



**Work Plan for the NCDENR Science Advisory Panel on
Aquatic Resource Restoration
March 2012**

A. Background

In April 2011, the N.C. Department of Environment and Natural Resources (NCDENR) convened a group of professionals and academics with expertise in particular subject areas associated with aquatic resource restoration. The group's purpose is to promote better integration of science into the practice of stream, wetland and riparian buffer restoration. The nine-member panel met four times in 2011 and worked to determine what issues would receive its initial attention.

B. Issues Identified for Focus of Work Plan

After identifying and considering many scientific challenges related to stream and wetland restoration, the group settled on three focus areas. Strong consideration was given to issues that will aid the Ecosystem Enhancement Program in the implementation of restoration projects for the purposes of compensatory mitigation. The issues that will be the focus of the panel's first work plan are briefly described below. Detailed descriptions of the issues and plans for addressing them are included in the remainder of the document. All of these initiatives will support improved restoration outcomes and the implementation of better compensatory-mitigation projects.

1. *Develop recommendations for considering EEP projects in a functional context and communicating project goals in functional terms.* Assessing stream condition is a critical component of determining the ultimate level of intervention in the design process. EEP consultants currently collect reach-scale geomorphic data, but rarely convert this into information that describes the potential to restore stream functions. Recommendations will be made on actions that can be taken by EEP and its consultants to utilize data already being collected in order to communicate restoration goals in terms of functional lift..

2. *Recommend approaches for the analysis of the sediment transport regime for a wide range of river systems in North Carolina.* The transport and deposition of bedload sediment play a critical role in the stability of both natural and reconfigured channels, and strongly dictate the type and quality of aquatic habitat that is present on the channel bed. There is significant confusion among restoration practitioners as to what type of sediment transport analysis could or should be undertaken for a particular site, or even if a transport study is required for the stream/basin considered for restoration or mitigation. Approaches to analyzing sediment regimes will be identified and characterized, and methods to quantify uncertainties associated with them will be explored. A decision framework to be applied in the characterization of the sediment transport regime, and the use of the generated data, will be developed.

3. *Recommend methods for evaluating wetland hydrology in re-establishment projects.* Hydrology must be restored if a wetland is to be re-established successfully. Currently, there is no standard set of methods for evaluating wetland hydrology in re-establishment projects. It is also not clear whether the criteria for restoration “success” must be defined differently for specific combinations of wetland type, soil type, and landscape position. A report that addresses a number of issues related to the assessment of wetland hydrology will be prepared.

C. Detailed Descriptions and Action Plans for Identified Issues

This section provides a more detailed description of each of the issues that the Science Advisory Panel will address along with the identification of who will work on the issue, what product will be developed and when it will be available for presentation to the whole panel.

1. *Develop recommendations for considering EEP projects in a functional context and communicating project goals in functional terms*

Issue Description

EEP hires consultants to evaluate and implement restoration projects for the purposes of compensatory mitigation. These consultants currently collect reach scale geomorphic data (existing conditions), but rarely convert this into information that describes the potential to restore stream functions.

Federal and state agencies acknowledge the importance of moving mitigation in the direction of measuring functional loss and replacement. The 2008 Mitigation Rule promotes the use of functional assessment methods, and in North Carolina a stream functional assessment methodology is in development. Until more formal methods are approved and accepted, there are likely some actions that can be taken by EEP and its consultants to utilize data already being collected for mitigation projects in order to communicate restoration goals in terms of functional lift.

Why It's Important

EEP consultants collect significant amounts of geomorphic data as part of the existing condition assessment (e.g., cross sections, bed form profiles, bed material, stream classification and channel evolution). However, these data rarely are turned into information that can be used to determine the restoration potential, which is defined as the highest level of restoration that can be achieved given project constraints and watershed conditions. Once the restoration potential is determined, specific design goals can be developed to restore functions rather than simply state that the goal is to improve dimension, pattern and profile. This shift will also improve the development of performance standards and project-specific monitoring efforts to demonstrate whether function-based goals have been achieved.

Panel Team

Will Harman (lead) with Dave Penrose and Martin Doyle

Name	Affiliation	Area of Expertise
Will Harman (lead)	Stream Mechanics	Geomorphology; Restoration Design
Dave Penrose	Watershed Science	Aquatic Ecology
Martin Doyle	Duke University	Geomorphology; Hydrology; Engineering

Approach

Team members will first meet with EEP staff to learn about existing assessment methodologies that are in use by the program. The team will also gather information on data sources (e.g., hydrologic, geomorphic, water quality and biological) that the program has available. The team will review the Stream Functions Pyramid and Framework that has been developed by Stream Mechanics (a private environmental company). In addition, a review will be conducted of other assessment methodologies recommended by other panel members and EEP. A good example of a stream

restoration/mitigation plan will be identified and reviewed, as will EEP's site selection methodology. After all of these items have been evaluated, the team will consider what recommendations can be made to promote the application of existing data toward a stream functions/condition approach.

Product

A memorandum to EEP will be prepared and will include recommendations for considering EEP projects in a functional context, as well as communicating project goals in functional terms. The memorandum will likely include recommendations and tips for selecting stream-restoration project sites, along with a description of critical components of stream assessment methodologies with examples of watershed- and reach-scale parameters and measurement methods. The product will help EEP consultants and mitigation providers better utilize geomorphic and biological data that they already collect to determine restoration potential and to establish function-based restoration goals.

Timeline

Meet with EEP to gather information on existing methods and data gathered	By the end of April 2012
Team members review the Stream Functions Pyramid and any other appropriate documents	April/May 2012
Team members individually itemize potential recommendations to be considered by the team	May 2012
Team members meet to consider and agree on what recommendations to be included in memorandum to EEP	May 2012
Team members present recommendations to full panel and invite additional input	May 30, 2012
Team leader drafts memorandum and distributes to team members	June 2012
Memorandum is finalized	As soon as possible after presentation to SAP

2. *Recommend tools for analyzing sediment regimes for stream restoration projects in North Carolina.*

Issue Description

The transport and deposition of bedload sediment play a critical role in the stability of both natural and reconfigured channels, and strongly dictate the type and quality of aquatic habitat that is present on the channel bed. An understanding of sediment-transport dynamics is therefore essential for the effective design of stream-restoration projects. Currently, however, there is significant confusion among practitioners as to what type of sediment transport analysis could or should be undertaken for a particular site, or even if a transport study is required for the stream/basin considered for mitigation. In addition, it is often unclear how transport data can be used to benefit restoration designs. Specific questions that arise include, among of host of others: When/where does a sediment transport analysis need to be conducted? Which approaches are appropriate for gravel versus sand- and silt-bed channels? Which methods can be applied to bi-modal (or mixed-load) channels? For what set of flow conditions should the analyses be performed? How much uncertainty exists within the generated results? And, how can sediment transport and competency data effectively be incorporated into project design (e.g., the design of constructed riffles).

Potential Components to be Evaluated

- i. *Identification and characterization of the approaches available to analyze the sediment regime.* Multiple methods exist to characterize the entrainment, transport and deposition of sediment within river systems. The prevailing engineering approach in North Carolina is to apply empirically derived, threshold entrainment equations to the channel bed material to determine if particles of a given size are likely to move under a given set of flow conditions (particularly bankfull). Although more than a dozen threshold equations have been developed over the past several decades, the relation developed by Andrews (1983) (or its Rosgen variants) for gravel-bed rivers in Colorado has been utilized most widely. The applicability of this equation to Piedmont and coastal streams in North Carolina (which may possess grain size distributions that are significantly different from those in Colorado) is questionable. In addition, while threshold equations provide insights into the potential for channel bed scour during floods, they are much less effective in assessing the potential

for sediment to be transported through the restored reach without significant aggradation or degradation. The inability of threshold equations to fully predict the potential for channel erosion or deposition results from the fact that channel stability is not only dependent on hydraulic conditions and sediment size, but on the amount of sediment that is delivered to the reach from upstream (i.e., sediment supply).

An alternative (although less frequently utilized) approach is to assess sediment transport rates for the restored reach. Unfortunately, direct measurement of bedload transport has proven problematic because of large temporal and spatial variations in sediment movement, even for a constant set of flow conditions. As a result, bedload transport is often assessed using various modeling routines. Although these models differ in their complexity, they are often data intensive, are difficult to calibrate and verify, and require a relatively high degree of training and experience for their effective application. Yet the insights that can be gained through such analysis can often be critically important in evaluating alternative stream restoration designs.

This component of the analysis will identify and characterize specific methods that may be applied to assess the sediment regime at a project site. The review will focus on several significant aspects of the selected/identified tools including data requirements and the time/effort required from their collection; the nature of the channel and bed material to which they can be applied; the flow conditions over which they may and should be applied; the output generated to describe the sediment regime; the uncertainty associated with the approach; and the training required for their utilization.

- ii. *Implications of result uncertainty to project design.* Regardless of the methods used to characterize sediment transport and deposition, the analysis will possess a degree of uncertainty that complicates their application to the design process. Often, the associated uncertainty is large, exceeding one to two orders of magnitude. The committee will explore methods to quantify uncertainty for identified approaches, and assess the implications of model uncertainty to project design.
- iii. *Decision analyses.* Given the variety of approaches available to characterize the sediment regime, and the uncertainty in the

generated results, decisions regarding their use in project design should be made on the basis of a structured decision-making framework. The committee will develop a framework to effectively characterize the sediment regime of a given hydrologic, geomorphic and physiographic environment, and to effectively incorporate the data into project designs.

Why It's Important

Post-project channel instability appears to be closely correlated with sediment transport dynamics, and a lack of incorporating a sound understanding of sediment supply, transport and depositional processes into project designs. When sediment transport analyses are conducted, they are often based on inappropriate approaches given the composition of the bed material that lead to erroneous conclusions with regards to channel stability and design. Moreover, estimates of sediment transport possess significant uncertainty. Improvements in channel design and project performance may therefore be attained through a detailed understanding of the tools and/or approaches that may be used to characterize the sediment regime, and the limitation of the generated results to project development.

Panel Team

Additional panel members will likely be added during the initial stages of the analysis.

Name	Affiliation	Area of Expertise
Jerry Miller (lead)	Western Carolina University	Fluvial Geomorphology; Contaminant Transport
Martin Doyle	Duke University	Geomorphology; Hydrology; Engineering
Michael Ellison	Ecosystem Enhancement Program	Ecosystem Restoration; Regulatory Compliance
David Froehlich		Water Resource Engineering; Numerical Modeling
Will Harman	Stream Mechanics	Geomorphology; Restoration Design
Ken Reckhow	Duke University; Cardno ENTRIX	Risk Assessment; Decision Making; Water Quality

Approach

A review of the existing tools available for the characterization of bedload transport dynamics will be undertaken, along with analyses of their application at selected restoration sites. The analysis may include:

- A review of the current literature and review of publically available software packages to identify and characterize the strengths and weaknesses of the approaches used to assess the sediment transport regime;
- Interviews and consultations with EEP, consultants, and academics to determine what methods have previously been used to characterize the sediment regime, and the sediment-associated problems that have been encountered at previously implemented restoration sites.

Product

The final product will be a white paper that provides assistance on the analysis of the sediment transport regime for a wide range of river systems in North Carolina, and the use of generated results in stream-restoration design. Specific components of the paper may include the following:

- i. Information that assists practitioners in determining the types of analyses that are available, the data required for their utilization, and the physical environment to which they may be effectively applied. Inherent in this component of the work will be guidelines on which approaches can be applied to gravel bed, mixed load and sand- and silt-bed channels.
- ii. Recommendations on the flow conditions for which sediment transport should be characterized.
- iii. A discussion of the nature and magnitude of uncertainty involved in the characterization of sediment transport, and guidelines regarding the implications of this uncertainty to project design. Examples of the sound use (or misuse) of sediment transport models to project design (e.g., the design of constructed riffles) will be included.
- iv. A framework for making decisions regarding the characterization of the sediment-transport regime, and the use of the generated data. Specific emphasis may be placed on assessing the risks associated with the uncertainty inherent in sediment-transport characterization. Discussion may include recommendations, perhaps in the form of a flow chart, on where sediment-transport analyses are required, and which approaches to use in a particular region given the uncertainty and risks involved.

- v. Recommendations regarding the integration of stream-channel assessment methods with the characterization of sediment transport.

The recommendations provided will focus on the need to balance cost/effort, data requirements, required training/expertise and the approach’s likely uncertainty.

Timeline

Assemble review team	Completed by May 31, 2012
Development of recommendation criteria	June 1, 2013
Finalize initial draft of white paper and submit for review	August, 2013
Revise and finalize white paper	December 31, 2013

- 3. *Recommend methods for evaluating wetland hydrology in re-establishment projects.*

Issue Description

Hydrology must be restored if a wetland is to be re-established successfully. If a site is not “wet enough,” then the restoration project will fail. Currently, there is no standard set of methods for evaluating wetland hydrology in re-establishment projects. It is also not clear whether the criteria for restoration success must be defined differently for specific combinations of wetland type, soil type and landscape position.

Potential Components to be Defined and Evaluated

- i. *Acceptable wetland hydrology for a particular wetland type.* It is assumed that wetland re-establishment projects will strive to restore a specific plant community. The hydrologic conditions (hydroperiod) needed by the plant community (i.e., depth and duration of saturation) should be known in order to assess hydrologic data that are collected on-site. It is assumed that one size or type of hydrologic condition won’t fit all plant communities.

As part of this component it is important to consider how the capillary fringe needs to be used in defining wetland hydrology. In addition, use of the technical standards for wetland hydrology and hydric soils will be reviewed for applicability to evaluate restored wetlands.

- ii. *Methods to measure wetland hydrology on-site.* Current methods include on-site measurements of water table levels, modeling of water table depths over time and estimating water budgets. Other techniques may also be available. Benefits and limitations of different methods will be evaluated.
- iii. *Methods to evaluate “normal rainfall conditions” in order to interpret short-term water table data.* Wetland hydrology can be determined easily if long-term (>5 years) records of water-table levels are available. Because collection of long-term data is expensive, shorter – term records might be used in some cases if the data include periods of normal rainfall conditions. Methods to evaluate such normal conditions will be discussed.
- iv. *Impact of soil and landscape on wetland hydrology.* A wetland re-establishment project may fail because the hydrology is “too dry” for the soil and landscape position of a site. For example, water table levels may need to be shallower in sandy soils than in clayey soils to create the necessary anaerobic conditions needed to re-establish wetland vegetation. The intent is to identify the soil and hydrologic conditions that make re-establishment difficult and probability of success low.

As part of this component the team will also consider whether soil types and landscape positions could be used in the *design process* to increase the likelihood that the hydrologic targets are met in restoration projects.

- v. *Use of GIS techniques, along with hydrologic data, to prepare maps of wetland boundaries in re-establishment sites.* Boundaries of wetlands must be determined to fully evaluate restoration sites. This can be difficult to do accurately using small amounts of point data obtained from monitoring wells. GIS techniques may help extrapolate well data across a site to delineate the boundaries of a restored wetland.

- vi. *Evaluate two conceptual tools developed by the USDA to aid in the prediction of wetland recovery: reference ecosystem models, and successional chronosequences.*

Why It's Important

The major factor that determines whether a wetland re-establishment project will be successful is the regaining of a suitable hydrology. Suitable hydrology requires, for example, that the water table be within 30 cm of the surface, or above the surface, for a sufficient period during the growing season to allow wetland plants to become dominant and wetland functions to be performed.

Wetland hydrology must occur for a minimum duration and frequency, and must meet the wetland criteria contained within the applicable Regional Supplement to the USACE 1987 Wetlands Delineation Manual – otherwise, it will not offset the permitted wetland loss.

Panel Team

Name	Affiliation	Area of Expertise
Mike Vepraskas (lead)	N.C. State University	Soil Science
Mac Haupt	Ecosystem Enhancement Program	Wetland science
Todd Tugwell	U.S. Army Corps of Engineers	Compensatory mitigation
Dave Lekson	U.S. Army Corps of Engineers	Compensatory mitigation
Wayne Skaggs	N.C. State University	Wetland hydrology modeling
Mike Burchell	N.C. State University	Wetland restoration design and construction
Steve Broome	N.C. State University	Wetland restoration
Pete Caldwell	U.S. Forest Service	Hydrology

Approach

The identified Panel Team will consider and deliberate the components identified in the issue description above and develop recommendations for those that can be readily addressed.

Product

A written report will be prepared that covers the components highlighted in the issue description provided above. The report will include specific recommendations for collecting and interpreting wetland hydrology data.

Timeline

Group meets to discuss issues, determine which components can be addressed and which cannot	March 31, 2012
Group meets again to discuss recommendations	April 30, 2012
Draft report prepared and circulated for comment	May 31, 2012
Final report prepared	June 30, 2012

D. Additional issues that will be monitored and may be taken up if necessary

Panel members have expressed an interest in providing comments on updates to the N.C. Stream Mitigation Guidelines that are anticipated to be released in the latter part of 2012. When public notice is issued and external input is sought on these updates, the panel will work together to develop comments within specified timeframes.