory mitigation project site is necessary to determine if the project is meeting its performance standards, and to determine if measures are necessary to ensure that the compensatory mitigation project is accomplishing its objectives. The submission of monitoring reports to assess the development and condition of the compensatory mitigation project is required, but the content and level of detail for those monitoring reports must be commensurate with the scale and scope of the compensatory mitigation. The mitigation plan must address the monitoring requirements for the compensatory mitigation project, including the parameters to be monitored, the length of the monitoring period, the party responsible for conducting the monitoring, the frequency for submitting monitoring reports to the district engineer, and the party responsible for submitting those monitoring reports to the district engineer".

Pursuant to the regulation-required mitigation plan elements outlined above, the Corps developed the draft monitoring metrics and performance standards to assist project sponsors with the evaluation of both freshwater wetland and non-tidal stream mitigation projects within the State of Georgia

COMMENTS: Anyone wishing to comment on this public notice should submit comments in writing to the Commander, U.S. Army Corps of Engineers, Savannah District, Regulatory Branch, Attention: Mr. Justin A. Hammonds, Post Office Box 528, Buford, Georgia 30515, no later than 60 days from the date of this notice. Please refer to project number SAS-2017-00592 in your comments.

If you have any further questions concerning this matter, please contact Mr. Justin A. Hammonds, Mitigation Liaison at (678) 804-5227 or Justin.A.Hammonds@usace.army.mil.

Enclosure

1. Draft Monitoring Guidelines & Performance Standards for Freshwater Wetlands and Non-Tidal Streams, U.S. Army Corps of Engineers (Corps), Savannah District

**Draft Monitoring Guidelines & Performance Standards  
for Freshwater Wetlands and Non-Tidal Streams  
U.S. Army Corps of Engineers (Corps), Savannah District  
(Version 1.0, November 8, 2018)**

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The U.S. Army Corps of Engineers, Savannah District (Corps) has selected the Hydrogeomorphic (HGM) Approach and the Stream Quantification Tool (SQT) as the frameworks for standardizing the calculation of mitigation credits for freshwater wetland and non-tidal stream mitigation projects in Georgia. The Corps has developed both the Freshwater Wetland HGM for Georgia (GA HGM) and the Georgia Interim SQT (GA SQT)<sup>1</sup> in Microsoft Excel spreadsheet format which use selected metrics representing each of the different functional categories outlined in the respective frameworks (i.e., HGM and SQT). The evaluation of each underlying measurement in the field is converted to an index value, between 0.0 and 1.0, based on established performance curves for each metric. The current performance curves have been developed from a combination of available regional reference data, published ranges for the selected

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<sup>1</sup> The Stream Quantification Tool includes five different functional categories: hydrology, hydraulics, geomorphology, physiochemical, and biology. In the development of the Georgia Interim SQT, the Corps made the decision to remove the hydrology and physiochemical functional categories from the standardized assessment of credit generation.

variables and best professional judgment. The index values have been further informed by input received during the stakeholder and peer review process. The resulting index values for all parameters included in the evaluation are combined (generally as arithmetic means) to produce a single overall index value between 0.0 and 1.0 for each wetland and stream assessment area. The potential mitigation credit generated by a project is then based on the difference between the pre-mitigation index value and the projected post-mitigation index value, taking into account any corresponding difference in wetland area (acres) and stream length (linear feet). The GA HGM and GA SQT are available on the Regulatory In-Lieu Fee and Bank Information Tracking System (RIBITS) website. Users are encouraged to download the latest version of the tools and all accompanying user manuals and resource documents at the time of intended use, as periodic updates to these documents are planned.

Users should be aware that there are additional requisite considerations for wetland and stream mitigation projects in Georgia that are not integrated within the GA HGM and GA SQT spreadsheets. The GA HGM and GA SQT components of a broader set of requirements, including interim performance standards described herein, that the Corps and Interagency Review Team (IRT) will use to evaluate the feasibility of freshwater wetland and non-tidal stream mitigation proposals and to assess the performance of freshwater wetland and non-tidal stream mitigation projects implemented in Georgia.

## **I. General Monitoring Requirements**

Monitoring of all freshwater wetland and non-tidal stream compensatory mitigation sites must comply with the requirements in this section. The protocols detailed within these guidelines apply to both baseline and post-construction monitoring activities.

- A. A final as-built survey report must be submitted following the completion of all mitigation activities in the Mitigation Work Plan, including planting, to document post-construction conditions (i.e., Year 0). Note that an as-built survey does not necessarily mean a single plan-view map; rather it is comprised of a compendium of applicable maps, graphs, photos, tables, etc. that thoroughly document the work performed on the site.
  - a. As-built survey reports should include pre-construction and post-construction topographic maps documenting the locations and depths of excavation and/or fill on the project site, if applicable.
  - b. As-built survey reports should include photographic documentation at all proposed permanent monitoring stations (groundwater monitoring wells, piezometers, stage recorders, biological sampling locations, etc.); a plan view diagram of all permanent monitoring stations; a copy of the recorded conservation easement and restrictive covenant (if not already provided to the Corps); verification of the installation of conservation easement/restrictive covenant boundary signage; and tabular vegetation

- data (species, caliper size, number of stems planted, and, if applicable, mapped planting zones for target vegetative communities).
  - c. Wetland acreage should be calculated based on the wetland area within the metes and bounds of the site, as delineated using the 1987 US Army Corps of Engineers Wetland Delineation Manual and applicable Regional Supplement.
  - d. Any changes to the post-construction wetland acreage relative to the acreage proposed in the Mitigation Work Plan must be documented and explained in the as-built survey report.
  - e. Stream lengths should be calculated and reported using the stream centerline, not the thalweg.
  - f. Any changes to the stream length relative to the channel length proposed in the Mitigation Work Plan must be documented and explained in the as-built survey report.
  - g. As-built survey reports must be provided to the Corps and IRT within 90 days of completion of all mitigation activities on the site, as described in the Mitigation Work Plan, for the construction milestone.
- B. Post-construction monitoring will take place consistent with the schedule outlined in Tables 1 and 2. General requirements for post-construction monitoring include the following:
  - a. Data collection for the first annual monitoring event must take place no fewer than eight (8) months following the date of the submittal of the as-built survey report;
  - b. The amount of time required to attain performance standards will vary by target aquatic resource type, mitigation treatment, baseline site conditions, the degree of pre-construction site preparation and post-construction site management;
  - c. All interim performance standards must be fulfilled before the Corps, in consultation with the IRT, will grant the Sponsor an interim mitigation credit release;
  - d. Following the achievement of the final performance standards, final mitigation credit determination will be based on site conditions at the time the Sponsor chooses to request the final credit release. Final mitigation credit determination must be requested within 15 years from the date of the original as-built survey.
- C. All annual monitoring data collected by the Sponsor, to be included in annual monitoring reports, must also be provided to the Corps and IRT electronically in one or more organized, unlocked, Microsoft Excel spreadsheets.
- D. Unless otherwise specified in the Mitigation Work Plan or Instrument, monitoring reports must be submitted for all years of the monitoring period. However, annual monitoring reports may not include data for all performance standards every year. Monitoring reports for each calendar year must be provided to the

IRT for review no later than February 1<sup>st</sup> of the following year. General requirements for monitoring reports include the following:

- a. An executive summary that describes the overall monitoring results, including hydrologic monitoring, vegetation monitoring, large woody debris monitoring, geomorphological monitoring, water quality, and macroinvertebrate monitoring (as applicable), areas of concern (e.g. exotic/invasive vegetation, stream instability, nuisance herbivory, etc.) and any adaptive management activities undertaken during the previous year (e.g. supplemental planting, reconstruction or modification of structural habitat features, etc.).
- b. Results of any monitoring parameters required to demonstrate project-specific performance standards.
- c. Performance standards, as provided in the Mitigation Work Plan or in the permit conditions, must be restated verbatim in each monitoring report.
- d. Each monitoring report should include a discussion/presentation of the current year's monitoring data in context with data collected during all previous years. Summary tables must include summary data from all previous years.

## **II. Evaluation of Normal Precipitation and Growing Season**

### **A. Precipitation**

Hydrologic data and aquatic biological data should be presented in context with measured precipitation collected during the monitoring period and normal precipitation based on the most recent 30-year period of record. Sprecher and Warne (2000) summarize the principal methods for assessing normal rainfall conditions. Rainfall must be measured on-site to determine whether there has been a departure from normal precipitation conditions during the monitoring period.

### **B. Growing Season**

For compensatory mitigation, the presence of wetland hydrology during the growing season is the general standard for wetland hydrologic monitoring. For the purposes of assessing the duration of the growing season for wetland compensatory mitigation sites, the Corps will utilize the median (50% long-term probability) long-term dates of 28°F air temperature reported in the NRCS WETS Tables.

## **III. Freshwater Wetland Monitoring**

### **A. Vegetation Monitoring**

Vegetative communities of freshwater wetlands will be monitored separately from those located in upland buffer zones. Wetland vegetative communities include all areas within the delineated wetland boundary. Upland buffer vegetative

communities extend from the outer boundary of the wetland vegetative community to the outer boundary of the zone for which upland buffer mitigation credit is proposed by the Sponsor.

Alternative vegetation planting and monitoring plans may be approved by the Corps, in consultation with the IRT, on a case-by-case basis to accommodate specific goals of the mitigation project. The following requirements apply to all freshwater wetland mitigation projects that include planting of woody vegetation.

- a. Vegetation monitoring should be conducted between August 1<sup>st</sup> and October 31<sup>st</sup>, consistent with the schedule outlined in Table 1. To the extent practicable, subsequent vegetation monitoring events should be scheduled as near as possible to the same date(s) as previous monitoring events.
- b. The presence of exotic/invasive species (in all strata) on or immediately adjacent to the mitigation site should be evaluated during each monitoring event and noted in the monitoring reports. The reported presence of invasive species should not be limited to coverage solely within permanent or random vegetation monitoring plots.
- c. A combination of permanent and random fixed-area plots should be used to monitor wetland and upland buffer zone vegetation, as follows:
  - i. Plots should be distributed throughout the site and provide a stratified, random coverage of all vegetation community types re-established, enhanced, or preserved. Every mitigation treatment area on the project site shall consist of one or more “monitoring units” defined by either differing baseline conditions (e.g. soil type, vegetative communities, hydrologic conditions, etc.) and/or mitigation treatments (e.g. mitigation objectives, proposed vegetative communities or hydrologic conditions, etc.). Each monitoring unit must include both permanent and random vegetation sampling plots. Note that spatially non-contiguous areas with comparable soil/hydrologic conditions, mitigation treatment or target condition will also comprise separate monitoring units.
  - ii. Permanent plots should comprise at least 50% of the total required number of plots per monitoring unit. Random plots should be established prior to each year of vegetation monitoring via random selection from a grid overlain on each monitoring unit. No vegetation sampling plot should overlap any portion of any other vegetative plot. It is recommended that individual monitoring units be subdivided into approximately equal areas equivalent in number to the number of random plots to be established therein. Random plots may then be established in each subdivision, thus ensuring a spatially wide distribution of plots within each monitoring unit.
  - iii. Generally, there will be one vegetation sample plot per five (5) acres of monitoring unit, but under no circumstance will there be

- fewer than two (2) sample plots in any single monitoring unit (1 permanent and 1 random).
- iv. The Corps and IRT retain discretion to require supplemental sample plots if portions of a monitoring unit appear to be underperforming, and/or also if they are under-represented by sample plots.
  - v. The location (GPS coordinates) of random plots must be identified in the associated annual monitoring report, and the plots must be marked in the field so they can be inspected by the IRT, if needed.
  - vi. Plot sizes for the determination of tree stem density and vigor should be a minimum of 0.1 acre (0.04 ha). Refer to the Prevalence Index discussion in Section III(B) for a description of recommended vegetation sample plot design.
  - vii. For projects that include stream channels, fixed-area wetland plots should not overlap the stream or the top of stream banks to safeguard that vegetation monitoring data does not include streambank live stakes.
- d. Vegetation monitoring plots must cumulatively comprise a minimum 2% area of each monitoring unit on the mitigation site. Exceptions may be permissible on a case-by-case basis for very small monitoring units or for large, homogeneous monitoring units. All exceptions to this requirement shall be specifically justified in the approved Mitigation Work Plan.
- e. Wetland vegetation monitoring data collected from the plots must include:
- i. Within each permanent vegetative monitoring plot:
    - 1. Tree/shrub species, height, identification as planted vs. volunteer, and age (based on the year the stem was planted, or first observed for acceptable volunteers); and,
    - 2. When individual trees reach a height sufficient to measure diameter at breast height (dbh; stem diameter at 4.5 feet above ground surface), dbh must also be reported;
  - ii. Within each random vegetative monitoring plot:
    - 1. Tree/shrub species and height; and,
    - 2. When individual trees reach a sufficient height, dbh must also be reported;
  - iii. For both permanent and random plots, all woody stems, including exotic/invasive species, should be recorded. Exotic/invasive species will not count toward success of performance standards.
- f. Individual plot data must be provided separately for planted and volunteer species. Plot data should be presented individually per plot, as well as averaged among plots within individual monitoring units.

## B. Prevalence Index

All permanent vegetation monitoring plots and all random vegetation monitoring plots will include a series of five (5) nested, one-square meter herbaceous



vegetation quadrats, consistent with the sample plot schematic drawings at Appendix A. The “alternative herbaceous coverage quadrats” depicted on the schematic drawings are only to be used if one or more pieces of large woody debris lie within one or more primary herbaceous quadrats and comprise  $\geq 10$  percent coverage of the primary quadrat(s).

Percent cover estimates of each species within the five herbaceous quadrats will be used to calculate the Prevalence Index to assess the relative hydrophytic status of the existing herbaceous vegetative cover and percent absolute cover of exotic/invasive species in the herbaceous stratum. The Prevalence Index is a weighted average wetland indicator status of all plant species in the sampling plot, based on each species’ abundance (absolute percent cover) and their assigned indicator status (OBL = 1, FACW = 2, FAC = 3, FACU = 4, and UPL = 5) (Lichvar et al., 2016).

The procedure for calculating the Prevalence Index is available from the Regional Supplement to the Corps Wetland Delineation Manual: Eastern Mountains and Piedmont Region, Version 2.0. Gage and Cooper (2010), as well as an applicable literature review.

### C. Wetland Hydrology Monitoring

Monitoring wetland hydrology requires measuring the frequency, depth, and duration of inundation and/or saturation of upper soil horizon(s) in relation to the ground surface elevation. The following requirements apply to all freshwater wetland mitigation projects, which will typically require the installation of monitoring wells, piezometers, and/or staff gages. Alternative monitoring plans may be approved by the Corps, in consultation with the IRT, on a case-by-case basis to accommodate non-standard techniques.

- a. Wells and piezometers must be installed in accordance with the techniques and standards described in ERDC TN-WRAP-05-2, with the exception that the depth of monitoring well installation should extend to 30 inches below ground surface. The Soil Characterization Data Form and Monitoring Well Installation Data Form in ERDC TN-WRAP-05-2 must be submitted to document compliance with the technical standard (Appendix A & B).
- b. Assessment of wetland hydrology requires field classification and mapping of soils onsite by a Certified Soil Classifier credentialed as a Soil Scientist. These professionals are identified in the latest listing of Individuals Approved by Georgia Department of Public Health to Conduct Soil Investigations throughout Georgia for On-site Sewage Management Systems.
- c. A sufficient number of monitoring wells, piezometers, and/or stage recorders must be installed to characterize each mitigation monitoring unit.

- i. Generally, there will be one monitoring well installed per five (5) acres of monitoring unit, but under no circumstance will there be fewer than two (2) wells in any single monitoring unit.
  - ii. Wells must be installed in representative site conditions (e.g. not within localized depressions) with appropriate spatial distribution based on the hydrologic complexity of the area and the targeted mitigation treatment. Arrangement of wells on transects oriented perpendicular to topographic gradients, adjacent to hydrologic alterations, and in proximity of soil and/or vegetative changes are preferred.
  - iii. Piezometers may be required where depth-specific hydraulic head measurements are necessary to characterize the hydrologic processes within a given mitigation treatment area (typically to characterize the vertical component of groundwater flow and to determine recharge and discharge conditions) or where a perched water table is present (installed above and below the impermeable layer).
  - iv. Stage recorders should be installed in open water channels (e.g. streams, ditches, etc.) to document water levels in these features relative to shallow ground water levels monitored in adjacent areas. Stage recorders in post-mitigation open water channels (e.g. restored streams) will document the depth, frequency, and extent of overbank flood events.
- d. Each monitoring well and piezometer must be surveyed to include GPS coordinates, elevation at ground surface, and elevation at the top of the riser. These may be relative elevations, if they are all tied to a common datum. Stage recorders should be surveyed together with corresponding channel and valley cross-sections, including applicable monitoring wells and/or piezometers installed on the same transect.
- e. All monitoring wells, piezometers, and stage recorders will be equipped with automated water level loggers. Recommended data collection intervals are as follows: shallow groundwater wells and piezometers every eight (8) hours (recorded at 0000, 0800, and 1600 hrs); open water stage recorders every 15 to 60 minutes.
- f. Data collected by non-vented water level loggers (e.g. Onset HOB0, Solinst Levellogger Edge, In-Situ Level Troll 400, etc.)<sup>2</sup> must be corrected for changes in barometric pressure recorded by one or more dedicated barometric pressure gages recording at the same interval as the monitoring well(s) or stage recorder(s). The location of each barometric pressure gage must be surveyed.

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<sup>2</sup> Reference to specific product names or manufacturers does not constitute implicit endorsement, approval, or disapproval of said products or manufacturers by the Corps.

- g. Quarterly maintenance (i.e., every three months) of all monitoring wells, piezometers, and stage recorders must be documented in annual monitoring reports and should include the Monitoring Well and Stage Recorder Maintenance Log (Appendix C) for each individual monitoring instrument. Any recorded instrumentation drift should be identified during quarterly maintenance, and the instrument should be appropriately recalibrated. Data collected should be adjusted to correct for any documented drift between readings.
- h. Individual hydrographs must be provided for each monitoring well, piezometer, and stage recorder. The hydrograph should include an overlay depicting on-site precipitation data, climatic range of normal precipitation, and the 30-day rolling average of precipitation. Hydrographs for monitoring wells and piezometers should also clearly identify a reference line at 12 inches below ground surface elevation and a demarcation for the start and end of the growing season (see Sprecher and Warne, 2000).
  - i. Data should be collected and presented for the entire 365-day monitoring year.
  - ii. Each monitoring well and piezometer hydrograph should include the hydrograph from the previous monitoring year.
  - iii. Hydrographs should be presented in landscape format on 8.5 x 11" paper, maximizing the x-axis to fill the page. All hydrographs presented for the same project must be presented at the same scale.
  - iv. All hydrology data (corrected for barometric pressure, if applicable) will be provided electronically to the Corps and IRT for each monitoring well, piezometer, and stage recorder in Microsoft Excel format.
- i. Inundation and/or saturation within 12 inches of the ground surface continuously for at least 14 days is referred to herein as a "saturation event." Each monitoring report should at a minimum include a summary table that identifies the longest continuous saturation event during the growing season and the percent of the growing season over which this event occurred, the number of discrete saturation events equal to or greater than 14 days duration during the growing season, and the cumulative number of days during the growing season for which documented saturation events occurred.

#### D. Large Woody Debris Monitoring

- a. At each wetland vegetative monitoring plot, two 50-foot (15.24-meter) transects perpendicular to each other should be established, one bearing

north and one bearing east, originating at the outer boundary of the sample plot (see Vegetation Plot Schematics at Appendix A).

- b. Along each transect, the diameter of each non-living woody stem equal to or greater than 7.5 centimeters (3 inches) in diameter and 1 meter (3.3 feet) in length that intersects the plane above the entire length of the 50-foot transect, must be measured and recorded. The Georgia Interim Freshwater Wetland HGM Workbook converts these diameters to an estimated volume per area using a method from the U.S. Department of Agriculture Forest Inventory Analysis (see the Georgia Interim Freshwater Wetland Hydrogeomorphic Workbook User Manual for more information).

#### **IV. Non-Tidal Stream Monitoring**

##### **A. Vegetation Monitoring**

Streamside vegetative communities will be monitored separately from those located in the broader riparian zone. Streamside vegetative communities are defined herein as those rooted in the near-stream zone lying between bankfull elevation and four (4) meters (approximately 13 feet) laterally from bankfull elevation. By contrast, riparian vegetative communities extend from the outer boundary of the streamside vegetative community to the outer boundary of the zone for which riparian vegetative mitigation credit is sought by the Sponsor.

The following requirements apply to all stream mitigation projects that include planting of woody vegetation. Alternative vegetation planting and monitoring plans may be approved by the Corps, in consultation with the IRT, on a case-by-case basis to accommodate non-standard techniques.

- a. Vegetation monitoring should be conducted between August 1<sup>st</sup> and October 31<sup>st</sup>, consistent with the schedule outlined in Table 2. To the extent practicable, subsequent monitoring events should be scheduled as near as possible to the same date(s) as previous monitoring events.
- b. The presence of exotic/invasive species (in all strata) on or immediately adjacent to the mitigation site should be evaluated during each monitoring event and noted in the monitoring reports. The reported presence of invasive species should not be limited to coverage solely within permanent or random vegetation monitoring plots.
- c. Planting in rows to facilitate mowing between planted species in the riparian area is acceptable. However, mowing should not take place in portions of the mitigation bank that are targeted as wetland re-establishment or enhancement. Note that mowed volunteer trees should not be counted in vegetation data presented in annual monitoring reports.

- d. Herbicides may be used in upland riparian areas to control nuisance volunteer or exotic/ invasive vegetation, provided that the specific herbicides proposed for use are identified in the mitigation bank's maintenance plan. All herbicides must be applied by a licensed applicator in accordance with product labeling. Any herbicides used near streams, wetlands, or open water areas must be approved for aquatic use. It is solely the responsibility of the project Sponsor to apply herbicides in accordance with all applicable local and federal rules and regulations, including but not limited to appropriate personal protection equipment for applicators and necessary controls to prevent off-site migration of herbicide.

#### B. Vegetation Monitoring In Streamside Vegetation Zones

- a. Monitoring in streamside vegetation zones will be conducted in assessment areas two (2) meters (6.5 feet) wide centered at each end of each channel cross-section (See Section IV(D)(b) for instructions for establishing cross-sections). Each streamside vegetation assessment area will encompass an assessment area of eight (8) square meters (86 square feet; 0.002 acres) on each streambank at each channel cross-section.
- b. Total percent cover of all woody perennial vegetation, excluding vines, that is rooted in the streamside vegetation zone will be estimated and reported individually for each assessment area during each vegetation monitoring event.
- c. A modified densiometer will be used to assess percent streamside canopy closure (Appendix D, Measuring Stream Channel Shading Using a Modified Convex Densiometer).

#### C. Vegetation Monitoring In Riparian Zones

- a. A combination of permanent and random fixed-area plots should be used to monitor vegetation in the riparian zone.
  - i. Plots should be distributed throughout the site and provide a stratified random coverage of all vegetation community types re-established, enhanced or preserved on the site. Every mitigation treatment area on the project site shall consist of one or more "monitoring units" defined by either differing baseline conditions (e.g. soil type, vegetative communities, hydrologic conditions, etc.) and/or mitigation treatments (e.g. mitigation objectives, proposed vegetative communities or hydrologic conditions, etc.). Each monitoring unit must include both permanent and random vegetation sampling plots. Note that spatially non-contiguous areas with comparable soil/hydrologic conditions, mitigation treatment or target condition will also comprise separate monitoring units.

- ii. Permanent plots should comprise at least 50% of the total required number of plots per monitoring unit. Random plots should be established prior to each year of vegetation monitoring via random selection from a grid overlain on each monitoring unit. No vegetation sampling plot should overlap any portion of any other vegetative plot. It is recommended that individual monitoring units be subdivided into approximately equal areas equivalent in number to the number of random plots to be established therein. Random plots may then be established in each subdivision, thus safeguarding a spatially wide distribution of plots within each monitoring unit.
- iii. Generally, there will be one vegetation sample plot per five (5) acres of monitoring unit, but under no circumstance will there be fewer than two (2) sample plots in any single monitoring unit (1 permanent and 1 random).
- iv. The IRT retains discretion to require supplemental sample plots if portions of a monitoring unit appear to be underperforming, and/or if they are under-represented by sample plots.
- v. The location (GPS coordinates) of random plots must be identified in the associated annual monitoring report, and the plots must be marked in the field so they can be inspected by the IRT, if needed.
- vi. Plot sizes for the determination of tree stem density and vigor should be a minimum of 0.1 acre (0.04 ha). Appendix A includes vegetation plot schematics that illustrate recommended sample plot design. Note that for typical upland riparian zones, the 1 square-meter herbaceous quadrats illustrated in the schematics are unnecessary.
- vii. Neither wetland vegetation monitoring plots, nor riparian vegetation monitoring plots should overlap streamside vegetation zones, as defined above.
- b. Monitoring plots must cumulatively comprise a minimum 2% area of each monitoring unit on the mitigation site. Exceptions may be permissible on a case-by-case basis for very small monitoring units or for large, homogeneous monitoring units. All exceptions to this requirement shall be specifically justified in the approved Mitigation Work Plan.
- c. Riparian vegetation monitoring data collected from the plots must include:
  - i. Within each permanent vegetative monitoring plot:
    - 1. Tree/shrub species, height, identification as planted vs. volunteer, and age (based on the year the stem was planted, or first observed for volunteers); and
    - 2. When individual trees reach a height sufficient to measure diameter at breast height (dbh; stem diameter at 4.5 feet above ground surface), dbh must also be reported;
  - ii. Within each random vegetative monitoring plot:
    - 1. Tree/shrub species and height;

2. When individual trees reach a sufficient height, dbh must also be reported; and
- iii. For both permanent and random plots, all woody stems, including exotic/ invasive species, should be recorded. Exotic/invasive species will not count toward success of performance standards.
- d. Individual plot data must be provided separately for planted and volunteer species. Plot data should be presented individually per plot, as well as averaged among plots within individual monitoring units.

#### D. Stream Channel Geomorphology and Stream Hydrology Monitoring

The monitoring requirements included in this section demonstrate the effectiveness of mitigation activities that physically alter the existing channel bed or banks, including any excavation, fill, construction, or installation of materials to improve channel stability or habitat conditions for aquatic biota. For the purposes of this document, a “reach” is defined as:

- a continuous section of an individual tributary where a similar design approach is applied and similar morphological characteristics are present; or
  - an individual tributary between confluences with other tributaries; or
  - an individual otherwise homogeneous tributary that is bisected by a feature (either natural or man-made) that changes the physical nature of the tributary. Examples may include bridge or pipeline crossings, fords, bedrock outcrops, etc.
- a. Channel geomorphology must be monitored annually until interim credit release and bi-annually thereafter until final credit release (Table 2).
    - i. It is recommended that stream surveys conducted to assess baseline conditions, document as-built conditions and for project performance monitoring generally follow the methodology contained in the *USDA Forest Service Manual, Stream Channel Reference Sites* (Harrelson, et.al., 1994).
  - b. Permanent, monumented cross-sections must be installed in each unique stream reach on the mitigation site at an approximate frequency of one per 20 bankfull-widths, measured along the centerline of the channel, or a minimum of one cross-section every 150 meters (approximately 500 linear feet) of the reach. Cross-sections should include pools and riffles in proportions generally consistent with percent-pool and percent-riffle in the approved mitigation design. The selection of channel cross-section monitoring stations should always include areas that may be predisposed to potential problems, such as particularly tight meanders, meanders just downstream from channel confluence points or areas where in-channel work corrected existing bank failures.
    - i. All channel cross-sections within riffles must include measurements of Bank Height Ratio (BHR) and Entrenchment

- Ratio (ER), each of which must be documented in monitoring reports.
- ii. Riffle and pool cross-sections should be co-located with longitudinal profiles as much as possible.
  - iii. Riffle cross-sections should also be surveyed together with stage recorders, where applicable.
- c. Longitudinal profiles will be collected from each unique stream reach on the mitigation site and will include the thalweg, water surface, bankfull, grade control structures (cross-vanes, j-hooks, etc.), stage recorders (that are coincident with the longitudinal profile), and top of bank.
- i. Each longitudinal profile should extend for a channel length of approximately 40x bankfull width or a minimum of 100 meters (328 feet) and two full channel meander wavelengths. Beginning and ending points for longitudinal profiles should both occur at the head of a riffle.
  - ii. Unique longitudinal profiles should be spaced a maximum of every 300 meters (approximately 1,300 feet) along homogeneous stream reaches.
- d. Continuously recording water level loggers must be installed to document hydrologic flow permanence and the occurrence of bankfull flow events. A minimum of one stage recorder must be installed on each tributary on the mitigation site. Additionally, one stage recorder is required no less than every 800 meters (approximately 2,640 feet) of channel length on any homogeneous stream reach.
- i. Stage recorders should be designed, installed, and surveyed to be capable of documenting the frequency and duration of overbank events, and should generally be installed within the glide immediately upstream of riffles.
  - ii. Data collected by non-vented water level loggers (e.g. Onset HOB0, Solinst Levelogger Edge, In-Situ Level Troll 400, etc.)<sup>3</sup> must be corrected for changes in barometric pressure recorded by one or more dedicated barometric pressure gages recording at the same times as the stage recorder(s). The location of each barometric pressure gage must be surveyed.
  - iii. Quarterly maintenance (i.e., every three months) of all stage recorders must be documented in annual monitoring reports and should include the Monitoring Well and Stage Recorder Maintenance Log (Appendix C) for each individual monitoring instrument. Any recorded instrumentation drift should be identified during quarterly maintenance, and the instrument should be appropriately recalibrated. Data collected should be adjusted to correct for any documented drift between readings.

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<sup>3</sup> Reference to specific product names or manufacturers does not constitute implicit endorsement, approval, or disapproval of said products or manufacturers by the Corps.



- iv. Individual hydrographs must be provided for each stage recorder. The hydrograph should include an overlay depicting on-site precipitation data, climatic range of normal precipitation, and 30-day rolling average of precipitation (see Sprecher and Warne, 2000).
- v. Data should be collected and presented for the entire 365-day monitoring year.
- vi. Hydrographs should be presented in landscape format on 8.5 x 11" paper, maximizing the x-axis to fill the page. All hydrographs presented for the same project must be presented at the same scale.
- vii. All hydrology data (corrected for barometric pressure, if applicable) will be provided electronically to the Corps and IRT for each monitoring well, piezometer, and stage recorder in Microsoft Excel format.

#### E. Stream Biological Monitoring

Macroinvertebrate community monitoring is required for all stream mitigation projects in Georgia on the schedule indicated in Table 2 to demonstrate anti-degradation pursuant to applicable water quality standards (i.e. designated uses) and potential biological improvement. The Sponsor may elect not to continue macroinvertebrate sampling once anti-degradation has been demonstrated at interim credit release. However, the Sponsor will then forfeit any potential mitigation credit generation in the biology functional category of the Georgia SQT.

Macroinvertebrate indicators are inherently sensitive to changes that occur anywhere within the watershed draining to the mitigation project, such as land use changes, meteorological changes (droughts, storms, etc.) or pollution entering the watershed (e.g., herbicide use, fertilizer application, road runoff, etc.). For macroinvertebrates, there may also be a lag period for re-colonization, and thus proximity of the mitigation site to intact sources of target macroinvertebrate community assemblages is an important consideration in site selection.

Macroinvertebrate sampling on perennial streams draining  $\leq 3.0$  square miles in the Piedmont (Ecoregion 45) or Blue Ridge (Ecoregion 66) in Georgia should be conducted following the *Standard Operating Procedures for the Collection and Analysis of Stream Benthic Macroinvertebrates for the Clean Water Act, Section 404 Regulatory Program in Georgia* (Appendix E), which were modified from the Qual-4 protocols of the North Carolina Division of Environmental Quality, *Standard Operating Procedures for the Collection and Analysis of Benthic Macroinvertebrates* (NCDEQ, 2016).

- a. Sampling should be undertaken between April 1 and June 30; Sampling should be conducted as near as possible to the same date each year

during the monitoring period to minimize seasonal differences in the data from year-to-year.

- b. If the drainage area of the stream > 3.0 square miles, or if the mitigation site lies outside of Ecoregions 45 or 66, early consultation and coordination with the Corps and the IRT will be required to establish biological monitoring protocols and performance standards.
- c. Macroinvertebrate sampling should be conducted on every perennial tributary greater than 150 meters (approximately 500 feet) in length. Additional sampling points are required per additional 300-meter increment of channel length on each homogeneous tributary (i.e., 300m = 1 point, 301m to 600m = 2 points, 601m to 900m = 3 points, etc.).
- d. One or more biological reference locations should also be sampled for comparison purposes. The reference reach(es) should be on a stream or streams with similar watershed characteristics as the mitigation site (e.g. drainage size, ecoregion, Rosgen stream type, stream evolution model phase, watershed land use, etc.) (Rosgen, 1993) (Cluer and Thorne, 2013). The reference location(s) may be located within an on-site preservation reach, or upstream of the mitigation site if stream conditions are appropriate, but should not be located downstream of mitigation activities.
- e. Biological sampling data should be presented in the subsequent monitoring report and include, at a minimum, a list of taxa collected at each sample station for each sampling event, the habit and functional feeding group designation of each taxon determined from the *Georgia SQT Macroinvertebrate Traits* table available on the Corps RIBITS web page and the calculations of standardized biological metric values described in the *Georgia Interim Stream Quantification Tool User Manual*, included as Appendix 11.19 of the *Savannah District's 2018 Standard Operating Procedure for Compensatory Mitigation*, also available on the Corps Savannah District's RIBITS web page.
  - i. Each report should include a summary of the current results and all past monitoring events in tabular format. Other summary or comparison statistics may also be acceptable on a case-by-case basis.
  - ii. Data for each sample station should be reported separately; that is, data from multiple sample stations, even those located on the same tributary or homogeneous reach, should not be pooled together for analysis or reporting.

## F. Stream Water Quality Monitoring

Water quality monitoring is not required for stream mitigation projects in Georgia. Early consultation and coordination with the Corps and the IRT will be required to establish applicable water quality monitoring protocols for those mitigation projects where existing water quality impairment may be addressed by actions proposed by the Sponsor.

## G. Large Woody Debris Monitoring

Sample reaches for large woody debris (LWD) should extend 100m in length, and must be permanently located within the same reach or sub-reach limits as the other geomorphology assessments. Additionally, the 100m stream reach from which the LWD Index (LWDI) (outlined in the GA SQT) is calculated should represent the 100m segment of the larger assessment reach that will yield the highest LWDI score. LWD surveys for both project construction and project monitoring should follow the methodology contained in the *Application of the Large Woody Debris Index: A Field User Manual* (Harman, et.al. 2017).

Table 1. Post-construction monitoring schedule for freshwater wetland mitigation projects in Georgia.

Wetland Monitoring Parameter	Years preceding interim credit release			
	As-Built	Continuous	Annual	Bi-annual
Vegetation	X		X	
Hydrology		X		
Prevalence Index	X		X	
Wetland Monitoring Parameter	Years following interim credit release			
	As-Built	Continuous	Annual	Bi-annual
Vegetation				X
Hydrology		X		
Prevalence Index				X
Large Woody Debris				X

Table 2. Post-construction monitoring schedule for non-tidal stream mitigation projects in Georgia.

Stream Monitoring Parameter	Years preceding interim credit release			
	As-Built	Continuous	Annual	Bi-annual
Hydrology		X		
Geomorphology				
Channel cross-sections	X		X	
Longitudinal profiles	X		X	
Vegetation	X		X	
Biology (macroinvertebrates)			X <sup>(1)</sup>	
Stream Monitoring Parameter	Years following interim credit release			
	As-Built	Continuous	Annual	Bi-annual
Hydrology	n/a	X		
Geomorphology	n/a			
Channel cross-sections	n/a			X
Longitudinal profiles	n/a			X
Large woody debris	n/a			X
Vegetation	n/a			X
Biology (macroinvertebrates)	n/a			X

<sup>(1)</sup> Sponsor may initiate biological monitoring at any time following construction, so long as s/he has at least two consecutive years of biological sampling that demonstrates attainment of interim success criteria prior to seeking the interim mitigation credit release.

## V. Freshwater Wetland Mitigation Performance Standards

Performance standards are observable or measurable physical (including hydrological), chemical and/or biological attributes that are used to determine if a compensatory mitigation project meets its objectives, (33 CFR 332.2; 40 CFR 230.92). The GA HGM directly incorporates a suite of performance standards in the assessment of final mitigation credit generation for wetland mitigation projects. Both interim performance standards and final performance targets necessary for wetland mitigation projects in Georgia are described in this section.

### A. Wetland and Upland Buffer Zone Vegetation Performance Standards

- a. Within planted portions of the mitigation site, there must be a minimum of 150 saplings per acre with a minimum 1-inch dbh at the interim performance milestone and a minimum 150 trees per acre with a minimum 3-inch dbh at the final performance milestone;
  - i. For any sapling or tree to count toward meeting the dbh performance standard, it may be either planted or volunteer, but it

must be a species from the approved vegetation list included in the Mitigation Work Plan. Vegetation lists and community composition should be informed by documented vegetation reference sites. Other species not included on the planting list may be considered by the IRT on a case-by-case basis.

- ii. Supplemental plantings and volunteers must be present for at least two growing seasons before counting toward meeting either interim or final performance standards.
  - iii. No single species may have a greater density than the equivalent maximum density of the most common species inventoried within the reference communities.
  - iv. In cases where plots are dominated by undesirable volunteer species, remedial action as specified in the Adaptive Management Plan or as directed by the Corps and IRT may be required.
- b. Exotic/invasive plant species must represent less than 5% of the absolute vegetative cover across all strata in all monitoring units at both interim and final performance milestones. The presence of individuals/stems of exotic/invasive species included on the Category 1 List of the Georgia Invasive Species Vegetation Task Force, which are of reproductive age, will preclude all monitoring units from meeting interim performance and/or final performance milestones. Note, monitoring and tracking of exotic/invasive species coverage is not limited to only the vegetation monitoring plots.
- c. Dominant species of the uppermost stratum on-site must correspond to the selected index value in the GA HGM, at interim and final performance milestone, respectively.
- d. The Prevalence Index for herbaceous vegetation in wetland mitigation areas, must be less than 3.0 in all monitoring units in order to meet interim and final performance milestones.

#### *B. Wetland Hydrology Performance Standard*

The GA HGM uses target wetland soil saturation ranges as performance standards to document the presence of hydric conditions. The Georgia Interim Freshwater Wetland HGM Workbook automatically incorporates the applicable hydrology performance standard based on user assigned workbook entries for the physiographic region where the project is located and the field-verified soil type. The Georgia Interim Freshwater Wetland Hydrogeomorphic Workbook User Manual describes the origin of these target saturation ranges and how they will be used to evaluate wetland hydrology performance standards.

Wetland hydrology will be evaluated based on growing season conditions demonstrated for 50 percent or greater of the monitoring years under “normal” or “drier” rainfall conditions. Wetland hydrology will be evaluated first for the interim performance milestone, and secondly for final performance. Wetland hydrology

data collected prior to achieving the interim performance milestone will not be used as a basis for meeting final performance. The sponsor will be required to maintain a hydrologic reference coupled with a precipitation gage to account for climatic variance outside of normal conditions. Extended periods of abnormal climatic conditions may require an extended monitoring period.

#### *C. Large Woody Debris Performance Standards*

The Large Woody Debris (LWD) variable subindex must match the selected GA HGM LWD value at final performance. Woody debris material must be comprised of species identified as part of the target wetland vegetative community. There is not an interim performance standard for LWD.

#### *D. Additional Wetland Performance Standards*

The Corps may require additional wetland performance standards on case-by-case basis, dependent upon project goals, objectives, and site conditions.

### **VI. Non-Tidal Stream Mitigation Performance Standards**

Performance standards are observable or measurable physical (including hydrological), chemical and/or biological attributes that are used to determine if a compensatory mitigation project meets its objectives, (33 CFR 332.2; 40 CFR 230.92). The Georgia Interim SQT directly incorporates a suite of performance standards in the assessment of final mitigation credit generation for stream mitigation projects. Interim performance standards and additional final performance targets necessary for stream mitigation projects in Georgia are described in this section.

#### *A. Streamside Vegetation Performance Standards*

- a. Within planted portions of streamside vegetation zones, there must be a minimum of 50 percent woody stem cover at the interim performance milestone; and
- b. Within planted portions of streamside vegetation zones, there must be a minimum of 80 percent canopy closure at final performance.

#### *B. Riparian Zone Vegetation Performance Standards*

- a. Within planted riparian zones of the mitigation site, there must be a minimum of 150 trees per acre with a minimum 1-inch dbh at interim performance milestone and a minimum 150 trees per acre with a minimum 3-inch dbh at final performance milestone;
  - i. For any tree to count toward meeting the dbh performance standard, it may be either planted or volunteer, but it must be a species from the approved planting list included in the Mitigation Work Plan. Other species not included on the planting list may be considered by the IRT on a case-by-case basis.

- ii. Supplemental plantings and volunteers must be present for at least two growing seasons before counting toward meeting either interim or final performance standards
- iii. No single species may have a greater density than the equivalent maximum density of the most common species inventoried within the reference vegetation communities.
- iv. In cases where plots are dominated by volunteer species, remedial action as specified in the Adaptive Management Plan or as directed by the Corps and IRT may be required.
- v. Exotic/invasive plant species coverage must be less than 5% absolute coverage across all strata in all monitoring units at both interim and final performance milestones. The presence of individuals/stems of exotic/invasive species included on the Category 1 List of the Georgia Invasive Species Vegetation Task Force, which are of reproductive age, will preclude all monitoring units from meeting interim performance and/or final performance milestones. Note, monitoring and tracking of exotic/invasive species coverage is not limited to only the vegetation monitoring plots.

*C. Stream Channel Geomorphology and Stream Hydrology Performance Standards*

- a. Bank height ratio (BHR) must not exceed 1.2 at any riffle cross-section.
- b. Entrenchment ratio (ER) must be no less than 2.4 for Rosgen C and E stream types, and no less than 1.4 for Rosgen A, B and Bc stream types at any riffle cross-section.
- c. Channel cross-sectional area and width/depth ratio should stay within design ranges throughout the monitoring period.
- d. The Large Woody Debris (LWD) variable subindex must match the selected GA SQT LWD value at final performance. There is not an interim performance standard for LWD.
- e. All stream channels must receive sufficient flow throughout the monitoring period to maintain an Ordinary High Water Mark (OHWM) in accordance with the requirements of RGL 05-05, dated December 7, 2005, which establishes the lateral extent of Corps jurisdiction for non-tidal waters for CWA Section 404.
- f. Continuous surface water flow in all tributaries must be documented to occur every year under normal climatic conditions consistent with targeted hydrologic flow regimes (e.g. perennial, intermittent);
- g. For intermittent flow conditions, continuous surface water flow must be documented to occur for at least 90 consecutive days;
- h. Perennial flow conditions, pursuant to stream mitigation hydrologic permanence in Georgia, will require continuous surface water flow  $\geq 90$  percent of a calendar year.

#### *D. Biological Monitoring Performance Standards*

- a. Interim and final biological performance standards for stream mitigation undertaken on perennial streams draining  $\leq 3.0$  square miles in the Piedmont (Ecoregion 45) or Blue Ridge (Ecoregion 66) in Georgia will be based on pre-construction (baseline) macroinvertebrate community assemblages.
  - i. The cumulative SQT index score at interim and final performance milestones must be no less than the baseline index score for 50 percent or greater of the monitoring years under normal rainfall conditions. Benthic macroinvertebrate data collected prior to the interim performance milestone will not be used as a basis for meeting final performance. Extended periods of abnormal climatic conditions will require an extended monitoring period.
- b. If the drainage area of the stream  $> 3.0$  square miles, or if the mitigation site lies outside of Ecoregions 45 or 66, interim and final performance standards will be determined on a case-by-case basis during early consultation and coordination with the Corps and the IRT and incorporated into the final approved Mitigation Work Plan.

#### *E. Water Quality Performance Standards*

Interim and final performance standards for water quality for stream mitigation in Georgia will be determined on a case-by-case basis, as applicable, during early consultation and coordination with the Corps and the IRT and incorporated into the final approved Mitigation Work Plan.

#### *F. Additional Stream Performance Standards*

The Corps may require other stream performance standards on case-by-case basis, dependent upon project goals, objectives and site conditions.

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## **VIII. Appendices**

Appendix A - Vegetation Plot Schematics

Appendix B - Soil Characterization Data Form

Monitoring Well Installation Data Form

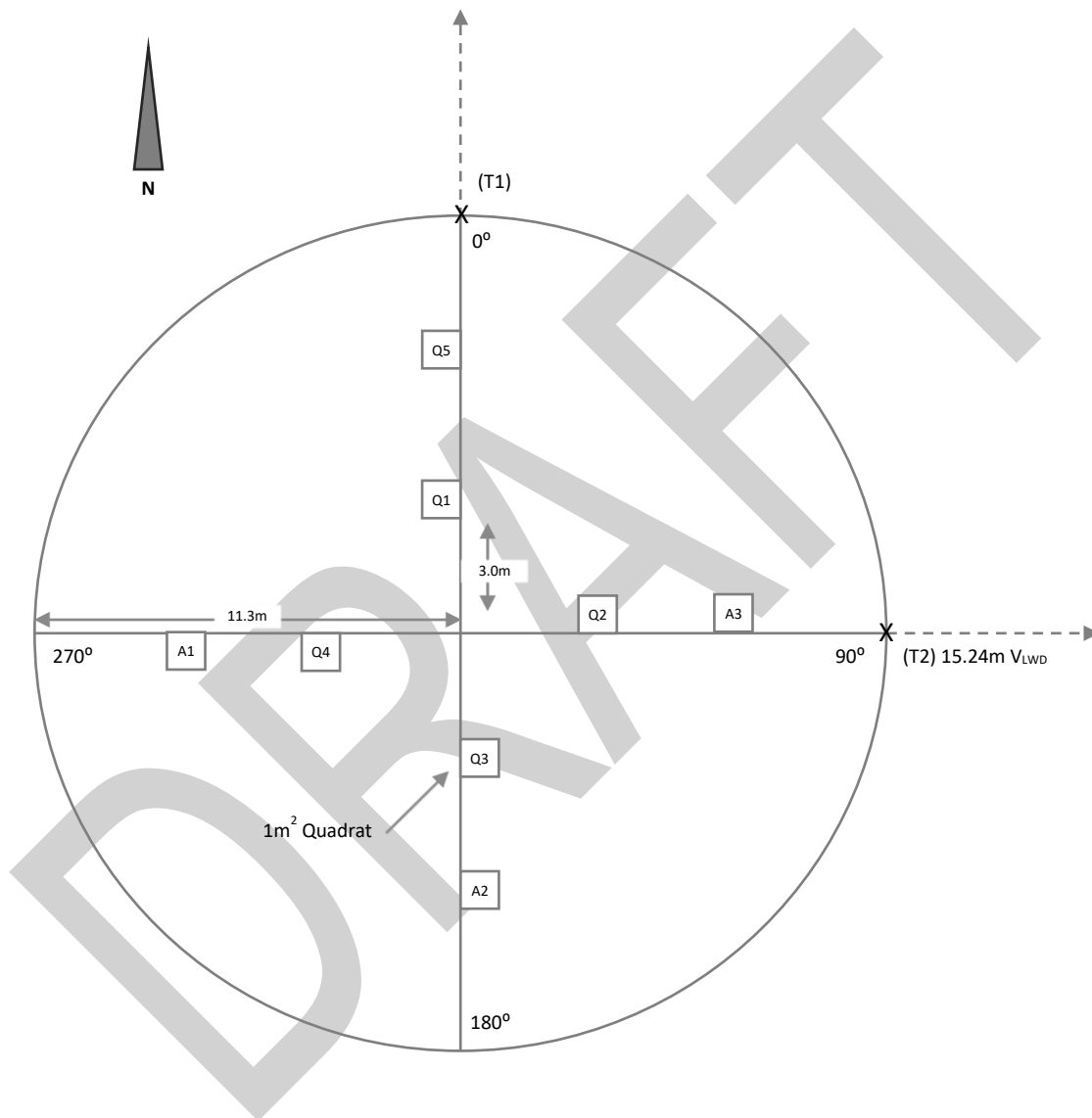
Appendix C - Monitoring Well and Staff Gage Maintenance Log

Appendix D - Measuring Stream Channel Shading Using a Modified Convex Densiometer

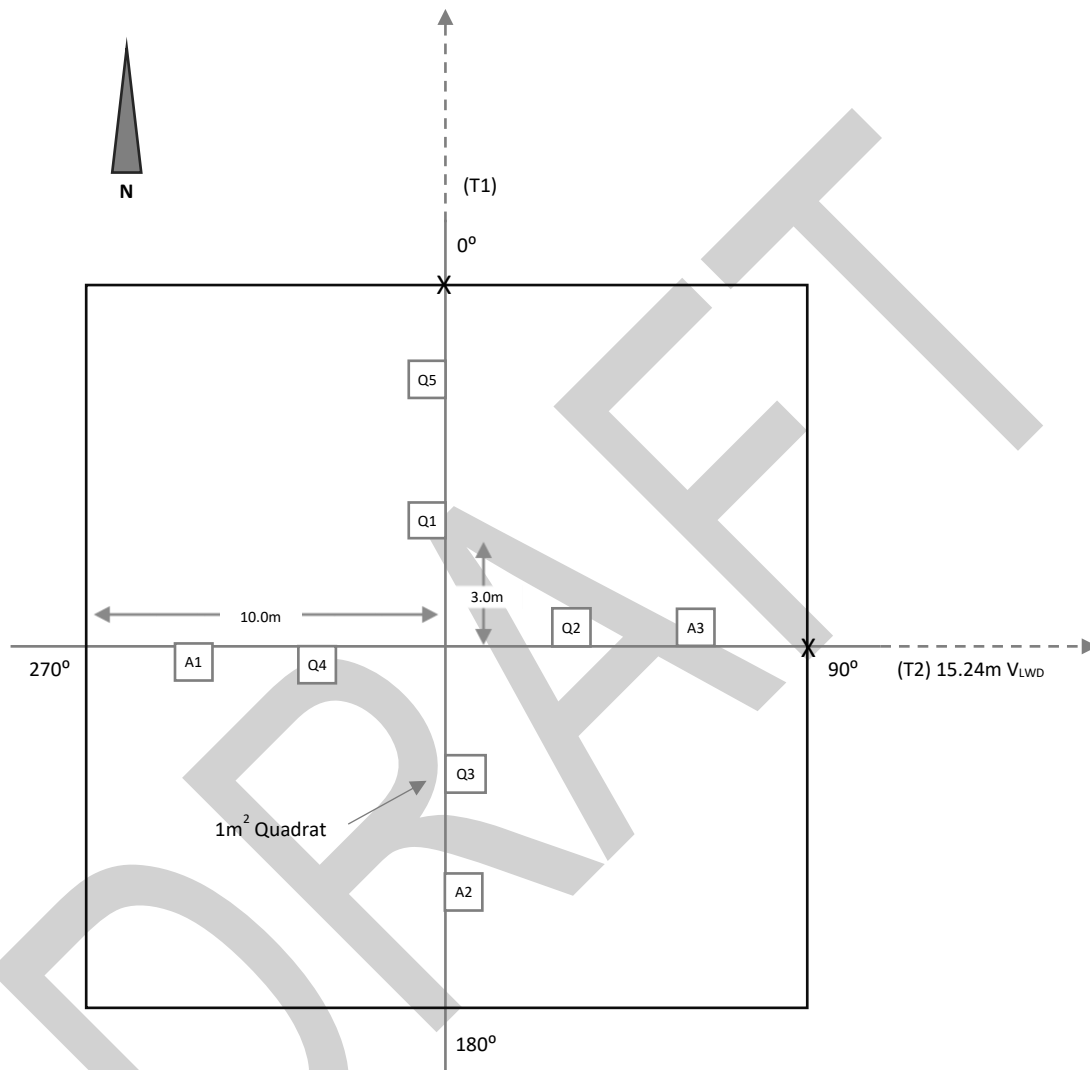
Appendix E - Standard Operating Procedures for the Collection and Analysis of Stream Benthic Macroinvertebrates for the Clean Water Act, Section 404 Regulatory Program in Georgia

## Appendix A

### Vegetation plot schematics



- Qx Herbaceous coverage quadrats
- Ay Alternative herbaceous coverage quadrats
- X Start point for large woody debris transects (Tx); 50 feet (15.24m)



- Qx Herbaceous coverage quadrats
- Ay Alternative herbaceous coverage quadrats
- X Start point for large woody debris transects (Tx); 50 feet (15.24m)

## Appendix B

### Soil Characterization Data Form & Monitoring Well Installation Data Form

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## APPENDIX A. SOIL CHARACTERIZATION DATA FORM

Soil Characterization Data Form						
Project Name Personnel			Date Soil Pit ID			
Horizon Depths (inches)	Texture	Matrix Color (Munsell moist)	Redoximorphic Features		Induration (none, weak, strong)	Roots
			Color	Abundance		
Comments:						

## APPENDIX B. MONITORING WELL INSTALLATION DATA FORM

Monitoring Well Installation Data Form						
Project Name _____			Date of Installation _____			
Project Location _____			Personnel _____			
Well Identification Code _____						
Attach map of project, showing well locations and significant topographic and hydrologic features.						
Characteristics of Instrument:						
Source of instrument/well stock _____						
Material of well stock _____			Diameter of pipe _____			
Slot width _____			Slot spacing _____			
Kind of well cap _____			Kind of well point/end plug _____			
Installation:						
Was well installed by augering or driving? _____						
Kind of filter sand _____			Kind of bentonite _____			
Depth to lowest screen slots _____			Riser height above ground _____			
Was bentonite wetted for expansion? _____						
Method of measuring water levels in instrument _____						
How was instrument checked for clogging after installation? _____						
Instrument Diagram <sup>a</sup>	Soil Characteristics					
	Texture	Matrix Color	Redoximorphic Features		Induration (none, weak, strong)	Roots
			Color	Abundance		

<sup>a</sup>Show depths (heights) of riser, well screen, sand pack, and bentonite in relation to soil horizons.

## Appendix C

### Monitoring Well and Staff Gage Maintenance Log

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## Monitoring Well Maintenance Log - SAS Project # \_\_\_\_\_

Well ID # \_\_\_\_\_ Coordinates \_\_\_\_\_ Personnel \_\_\_\_\_ Date Installed \_\_\_\_\_

Maintenance History (Dates clogged, cleaned, replaced, etc.) \_\_\_\_\_

Date/Time	Method of Measuring Water Level in well	Height of Riser Above Ground Surface Elevation (GSE)	Depth to Water From Top of Riser	Water Level Below GSE	Automated Level logger -Water Level Below GSE	% Difference Between Automated Level Logger and Manual Water Level Reading

Comments (Instrumentation drift recorded? Pipe checked for clogging? Pipe checked for movement? Vandalism? Well Cap Missing? Etc.)

## Appendix D

### Measuring Stream Channel Shading Using a Modified Convex Densiometer

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## Measuring Stream Channel Shading Using a Modified Convex Densiometer

The following standard method is to be used for performing semi-quantitative field measurements of stream channel shading in streams using a convex densiometer (aka, Model A spherical densiometer), modified according to Strickler (1959) and USEPA (2013) (Figure 1). The modification reduces the observations of cover on the sides and behind the observer, thus minimizing repeated observations of the same component(s) of cover on the same channel cross-section.

The observer will measure stream channel shading at water's edge at each channel cross-section throughout the mitigation site.

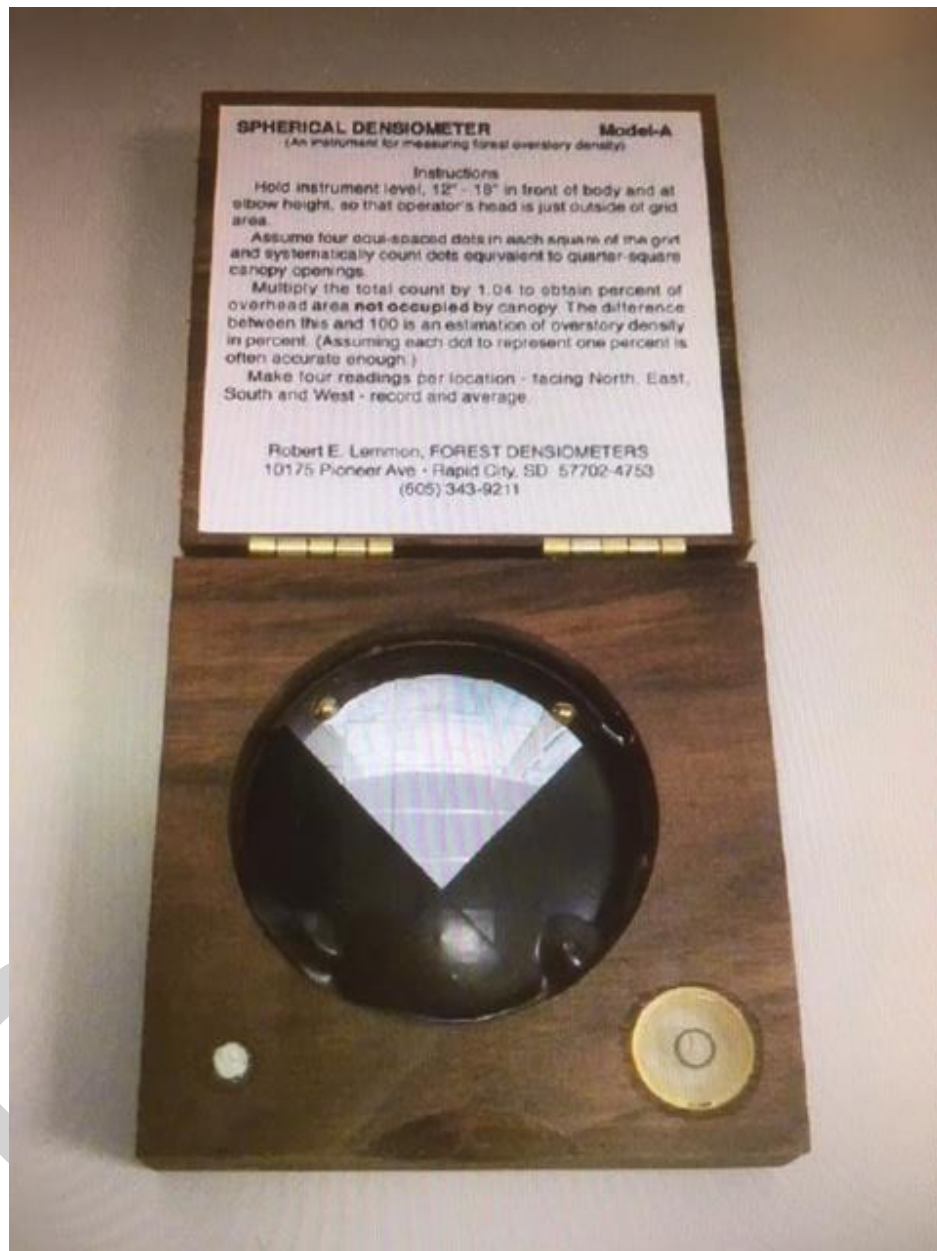
- At each channel cross-section, the observer will take one canopy measurement at the left bank sampling point and one canopy measurement at the right bank sampling point. The sample point will be the points on the cross-section at water's edge (i.e. left edge of water ( $n_{lew}$ ) and right edge of water ( $n_{rew}$ ) and 32.5 cm (12 inches) above the water surface. This will allow for inclusion of shading from understory species, and also standardizes data collection among observers and between mitigation sites.
- Standing at the  $n_{lew}$  sampling station, the observer will face the left bank (i.e. he will be standing in the water). He will ensure that the densiometer stays level using the bubble level on the densiometer and position his head just outside the field of view at the bottom of the densiometer. The observer will count the number of etched-grid intersections on the mirror obscured by overhead vegetation. There are 17 available intersections (Figure 2). The observer will record a number ( $n_{lew}$ ) between 0 (no points covered) to 17 (all points covered).
- The observer will then move to the  $n_{rew}$  sampling station, and repeat the procedure facing the right bank ( $n_{rew}$ ).
- Stream channel shading is calculated as the ratio of covered intersections ( $\sum n_{lew}, n_{rew}$ ) to total intersections (34) for each channel cross-section.

$$\text{Percent Channel Shading at Channel Cross-Section} = (\sum n_{lew}, n_{rew})/34 \times 100$$

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J. Sawyers (2011)

Figure 1. Spherical densiometer modified to leave 17 points of observation at gridded line intersections.



J. Sawyers (2011)

Figure 2. Locations on the face of the densiometer used to assess stream channel shading (vis a vis canopy coverage).

## Appendix E

### Standard Operating Procedures for the Collection and Analysis of Stream Benthic Macroinvertebrates for the Clean Water Act, Section 404 Regulatory Program in Georgia

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Standard Operating Procedures for the Collection and Analysis of Stream  
Benthic Macroinvertebrates for the Clean Water Act, Section 404  
Regulatory Program in Georgia

November 2018 (Draft Version 1.0)

## **1.0 INTRODUCTION**

The procedures described in this document establish standard operating procedures for collecting and analyzing stream benthic macroinvertebrate communities for the Clean Water Act, Section 404 regulatory program in Georgia.

## **2.0 PRE-SAMPLING PROCEDURES**

### **2.1 Personnel Qualifications**

An experienced benthic biologist trained and skilled in field benthic sampling methods and organism identification must be present for all sample collections. Personnel must know insect morphology; be capable of using dichotomous keys; and have knowledge of the benthic macroinvertebrate taxa found in Georgia and in various stream habitats. New or inexperienced personnel may be used as team members if close supervision is provided by the experienced biologist during sample collection, sample picking and visual collections.

### **2.2 Equipment and Supplies**

Stream mitigation performance standards in the Piedmont and Blue Ridge Ecoregions of Georgia were generated using data collected according to the “*Standard Operating Procedures for Collection and Analysis of Benthic Macroinvertebrates*” in North Carolina (NCDEQ, 2016). The items listed below are representative of typical equipment and supplies specified by NCDEQ (2016).

#### **Field Supplies**

- Triangle frame or D-frame sweep nets with 800-900 micron Nitex™ mesh
- Sieve buckets with 600 micron mesh (US Standard No. 30)
- Wash tubs and picking trays
- Forceps
- 6-dram glass vials with polyseal screw caps
- Plastic containers with tightly sealing lids large enough to hold several 6-dram vials (2/crewmember)
- Ethyl alcohol for sample preservation
- Labels and collection cards, pencils
- Digital camera

- GPS unit
- Water quality meter (capable of measuring temperature, dissolved oxygen, specific conductance and pH)

### 2.2.1 Calibration and Standardization

All meters and other equipment must be calibrated in the lab or other controlled environment (e.g., hotel room) and a lab calibration form completed before being taken into the field each day. Lab calibration forms or field book entries of meter calibration become part of the sample record. Meters must be checked after sampling each day using laboratory standards and buffers for specific conductance and pH.

## 3.0 SAMPLING PROCEDURE

### 3.1 Overview

The following are primary elements to be considered when performing sampling, which are also discussed further throughout the document:

Documentation. Proper documentation of site layout and conditions is required. Photographs facing upstream and downstream from both the start and end of the sample reach must be taken, and a site sketch should be made that shows any unique habitats for those basin assessment locations that do not have site sketches. This sketch should include enough detail that subsequent field crews can return to the same sampling location.

High Flow Conditions. Most of the sampling methodologies described in this manual require that freshwater streams or rivers be wadeable for safe and effective data collection. In addition to safety concerns for field personnel, high water conditions severely impair sampling efficiency by making some critical habitats inaccessible. If high water makes sampling conditions unsafe, it is better to return to the site during a more appropriate flow regime.

Low Flow. Drought conditions can play a major role in altering the composition of the benthic fauna. Every effort should be made in locations that are susceptible to flow interruption during droughts to be sure that flow has been continuous prior to sampling. Flowing water in a stream immediately following a period of rain may mask antecedent conditions. Prior flow conditions can be difficult to determine, especially in smaller streams, but USGS flow data from nearby streams and rainfall records from nearby climate stations should be used to make the best determination of prior flow conditions. Sampling should be delayed, if possible, when recent flow conditions have been extremely high or low.

Physicochemical measurements. Water temperature, pH, specific conductance, turbidity and dissolved oxygen measurements are obtained and recorded.



Chain of Custody. Sample containers are labeled before leaving the site with waterbody name, sample reach location, collection card number, initials of collectors, and date of collection.

## **3.2 Pre-sampling Site Assessment**

### **3.2.1 Conditions and Flow**

The target stream reach for sampling is 100 meters in length. Before sampling a site, survey the upstream and downstream segments for adequate available habitat and note any potential adverse conditions that may affect biological communities (e.g. unrestricted cattle access to the stream, all-terrain vehicle crossings, etc.).

### **3.2.2 Habitat Assessment**

A habitat assessment should be completed for all collections using the directions given on the habitat assessment form. In most areas, it is obvious whether the Mountain/Piedmont habitat form (Appendix A) or the Coastal Plain habitat form (Appendix B) should be used. In some transitional areas, however, a field decision must be made as to which form to use. If the stream is naturally rocky with a riffle-pool sequence then the Mountain/Piedmont habitat form should be used, even if the Level IV ecoregion (Griffith *et al.*, 2001) map puts the site in the coastal plain. The reverse is true for a naturally sandy, low gradient stream located on the map in the Piedmont, but near a coastal plain ecoregion.

In addition to above assessment, an evaluation of benthic quality should be performed and recorded on the benthos collection card at Appendix C. Field observations should include:

*Immediate watershed.* Record type of land use, extent of disturbed land, any floodplain deposition of sediment, any evidence of stream widening and/or infill, presence of upstream tributaries or dams (including beaver dams), evidence of recent water level changes such as leaf packs out of water, submerged terrestrial vegetation and/or sediment on vegetation above water level, any livestock with access to stream, any point sources and any unique habitats. These observations should generally be limited to the view-shed of the field crew from the upper end of the sample reach.

*Substrate.* Two collectors make independent visual estimates of substrate percentages and the average values are recorded on the collection card. Also note embedded substrate (interstitial spaces filled with sand); any atypical habitats such as bridge rubble, large bedrock or other rock outcrops or unusual geological formations, abrupt changes in slope, presence of normal riffle-pool sequence (riffles spaced at intervals equal to 5-7 times bankfull stream width), any large areas of unstable coarse sand or movement of bedload material and amount of substrate covered with periphyton or silt.

*Width.* Measure the wetted width of the stream using a tape measure at two points that are representative of the area sampled. Any unusual characteristics, such as a braided channel, should also be noted and recorded.

*Water.* Look for color, odor (especially sewage and/or chlorine), foaming, algal mats, and oil sheen.

*Benthic Community.* Note presence of organisms not usually collected such as mussels, and also any organisms that are very abundant.

The time necessary to collect at a sample reach may vary depending on factors such as stream size, flow conditions and the degree to which samples are picked in the field.

### 3.2.3 Physicochemical Measurements

A calibrated water quality sonde or multiple parameter-specific meters should be used to measure the following: temperature, pH, specific conductance, turbidity and dissolved oxygen. The five values are recorded on both the habitat form and the collection card.

## 3.3 Sample Methods

### 3.3.1 Sample Period

Samples collected from streams north of the Fall Line in Georgia should be sampled April 1 to June 30. This includes all of Ecoregions 45, 66 and 67. Streams lying south of the Fall Line, including all of Ecoregions 65 and 75, should be sampled January 15 to March 15.

### 3.3.2 Modified Qual-4 Method

The field sampling method used to assess biological conditions of Georgia streams for the Clean Water Act, Section 404 regulatory program is modified from the Qual-4 method used by the North Carolina Division of Water Resources (NCDEQ, 2016). Using the Modified Qual-4 method, four collections are made:

- one riffle-kick
- one sweep
- one leaf-pack
- visual

Invertebrates may be picked from the sample in the field using forceps and picking trays, and preserved in glass vials containing 95% ethyl alcohol. The Georgia Interim Stream Quantification Tool relies on proportions of total taxa richness metrics.

Therefore, it is critical that all representative taxa of the entire macroinvertebrate sample be picked from each of the collections. Alternatively, detritus collected during sampling may be preserved in the field and returned to the laboratory for picking. In either case, there is no need to pick and/or retain all individuals of every taxon. Instead, 3-5 specimens of each taxa should be adequate to ensure accurate identification.

### 3.3.2.1 Riffle-kick Collection

Approximately two square meters of substrate, sampled from at least two unique riffles in the sample reach, should be disturbed for a typical riffle-kick collection. Rocks that are highly embedded or too large to be dislodged should be moved by hand, if possible. Rocks too large to be moved safely should be manually “scrubbed down” to dislodge organisms. Careful attention should be made throughout the kick to manually dislodge taxa such as *Neophylax*, *Goera*, *Glossosoma*, *Epeorus*, *Drunella*, etc. that are particularly adept at maintaining robust contact with substrates. In addition, if *Podostemum* or other mosses are present on the substrate in your riffle kick, make certain to “scrub” these “vegetated” surfaces down as numerous unique taxa are associated with these habitats (e.g., *Micrasema*).

North of the Fall Line, rocks, cobble, and gravel are typically plentiful and obtaining a “traditional” riffle-kick in rocky substrate is straightforward. South of the Fall Line (and in some sandy piedmont streams), rocky substrates are either absent or buried. In such instances, riffle-kick collections can still be obtained by targeting log jams, stick and leaf packs, debris dams, sandy runs, and gravel. In such situations, the same general two meters of bottom substrate should be disturbed to obtain the collection. Before initiating a riffle-kick, make certain the bottom of the net is in full contact with the bottom of the stream channel. If there are gaps between the substrate surface and the bottom of the net, organisms will be missed. This issue is a particular concern in areas of high velocity. While sampling, it is also a good idea to remove fresh (“un-seasoned”) fragments of leaves, sticks, as well as trash that are likely not harboring organisms.

As in all aspects of benthic macroinvertebrate sampling, extreme caution should be used in obtaining a kick in turbid water or in water that is exceeding base flow during the sample. Aside from the obvious safety concerns for the field crew, sampling in turbid water may mask the presence of some available habitats while sampling in discharges exceeding base flow may lead either to sampling areas that might be dry during lower flow conditions or by making some critical habitats inaccessible. In such instances, careful attention should be made to identify the thalweg and concentrate the riffle kick collection in these areas.

After the collection has been obtained, it is advisable to fold the net over itself to keep organisms from escaping and to keep the net as level as possible until it is placed in the

rinse bucket. Remove non-target taxa, such as fish, mussels and amphibians. Rinse until the net is free of debris and check for attached organisms. Dump the sample from the bucket into a tub or tray for picking and make sure to wash the remaining debris from the bucket into the tub or tray to ensure all material is retained for examination.

### 3.3.2.2 Sweep Collection

A sweep is defined as a timed 10-minute collection that targets macrophytes, root mats/undercut banks, and detritus deposits in approximate proportion to their abundance in the sample reach. Note that the 10-minute timeframe is based on actual collecting/sampling of habitats; not including the time required to walk between target habitat types in different areas of the sample reach. If available habitats for sweep sampling are so limited that 10 minutes of sampling is impractical, describe this on the benthos collection card (Appendix C).

Not all streams will have the same habitat components, and sweeps of root mats, undercut banks, detritus deposits and macrophytes should target areas of differing flow regimes. Obtaining a sweep from only one zone of current velocity should be avoided and may require a search of the entire reach to find suitable habitat in a variety of current velocities. In waterbodies where there is a lack of well-developed root mats, undercut banks or macrophytes, supplemental sweeps can be made on large bedrock or boulder substrates, particularly if moss or *Podostemum* is present. An effective way to do this is to place the sweep net flush to the substrate below the area of interest and then to mechanically “scrub” the surface. In addition to this supplemental sweep, riffle areas of substrate that were possibly under-sampled during the kicks (e.g., small gravel) can also be targeted. Typically, sand or gravel riffles can be kicked by placing the sweep net downstream of the target area and then disturbing the targeted portion of the substrate. In addition, in areas of slack flow (typically near the shoreline) look for silty areas, and within these areas of silt deposition look carefully for holes (the diameter of a small nail) that could indicate the presence of burrowing mayflies. Running your sweep net a few inches into this silt will likely result in the collection of these taxa.

Given their close proximity to the surface of the water, root mats, undercut banks, and macrophytes are particularly susceptible to temporary drying or brief inundation related to droughts or spates. Therefore, if sampling is being conducted during periods of higher-than-normal flows, it is imperative to compensate for the temporary inundation of apparent habitat that (while currently wetted) was likely dry before the increased discharge. In such instances, it is advisable to conduct your sweep from depths deeper than normal.

Regardless of flow levels, it is always advisable with this collection type to collect from the habitat starting downstream and working in the upstream direction. This practice will prevent sediment from being introduced into uncollected habitat downstream. In general, the cumulative amount of material collected in the sweep net should be just slightly larger than a softball. When the collection is complete, dump the material from

the net into the tub or tray making sure to backwash the remaining debris from the net into the tub or tray to ensure all material is processed. A careful examination of the net should be made to remove any attached organisms.

### 3.3.2.3 Leaf-pack Collection

The investigator should not expend too much effort searching for leaf-packs in areas of reduced flow unless that is the only flow regime present. Careful attention should be made to the condition of the leaf material comprising the pack. Fresh material should not be targeted. If collected together with suitable material, it should be discarded during the elutriation process. Leaf packs should be comprised of well-conditioned material, generally brown to dark brown in color. Black leaves, consistent with anoxic conditions, should be avoided unless that is the only material present. Often when working in the mountains, *Rhododendron* is the dominant leaf type—particularly in small streams and at higher altitudes. While this material (if properly conditioned) is suitable, it is not ideal, and reasonable effort should be expended in obtaining deciduous leaf material. Similarly, when working in the coastal plain, American holly (*Ilex opaca*) is often a large constituent of leaf pack material. While this is suitable substrate if conditioned, effort should also be made to target deciduous material when possible.

Sticks are often collected with leaf material, but are not the primary target of this collection. Unless it is the only material present, grass clippings and other weedy debris should not be used as part of this collection type. Obtaining a leaf-pack during high flows can be problematic as material currently in flow may actually have been only very recently deposited and thus not consistently exposed to water and not adequately conditioned. To avoid this condition, always target leaf-packs in the deepest areas of the flow to ensure maximum exposure to water. Avoid taking your entire collection from just one area within the sample reach. It is always best to take from multiple leaf packs (regardless of type) from various areas throughout the reach to ensure as representative a collection as possible.

In general, half the volume of the wash bucket is sufficient for a typical leaf-pack. More material is acceptable, but will result in more time spent in the elutriation process. In either case, elutriation is a crucial step in order to reduce the volume of the sample to a manageable size for picking. To elutriate a sample, submerge the bucket to a maximum of about two inches from the top of the bucket and grab a small handful of material. Work the material between your fingers while rapidly washing it in the standing water of the wash bucket. Washing should be a vigorous process and is intended (along with working the material in your hand) to dislodge invertebrates from the leaf material and to deposit them into the rinse bucket. Repeat this process until the volume of the sample in the bucket is reduced to about two to three inches in depth. During the elutriation process, it is advisable to rinse the elutriated material by filling the bucket to within one inch of the top and rotating the bucket by the handle rapidly clockwise and counterclockwise until the water is drained. This technique is particularly useful in silty or muddy conditions since rinsing the collection of excessive silt will result

in clearer water in the picking tray and thus, an easier and more accurate field pick of the sample.

#### 3.3.2.4 Visuals

Ideally, three investigators participate in this portion of the field collection, which is done after all other collections have been made and field-picked. Approximately 10 minutes should be allotted for visual collections, for a cumulative visual collection occurring over a 30-minute period. If a two-member (or one-member) crew is performing the collection, then the time spent on this collection by each investigator should be increased as appropriate to total a combined 30 minutes. Often, in areas of very poor habitat or very poor diversity, 10 minutes will provide more than enough time to obtain a representative collection. In areas of high habitat heterogeneity or very high diversity, even 15 minutes may not allow for enough time to obtain a good collection.

The intent of the visual collection is to specifically target microhabitats that were either not sampled within any of the other collection methods or were under-collected. Examples generally include very large substrates (e.g., logs and boulders) in areas of very high or very low flow. For example, the undersides of rocks in pools and areas of slow flow, as well as cracks and crevices in rocks in the same areas should be examined closely. Rotate the rock in multiple orientations to make maximum use of ambient light and to reduce glare. This approach will promote finding small or cryptic taxa. Also, it is often helpful to gently splash water onto substrate surfaces as the disruption of the brief surface tension will reveal the presence of many small organisms that are otherwise hard to see.

In areas of high to medium flows, pay close attention for the presence of mineral-cased caddisflies that are often recessed into rock crevices (e.g., *Neophylax*) or sometimes found firmly adhered to the surface of the rock (e.g., *Glossosoma*). These taxa are often not dislodged during the riffle-kick collections, so effort must be made to target them during visuals. Similarly, many mayflies (e.g., *Epeorus*) that are adapted to clinging tightly to surfaces in fast current will sometimes not be dislodged during the riffle-kick and thus, must be searched for during visual collections.

It is strongly advised to pack at least three extra vials to be used solely for visual collections; this prevents loss in the event of a dropped vial. Visual collections are made at the end of the assessment in order to facilitate the identification of under-sampled habitats. Time spent on visual collections (per investigator and cumulative) should be noted on the benthos collection card (Appendix C).

## 4.0 DATA PROCESSING

The Georgia Interim Stream Quantification Tool (GA SQT) utilizes assessment metrics based on proportions of total taxa richness, rather than actual percentages of organisms present in the sample. Consequently, while all representative taxa in the entire

macroinvertebrate sample (i.e. all four collections per sample reach) must be picked for identification to obtain accurate taxa richness data; actual enumeration of all specimens per taxa is not required.

Each taxon must be identified and assigned to its respective habit and trophic habit listed on the “*Georgia SQT Macroinvertebrate Traits*” table available on the Corps Savannah District’s Regulatory In-Lieu Fee and Bank Information Tracking System (RIBITS) web page. Taxa missing from the above-referenced table must be assigned habit and trophic habit following nomenclature in Poff et al. (2006) (Table 1). Existing databases compiled by Vieira et al. (2006) and should be consulted first. Taxa absent from each of these references may be assigned habit and trophic habit based on other commonly accepted references (e.g. Merritt et al., 2008), so long as the reference is identified within the sample record.

Table 1. Habit and trophic habit nomenclature, following Poff et al. (2006).

ID	Habit	ID	Trophic Habit
1	Burrower	1	Collector-Gatherer
2	Climber	2	Collector-Filterer
3	Sprawler	3	Herbivore (Scraper, Piercer)
4	Clinger	4	Predator
5	Swimmer	5	Shredder (Detritivore)
6	Skater		

The proportion of total genus-level taxa richness of the sample comprising each habit and trophic habit is computed. A list of all sampled taxa and corresponding habit and trophic habit designations must be provided to the Corps and IRT in a single Microsoft Excel worksheet. The same workbook should also include additional dedicated worksheets (aka “tabs”) reflecting the electronic transfer of all field data collected on habitat sheets (Appendices A or B, as applicable) and the benthos collection card (Appendix C). Thus, one Microsoft Excel workbook (aka “file”) per sample reach should contain three worksheets representing a complete digital record of the sample site, its sampled macroinvertebrate community assemblage and its physicochemical and habitat conditions.

#### 4.1 Piedmont and Blue Ridge Ecoregions

In the Piedmont (Ecoregion 45) and Blue Ridge (Ecoregion 66), the following selected metrics are utilized in the GA SQT:

- Proportion Genus-level EPT<sup>4</sup> Richness
- Proportion Genus-level Clinger Richness
- Proportion Genus-level Shredder Richness
- Proportion Genus-level Burrower Richness

The proportion-based values of the reference dataset were standardized according to the percent-of-standard method (Barbour et al. 1999) using “ceilings” and “floors” to limit the influence of biological assemblages corresponding to values outside of the 95<sup>th</sup> percentile and 5<sup>th</sup> percentile. Standardization equations in Table 2, use the specific “ceiling” and “floor” values for each assessment metric in each ecoregion as presented in Table 3. If a standardized assessment metric value for any given sample is greater than 100 (i.e. a data value above the 95<sup>th</sup> percentile of the reference data), it must be corrected to equal 100. Similarly, if a standardized assessment metric value is less than 0 (i.e. a data value below the 5<sup>th</sup> percentile of the reference data), it must be corrected to equal 0.

The “*Georgia Stream Quantification Tool*” Microsoft Excel workbook, available on the Corps Savannah District’s RIBITS web page, automates these calculations. Users are required only to enter the “raw” proportion-based values for the above-referenced four assessment metrics into the “Field Value” cells of the spreadsheet, and those values are then standardized by the spreadsheet.

Table 2. Standardization equations for benthic macroinvertebrate measurement methods for the Piedmont and Blue Ridge ecoregions.

Standardized Proportion Genus-level EPT Richness	$= \frac{(Prop\ EPT\ Rich - Floor)}{(Ceiling - Floor)} * 100$	Equation (1)
Standardized Proportion Genus-level Clinger Richness	$= \frac{(Prop\ Clinger\ Rich - Floor)}{(Ceiling - Floor)} * 100$	Equation (2)
Standardized Proportion Genus-level Shredder Richness	$= \frac{(Prop\ Shredder\ Rich - Floor)}{(Ceiling - Floor)} * 100$	Equation (3)
Standardized Proportion Genus-level Burrower Richness	$= \frac{(Ceiling - Prop\ Burrower\ Rich)}{(Ceiling - Floor)} * 100$	Equation (4)

<sup>4</sup> Taxa in the Ephemoptera, Plecoptera and Trichoptera orders (i.e. mayflies, stoneflies and caddisflies).



Table 3. Ceiling and floor values used to standardize raw proportion metrics according to Equations 1 through 4.

Metric		Piedmont	Blue Ridge
Proportion Genus-level EPT Richness	Ceiling	43.4	66.7
	Floor	9.7	16.4
Proportion Genus-level Clinger Richness	Ceiling	48.0	56.9
	Floor	24.0	20.0
Proportion Genus-level Shredder Richness	Ceiling	16.2	23.3
	Floor	3.3	7.7
Proportion Genus-level Burrower Richness	Ceiling	30.0	30.3
	Floor	14.6	8.2

## 4.2 Coastal Plain Ecoregions

<<< Under development >>>

## 5.0 REFERENCES

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## **6.0 APPENDICES**

Habitat Assessment Field Data Sheet: Mountains/Piedmont Streams (Ecoregions 45, 66 and 67)

Habitat Assessment Field Data Sheet: Coastal Plain Streams (Ecoregions 65 and 75)

Benthos Collection Card

10/2018

## Habitat Assessment Field Data Sheet

### Mountain/ Piedmont Streams

TOTAL SCORE \_\_\_\_\_

Directions for use: The observer is to survey a **minimum of 100 meters** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

Stream \_\_\_\_\_ Location/road: \_\_\_\_\_ Lat/Long \_\_\_\_\_ County \_\_\_\_\_

Date \_\_\_\_\_ Site# \_\_\_\_\_ Basin \_\_\_\_\_ HUC8 \_\_\_\_\_ Ecoregion \_\_\_\_\_

Drainage Area (sq mi) \_\_\_\_\_ Observer(s) \_\_\_\_\_

**Water Quality:** Temperature \_\_\_\_\_ °C pH \_\_\_\_\_ DO \_\_\_\_\_ mg/l Specific conductance \_\_\_\_\_ μS/cm Turbidity \_\_\_\_\_ ntu

**Physical Characterization: Visible land use refers to immediate area that you can see from sampling location - include what you estimate driving thru the watershed in watershed land use.**

Visible Land Use: \_\_\_\_\_ %Forest \_\_\_\_\_ %Residential \_\_\_\_\_ %Active Pasture \_\_\_\_\_ % Active Crops \_\_\_\_\_ %Fallow Fields \_\_\_\_\_ %

Commercial \_\_\_\_\_ %Industrial \_\_\_\_\_ %Other - Describe: \_\_\_\_\_

Watershed land use : ☐ Forest ☐ Agriculture ☐ Urban ☐ Animal operations upstream
**Width:** (meters) Wetted \_\_\_\_\_ Channel (at top of bank) \_\_\_\_\_ Bankfull \_\_\_\_\_ **Stream Depth:** (m) Avg \_\_\_\_\_ Max \_\_\_\_\_
**Bank Height** (from deepest part of riffle to top of bank): (m) \_\_\_\_\_

**Bank Angle:** \_\_\_\_\_ ° or ☐ NA (Vertical is 90°, horizontal is 0°. Angles > 90° indicate slope is towards mid-channel, < 90° indicate slope is away from channel. NA if bank is too low for bank angle to matter).

☐ Channelized Ditch☐ Deeply incised-steep, straight banks ☐ Both banks undercut at bend☐ Channel filled in with sediment☐ Recent overbank deposits ☐ Bar development☐ Buried structures ☐ Exposed bedrock

☐ Excessive periphyton growth      ☐ Heavy filamentous algae growth ☐ Green tinge      ☐ Sewage smell  
 Manmade Stabilization: ☐ N    ☐ Y: ☐ Rip-rap, cement, gabions    ☐ Sediment/grade-control structure ☐ Berm/levee  
**Flow conditions** : ☐ High    ☐ Normal    ☐ Low  
**Turbidity**: ☐ Clear    ☐ Slightly Turbid    ☐ Turbid    ☐ Tannic    ☐ Milky    ☐ Colored (from dyes)  
**Good potential for Wetlands Restoration Project??**    ☐ YES    ☐ NO    **Details** \_\_\_\_\_

**Channel Flow Status**

Useful especially under abnormal or low flow conditions.

- |  |                          |
|--|--------------------------|
| A. Water reaches base of both lower banks, minimal channel substrate exposed .....     | <input type="checkbox"/> |
| B. Water fills >75% of available channel, or <25% of channel substrate is exposed..... | <input type="checkbox"/> |
| C. Water fills 25-75% of available channel, many logs/snags exposed.....               | <input type="checkbox"/> |
| D. Root mats out of water.....   | <input type="checkbox"/> |
| E. Very little water in channel, mostly present as standing pools.....                 | <input type="checkbox"/> |

**Weather Conditions:** \_\_\_\_\_ **Photo Nos:** \_\_\_\_\_

**Remarks:**

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**I. Channel Modification**

- |   | <u>Score</u> |
|---|--------------|
| A. channel natural, frequent bends.....                                 | 5            |
| B. channel natural, infrequent bends (channelization could be old)..... | 4            |
| C. some channelization present.....                                     | 3            |
| D. more extensive channelization, >40% of stream disrupted.....         | 2            |
| E. no bends, completely channelized or rip rapped or gabioned, etc..... | 0            |

☐ Evidence of dredging    ☐ Evidence of desnagging=no large woody debris in stream    ☐ Banks of uniform shape/height

Remarks \_\_\_\_\_ Subtotal \_\_\_\_\_

**II. Instream Habitat:** Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >70% of the reach is rocks, 1 type is present, circle the score of 17. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as **Rare**, **Common**, or **Abundant**.

\_\_\_\_ Rocks    \_\_\_\_ Macrophytes    \_\_\_\_ Sticks and leafpacks    \_\_\_\_ Snags and logs    \_\_\_\_ Undercut banks or root mats

**AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER**

	>70%	40-70%	20-40%	<20%
	Score	Score	Score	Score
4 or 5 types present.....	20	16	12	8
3 types present.....	19	15	11	7
2 types present.....	18	14	10	6
1 type present.....	17	13	9	5
No types present.....	0			

☐ No woody vegetation in riparian zone      Remarks \_\_\_\_\_      Subtotal \_\_\_\_\_

**III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder)** Look at entire reach for substrate scoring, but only look at riffle for embeddedness, and use rocks from all parts of riffle-look for “mud line” or difficulty extracting rocks.

	Score
<b>A. substrate with good mix of gravel, cobble and boulders</b>	
1. embeddedness <20% (very little sand, usually only behind large boulders).....	15
2. embeddedness 20-40%.....	12
3. embeddedness 40-80%.....	8
4. embeddedness >80%.....	3
<b>B. substrate gravel and cobble</b>	
1. embeddedness <20%.....	14
2. embeddedness 20-40%.....	11
3. embeddedness 40-80% .....	6
4. embeddedness >80%.....	2
<b>C. substrate mostly gravel</b>	
1. embeddedness <50%.....	8
2. embeddedness >50%.....	4
<b>D. substrate homogeneous</b>	
1. substrate nearly all bedrock.....	3
2. substrate nearly all sand .....	3
3. substrate nearly all detritus.....	2
4. substrate nearly all silt/ clay.....	1

Remarks \_\_\_\_\_ Subtotal \_\_\_\_\_

**IV. Pool Variety** Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams, or side eddies.

	Score
<b>A. Pools present</b>	
1. Pools Frequent (>30% of 200m area surveyed)	
a. variety of pool sizes.....	10
b. pools about the same size (indicates pools filling in).....	8

## 2. Pools Infrequent (&lt;30% of the 200m area surveyed)

a. variety of pool sizes..... 6

b. pools about the same size..... 4

**B. Pools absent**..... 0

Subtotal\_\_\_\_\_

☐ Pool bottom boulder-cobble=hard ☐ Bottom sandy-sink as you walk ☐ Silt bottom ☐ Some pools over wader depth

Remarks\_\_\_\_\_

Page Total\_\_\_\_\_

**V. Riffle Habitats**Definition: Riffle is area of reaeration-can be debris dam, or narrow channel area. Riffles **Frequent** Riffles **Infrequent**Score Score

A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream.... 16 12

B. riffle as wide as stream but riffle length is not 2X stream width ..... 14 7

C. riffle not as wide as stream and riffle length is not 2X stream width ..... 10 3

**D. riffles absent**..... 0Channel Slope: ☐ Typical for area ☐ Steep=fast flow ☐ Low=like a coastal stream Subtotal\_\_\_\_\_**VI. Bank Stability and Vegetation****A. Erosion**

1. No, or very little, erosion present ..... 7

2. Erosion mostly at outside of meanders ..... 6

3. Less than 50% of banks eroding..... 3

4. Massive erosion..... 0

Erosion Score\_\_\_\_\_

**B. Bank Vegetation**

1. Mostly mature trees (&gt;12" DBH) present..... 7

2. Mostly small trees (&lt;12" DBH) present, large trees rare ..... 5

3. No trees on bank, can have some shrubs and grasses ..... 3

4. Mostly grasses or mosses on bank..... 2

5. Little or no bank vegetation, bare soil everywhere..... 0

Vegetation Score\_\_\_\_\_

Remarks\_\_\_\_\_ Subtotal\_\_\_\_\_

**VII. Light Penetration** Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead. Note shading from mountains, but not use to score this metric.ScoreA. Stream with **good** canopy with some breaks for light penetration ..... 10B. Stream with **full canopy** - breaks for light penetration absent..... 8C. Stream with **partial** canopy - sunlight and shading are essentially equal..... 7D. Stream with **minimal** canopy - full sun in all but a few areas..... 2E. **No canopy** and no shading..... 0

Remarks \_\_\_\_\_

Subtotal \_\_\_\_\_

**VIII. Riparian Vegetative Zone Width**

Definition: Riparian zone for this form is area of natural vegetation adjacent to stream (can go beyond floodplain). Definition: A break in the riparian zone is any place on the stream banks which allows sediment or pollutants to directly enter the stream, such as paths down to stream, storm drains, uprooted trees, otter slides, etc.

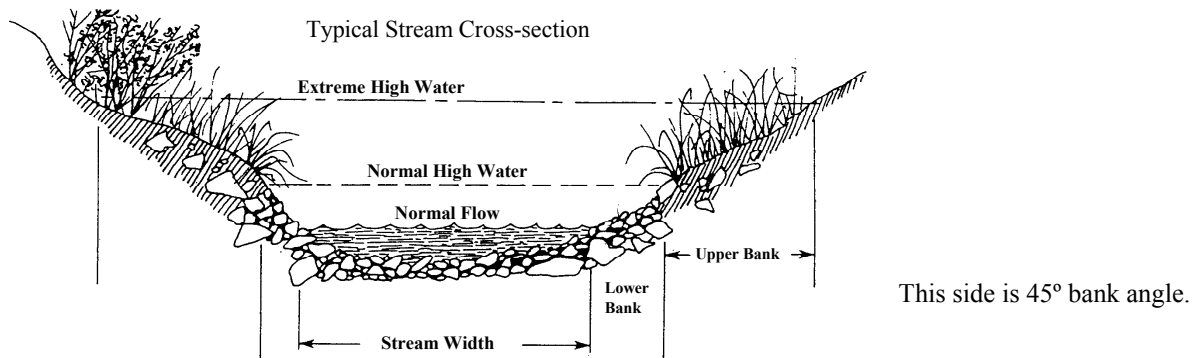
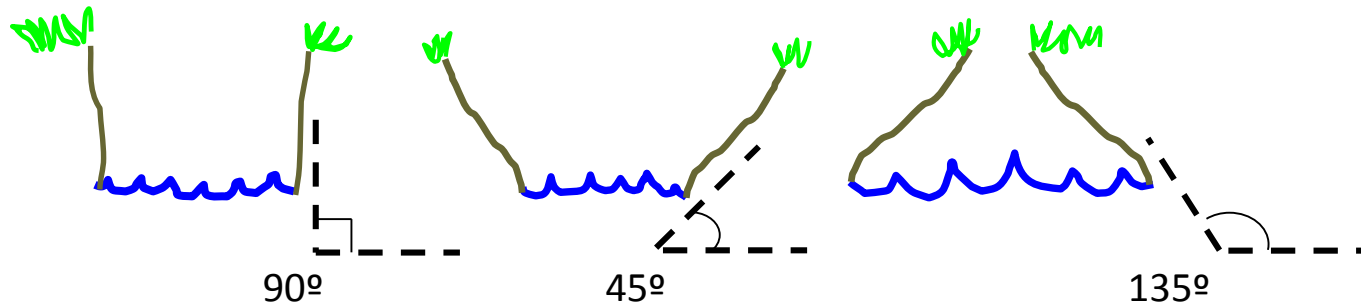
FACE UPSTREAM		Lft. Bank	Rt. Bank
Dominant vegetation: <input type="checkbox"/> Trees <input type="checkbox"/> Shrubs <input type="checkbox"/> Grasses <input type="checkbox"/> Weeds/old field <input type="checkbox"/> Exotics (kudzu, etc)		Score	Score
A. Riparian zone <b>intact</b> (no breaks)			
1. width > 18 meters.....		5	5
2. width 12-18 meters.....		4	4
3. width 6-12 meters.....		3	3
4. width < 6 meters.....		2	2
B. Riparian zone <b>not intact</b> (breaks)			
1. breaks rare			
a. width > 18 meters.....		4	4
b. width 12-18 meters.....		3	3
c. width 6-12 meters.....		2	2
d. width < 6 meters.....		1	1
2. breaks common			
a. width > 18 meters.....		3	3
b. width 12-18 meters.....		2	2
c. width 6-12 meters.....		1	1
d. width < 6 meters.....		0	0
Remarks _____		Subtotal _____	

Page Total \_\_\_\_\_

☐ Disclaimer-form filled out, but score doesn't match subjective opinion-atypical stream.**TOTAL SCORE** \_\_\_\_\_

## Supplement for Habitat Assessment Field Data Sheet

Diagram to determine bank angle:





Site Sketch:

Other comments:	

10/2018

## Habitat Assessment Field Data Sheet Coastal Plain Streams

TOTAL SCORE: \_\_\_\_\_

Directions for use: The observer is to survey a **minimum of 100 meters** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

Stream \_\_\_\_\_ Location/road: \_\_\_\_\_ Lat/Long \_\_\_\_\_ County \_\_\_\_\_

Date \_\_\_\_\_ Site# \_\_\_\_\_ Basin \_\_\_\_\_ HUC8 \_\_\_\_\_ Ecoregion \_\_\_\_\_

Drainage Area (sq mi) \_\_\_\_\_ Observer(s) \_\_\_\_\_

Water Quality: Temperature \_\_\_\_\_ C pH \_\_\_\_\_ DO \_\_\_\_\_ mg/l Specific conductance \_\_\_\_\_  $\mu$ S/cm Turbidity \_\_\_\_\_ ntu

**Physical Characterization: Visible land use refers to immediate area that you can see from sampling location. Check off what you observe driving thru the watershed in watershed land use.**

Visible Land Use: \_\_\_\_\_ %Forest \_\_\_\_\_ %Residential \_\_\_\_\_ %Active Pasture \_\_\_\_\_ % Active Crops

\_\_\_\_\_ %Fallow Fields \_\_\_\_\_ % Commercial \_\_\_\_\_ %Industrial \_\_\_\_\_ %Other - Describe: \_\_\_\_\_

Watershed land use ☐ Forest ☐ Agriculture ☐ Urban ☐ Animal operations upstreamWidth (meters): Wetted \_\_\_\_\_ Channel (at top of bank) \_\_\_\_\_ Bankfull \_\_\_\_\_ Stream Depth (m): Avg \_\_\_\_\_ Max \_\_\_\_\_ ☐ Braided channel

Bank Height (from deepest part of channel to top of bank): (m) \_\_\_\_\_

Flow conditions : ☐ High ☐ Normal ☐ Low

Channel Flow Status :

Useful especially under abnormal or low flow conditions.

- A. Water reaches base of both banks, minimal channel substrate exposed ..... ☐
- B. Water fills >75% of available channel, or <25% of channel substrate is exposed..... ☐
- C. Water fills 25-75% of available channel, many logs/snags exposed..... ☐
- D. Root mats out of water..... ☐

E. Very little water in channel, mostly present as standing pools..... ☐

**Turbidity:** ☐Clear ☐Slightly Turbid ☐Turbid ☐Tannic ☐Milky ☐Colored (from dyes) ☐Green tinge

☐Channelized ditch  
☐Deeply incised-steep, straight banks ☐Both banks undercut at bend ☐Channel filled in with sediment  
☐Recent overbank deposits ☐Sewage smell

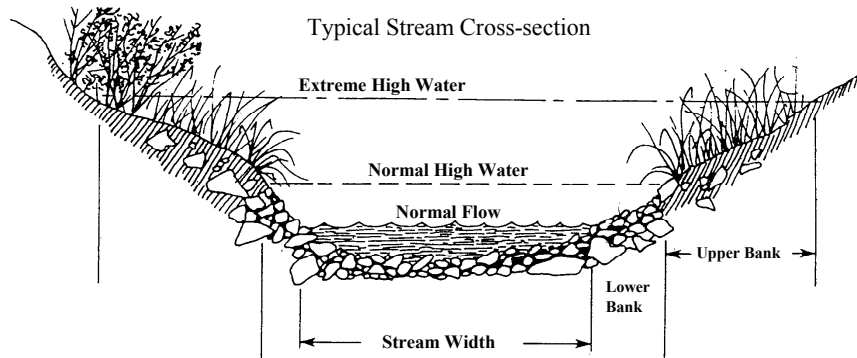
☐Excessive periphyton growth ☐Bar development  
☐Heavy filamentous algae growth

Manmade Stabilization: ☐N ☐Y: ☐Rip-rap, cement, gabions ☐Sediment/grade-control structure ☐Berm/levee

**Weather Conditions:** \_\_\_\_\_ **Photo Nos:** \_\_\_\_\_

**Remarks:** \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

# TYPICAL STREAM CROSS SECTION DIAGRAM



This side is 45° bank angle.

**I. Channel Modification**

	<u>Score</u>
A. Natural channel-minimal dredging.....	15
B. Some channelization near bridge, or historic (>20 year old), and/or bends beginning to reappear..	10
C. Extensive channelization, straight as far as can see, channelized ditch.....	5
D. Banks shored with hard structure, >80% of reach disrupted, instream habitat gone.....	0
Remarks _____	Subtotal _____

**II. Instream Habitat:** Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >50% of the reach is snags, and 1 type is present, circle the score of 16. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as Rare, Common, or Abundant.

\_\_\_\_Sticks \_\_\_\_Snags/logs \_\_\_\_Undercut banks or root mats \_\_\_\_Macrophytes \_\_\_\_Leafpacks

**AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER**

	>50%	30-50%	10-30%	<10%
	<u>Score</u>	<u>Score</u>	<u>Score</u>	<u>Score</u>
4 or 5 types present.....	20	15	10	5
3 types present.....	18	13	8	4
2 types present.....	17	12	7	3
1 type present.....	16	11	6	2
No substrate for benthos colonization and no fish cover.....	0			

☐ No woody vegetation in riparian zone      Remarks \_\_\_\_\_      Subtotal \_\_\_\_\_

**III. Bottom Substrate** (silt, clay, sand, detritus, gravel) look at entire reach for substrate scoring.

<b>A. Substrate types mixed</b>	<u>Score</u>
1. gravel dominant.....	15
2. sand dominant.....	13
3. detritus dominant.....	7
4. silt/clay/muck dominant.....	4
<b>B. Substrate homogeneous</b>	
1. nearly all gravel.....	12
2. nearly all sand .....	7
3. nearly all detritus.....	4
4. nearly all silt/clay/muck.....	1

Remarks \_\_\_\_\_ Subtotal \_\_\_\_\_

**IV. Pool Variety** Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow.

**A. Pools present**Score

- |  |    |
|--|----|
| 1. Pools Frequent (>30% of 100m length surveyed)               |    |
| a. variety of pool sizes.....                                  | 10 |
| b. pools about the same size (indicates pools filling in)..... | 8  |
| 2. Pools Infrequent (<30% of the 100m length surveyed)         |    |
| a. variety of pool sizes.....                                  | 6  |
| b. pools about the same size.....                              | 4  |

**B. Pools absent**

- |  |   |
|--|---|
| 1. Deep water/run habitat present..... | 4 |
| 2. Deep water/run habitat absent.....  | 0 |

Subtotal\_\_\_\_\_

Remarks\_\_\_\_\_

Page Total\_\_\_\_\_

**V. Bank Stability and Vegetation****A. Erosion**

1. No, or very little, erosion present ..... 10  
 2. Erosion mostly at outside of meanders ..... 6  
 3. Less than 50% of banks eroding ..... 3  
 4. Massive erosion ..... 0
- Erosion Score \_\_\_\_\_

**B. Bank Vegetation**

1. Mostly mature trees (>12" DBH) present ..... 10  
 2. Mostly small trees (<12" DBH) present, large trees rare ..... 7  
 3. No trees on bank, can have some shrubs and grasses ..... 4  
 4. Mostly grasses or mosses on bank ..... 3  
 5. Little or no bank vegetation, bare soil everywhere ..... 0
- Vegetation Score \_\_\_\_\_

Remarks \_\_\_\_\_ Subtotal \_\_\_\_\_

**VI. Light Penetration** (Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead).

- |  | <u>Score</u>   |
|--|----------------|
| A. Stream with <b>good</b> canopy with some breaks for light penetration .....         | 10             |
| B. Stream with <b>full canopy</b> - breaks for light penetration absent.....           | 8              |
| C. Stream with <b>partial</b> canopy - sunlight and shading are essentially equal..... | 7              |
| D. Stream with <b>minimal</b> canopy - full sun in all but a few areas.....            | 2              |
| E. <b>No canopy</b> and no shading.....  | 0              |
|  | Subtotal _____ |

Remarks \_\_\_\_\_

**VII. Riparian Vegetative Zone Width**

Definition: A break in the riparian zone is any area which allows sediment to enter the stream. Breaks refer to the near-stream portion of the riparian zone (banks); places where pollutants can directly enter the stream.

- |   | Lft. Bank<br>Score | Rt. Bank<br>Score |
|---|--------------------|-------------------|
| A. Riparian zone <b>intact</b> (no breaks)  |                    |                   |
| 1. zone width > 18 meters.....              | 5                  | 5                 |
| 2. zone width 12-18 meters.....             | 4                  | 4                 |
| 3. zone width 6-12 meters.....              | 3                  | 3                 |
| 4. zone width < 6 meters.....               | 2                  | 2                 |
| B. Riparian zone <b>not intact</b> (breaks) |                    |                   |

1. breaks rare

a. zone width > 18 meters.....	4	4
b. zone width 12-18 meters.....	3	3
c. zone width 6-12 meters.....	2	2
d. zone width < 6 meters.....	1	1

2. breaks common

a. zone width > 18 meters.....	3	3
b. zone width 12-18 meters.....	2	2
c. zone width 6-12 meters.....	1	1
d. zone width < 6 meters.....	0	0

Remarks \_\_\_\_\_

Subtotal \_\_\_\_\_

Page Total \_\_\_\_\_

**TOTAL SCORE** \_\_\_\_\_

**BENTHOS COLLECTION CARD**

DATE \_\_\_\_\_ COLLECT TIME \_\_\_\_\_ COLLECTORS \_\_\_\_\_ CARD# \_\_\_\_\_

WATERBODY \_\_\_\_\_

STAT. LOC. \_\_\_\_\_ RIVER BASIN \_\_\_\_\_ COUNTY \_\_\_\_\_

**Substrate:**

Boulder (10")

\_\_\_\_\_ %

**River:**

Mean depth

\_\_\_\_\_

**Field Parameters:**

Bank Erosion

N

Mod

Sev

\_\_\_\_\_

Cobble (2 1/2-10")

\_\_\_\_\_ %

Maxim. depth

\_\_\_\_\_

Canopy

%

Type

\_\_\_\_\_

Gravel (1/12-2 1/2")

\_\_\_\_\_ %

Width

\_\_\_\_\_

Aufwuchs

N

Mod

Abund.

\_\_\_\_\_

Sand (1/12")

\_\_\_\_\_ %

Current

\_\_\_\_\_

Podostemum

N

Mod

Abund.

\_\_\_\_\_

Silt, fine Partic.

\_\_\_\_\_ %

Recent Rain ?

\_\_\_\_\_

Tribes Present?

\_\_\_\_\_

Other

\_\_\_\_\_ %

**Photos****( # )**

\_\_\_\_\_

**Instream Habitat: (0,+,++)**

Pools

\_\_\_\_\_

Backwaters

\_\_\_\_\_

Kicks

\_\_\_\_\_

**Water Chemistry:**

Temperature (°C)

\_\_\_\_\_

Riffles

\_\_\_\_\_

Detritus

\_\_\_\_\_

Sweeps

\_\_\_\_\_

Dissolved Oxygen (mg/L)

\_\_\_\_\_

Snags

\_\_\_\_\_

Aquatic Weeds

\_\_\_\_\_

Leaf Packs

\_\_\_\_\_

Conductivity (µmhos/cm)

\_\_\_\_\_

Undercut Banks

\_\_\_\_\_

Other

\_\_\_\_\_

Rock-Log

\_\_\_\_\_

pH

\_\_\_\_\_

Root Mats

\_\_\_\_\_

Sand

\_\_\_\_\_

Visuals

\_\_\_\_\_

Other

\_\_\_\_\_

Field Observations:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_