GUIDELINES FOR NATURAL STREAM CHANNEL DESIGN FOR PENNSYLVANIA WATERWAYS

Developed by the

Keystone Stream Team

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Prepared by the

Alliance for the Chesapeake Bay

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The Keystone Stream Team welcomes comments on these guidelines. Please submit to www.canaanvi.org/nscdguidelines. Electronic copies of this document are available by downloading from this website.

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Chapter 1
INTRODUCTION

Why Develop Guidelines for Natural Stream Channel Design?

Natural stream channel design (NSCD) is relatively new to Pennsylvania. Our understanding of what works best to restore a channel's natural stability is still evolving, particularly across a state as diverse in geography and land use as Pennsylvania. The learning curve for professionals engaged in natural stream channel design is rising as experiences are shared about how to work with, not against, a stream's natural form and function.

It is the purpose of these guidelines to provide a common process for planning, designing, and evaluating natural stream channel restoration projects. They are focused strictly on *restoration* projects -- i.e, projects that return a stream, its floodplain, and riparian area to its natural or stable dimension, pattern, and profile as well as re-establish its proper biological habitat and function. (See *Scope of Guidelines* for clarification of restoration versus stablization and enhancement projects.)

These guidelines are aimed at professionals involved in stream restoration design, construction, and permitting. Watershed organizations may also find them educational in working with these professionals. The guidelines are intended to open communication, facilitate the exchange of inter-agency information, and build consistency in natural stream channel designs. They will undoubtedly change over time to reflect both new-found successes and failures of design methods, as well as changes to permitting programs at both the state and federal levels. This document is not intended to provide a cookbook approach to natural stream channel design nor serve as a how-to manual.

The *Guidelines for Natural Stream Channel Design for Pennsylvania Waterways* were developed by the Keystone Stream Team, an informal group comprised of government and environmental resource agencies, university researchers, sportsmen, citizen-based watershed groups, and private companies. As a result of the first Natural Stream Design Summit held in February 2000, a list of challenges was developed with regard to stream restoration permitting, data management, design and implementation, problem identification, success criteria, and education. The Keystone Stream Team categorized and prioritized this list of challenges. At the top of the list was the need to develop design guidelines for professionals in natural stream channel restoration.

What is Natural Stream Channel Design?

Streams are not simply stormwater conveyances. Streams are complex ecosystems with morphological characteristics that are dependent on appropriate geomorphic dimension, pattern, and profile as well as biological and chemical integrity. Proper stream function also includes the transport of water and sediment produced by the stream's watershed in dynamic equilibrium. (*Dimension* includes a stream's width, mean depth, width/depth ratio, maximum depth, floodprone area width, and entrenchment ratio. *Pattern* refers to a stream's sinuosity, meander wavelength, belt width, meander width ratio, & radius of curvature, and *profile* includes the mean water surface slope, pool/pool spacing, pool slope, & riffle slope.)

Natural stream channel design addresses the entire stream system. It is based on fluvial geomorphology, or FGM, which is the study of a stream's interactions with the local climate, geology, topography, vegetation, and land use -- how a river carves its channel within its landscape. The underlying concept of natural stream channel design is to use a stable natural channel as a blueprint or template. This blueprint, or reference reach, will include the pattern, dimension, and profile for the stream to transport its watershed's flows and sediment as it dissipates energy through its particular geometry and in-stream structures. Project design (channel configuration, structures, nonstructural techniques, etc.) must account for the stream's ability to transport water and sediment.

Natural stream channel design also depends on the accurate identification of stream classification types. Stream type is a powerful tool to use in decision-making when combined with knowledge and field experience in natural stream channel design.

In addition to providing a stable condition, natural stream channel design promotes a biologically diverse system. Many of the structures employed "buy time" until riparian vegetation becomes established and matures. The establishment of a vegetated buffer that has long term protection is key to natural design and will provide a number of aquatic and terrestial benefits. These benefits include root-mass that stabilizes the bank, shade that buffers stream temperature, leaves that provide energy, food and shelter for wildlife, wildlife travel corridors, added roughness to the floodplain which helps to reduce stream energy, and the uptake of nutrients from the soil.

Restoration of the proper dimension will insure that the stream is connected to the floodplain so that riparian vegetation and other components that roughen the channel will mitigate damage from flood-flows. Structures used in natural stream channel design such as vanes, cross-vanes, and root-wads create and maintain pool habitat, which is often minimal in degraded channels. In other words, they maintain the dimension, pattern and profile (or slope) of the stream. Restored streams provide for sediment transport and the sorting of bed material that results in the development of habitat diversity.

All successful natural stream channel designs achieve sediment transport, habitat enhancement, and bank and channel stabilization. The degree to which projects meet these goals depends on a project's specific objectives. Ultimately, a stream considered stable or "in equilibrium" can carry the sediment load supplied by the watershed without changing its dimension (cross sectional area, width, depth, shape), pattern (sinuosity, meander pattern), or profile (longitudinal pattern and slope), and without aggrading (building up of bottom materials) or degrading (cutting down into the landscape and abandoning the natural floodplain).

What Makes a Successful Natural Stream Channel Design Project?

Professionals engaged in successful natural stream channel design:

1) Assess the stability of a stream and its ecological functions;

2) Determine the appropriate level of intervention;
3) Accommodate a range of flows in the final design;
4) Determine the most probable stable form (stream type) based on stable reference reach & valley type;
5) Validate the final design using hydraulic models for analyses;
6) Select channel stabilization techniques that incorporate natural or native materials that provide for vertical and lateral stability; and
7) Monitor to measure success of the restoration project.

Successful stream corridor restoration depends on an understanding of how water and sediment are related to channel form and function and on what processes are involved with channel evolution. This is particularly important in the context of Pennsylvania's diverse geology. What works in the lowlands of southcentral Pennsylvania may not work in the glacial till streams of northeastern Pennsylvania or in streams impacted by coal mining. There can be no "one size fits all" design package for natural stream restoration. Data from the affected site and data from reference reaches and regional curves from the same physiographic regions and stream types are critical to designing channels that will not fail under the most frequent, channel-forming storm events.

Successful projects usually involve teams that include biologists, hydrologists, and engineers who understand natural stream functions. Successful teams make the effort to evaluate reference streams in planning and designing restoration projects, and they consider multiple alternatives before deciding on the best approach for a given stream project. Most importantly, successful stream restoration requires that we all learn from past mistakes and avoid repeating them.

Furthermore, natural stream channel design must allow for the integration of "unnatural" design features (traditional hard-engineering) on sites where adjacent land uses restrict efforts to work with a new or existing floodplain. Because natural channel design places great emphasis on connecting a stream with its floodplain, design options are limited in developed areas where lateral excavation of the streambanks is restricted. For more guidance on NSCD options, see Chapter 3 *Meeting with the Watershed Community.*

Scope of Guidelines

These guidelines are intended for stream channel *restoration* work only. For purposes of this guide, "restoration" is defined as

> "*the process of converting an unstable, altered, or degraded stream corridor, including adjacent riparian zone and flood-prone areas to its natural or referenced, stable conditions considering recent and future watershed conditions. This process also includes restoring the geomorphic dimension, pattern, and profile as well as biological and chemical integrity, including transport of water and sediment produced by the stream's watershed in order to achieve dynamic equilibrium.*"

In developing this document, much discussion centered around the application of these guidelines for projects considered "small-scale" or "remedial" in nature. After considerable debate, the Keystone Stream Team concluded that these guidelines should provide direction on restoration projects (as described above), which are usually of a larger scale than those designed to offer a more limited environmental or ecological benefit. In other words, professional judgment is imperative in making the distinction between stream *restoration* projects and stream *enhancement* or stream *stabilization* projects.

For purposes of this guide, *stream enhancement* is defined as "the process of implementing certain stream rehabilitation practices in order to improve water quality and/or ecological function." These practices are typically conducted on the stream bank or in the flood prone area but may also include the placement of instream habitat structures; however, they should only be attempted on a stream reach that is not experiencing severe aggradation or erosion. Care must be taken to ensure that the placement of instream structures will not affect the overall dimension, pattern, or profile of a stable stream.

Stream stabilization is the in-place stabilization of a severely eroding streambank and stream bed. Stabilization techniques which include "soft" methods or natural materials (such as root wads, rock vanes, vegetated crib walls) may be considered part of a restoration design. However, stream stabilization techniques that consist primarily of "hard" engineering, such as concrete lined channels, rip rap, or gabions, while providing bank stabilization, will not be considered restoration or enhancement in most cases.

Some techniques provide both stabilization and enhancement. These include the placement of appropriate instream grade control structures and the establishment of appropriate stream bank vegetation.

All situations should be evaluated on a case-by-case basis using the best professional judgment available. Meetings with the watershed community as described under Chapter 3 will help answer the question of what type of project you have. Regardless of scale, it remains critical to consider a site's larger watershed conditions and to have field-verified data to support even smaller stream restoration projects. Permit conditions, as explained in Chapter 5, provide further qualifications for projects that would fall under enhancement or stabilization categories.

Specifically, these guidelines provide direction on the following topics as they apply to natural stream channel design:

- Problem Identification (watershed & stream assessment)
- Working with the Watershed Community (asking the right questions)
- Data Collection & Analysis
- Evaluation of Design Options
- Creating the Right Design
- Permitting Guidance
- Selecting a Qualified Consultant
- Construction Considerations
- Pre- and Post-Construction Monitoring

These guidelines are not an endorsement of one methodology or tool to the exclusion of others due to the fact that the design of natural channels is a developing science. However, the Keystone Stream Team recognizes the increasing usefulness of Dave Rosgen's stream classification system and design methodologies. Conversely, the group recognizes the need to address the strengths and limitations of all restoration methodologies and attempts to explain some of these observations in Chapter 4 *Data Collection & Analysis.*

Where approval has been granted, the guidelines refer users to various tools and methodologies and credits the originators of these tools. Included in this document are sets of tables, charts, and other forms that the Keystone Stream Team believes are most helpful in data collection & analysis. Use them at will. Forms can be duplicated for use in the field. See Appendix I.

It is also important to note that the guidelines suggest a sequence of steps to get from planning to implementation. However, the exact sequence may vary depending on the person or group that has initiated the project and what type of information is already available. More important than the sequence is the attempt to cover the elements presented under each step so as not to overlook something altogether.

Finally, it's important to stress that these guidelines are an evolving document and the result of collective experience by a wide variety of professionals. Content is based on what members of the Keystone Stream Team have learned about natural stream channel design in the field. It is the team's intention that these guidelines will serve to save practioners time and money by avoiding mistakes in design and implementation. The content of the guidelines will change as more is learned through field experiences.

Chapter 2
ASSESSMENT – "READING THE RIVER"

Two questions are critical to determining what approach to take in design. First, is the stream's condition a reflection of a locally unstable situation or of a larger, watershed-wide problem? Secondly, how far from a "stable" form is the reach of stream you're proposing to remedy?

In order to answer these questions, it's important to properly "read the river" in its current state. This involves assessing the big picture (watershed assessment) as well as the local project area. Before attempting a solution, you must thoroughly identify and understand all causes of the observed problems.

Streams tend to evolve toward a state of equilibrium with their current flow characteristics. We usually choose to intervene for a variety of reasons. To determine the degree of intervention, it's important to know the evolution of the stream -- at what stage is a particular stream or river in relation to its potential end-point of equilibrium? Designs must be compatible with the stream's natural tendency to evolve into a particular morphological form. In other words, you should begin by asking the question, "What stream type should this be?"

Channel evolution models and stream classification systems can help predict future upstream or downstream changes in habitat and stream morphology. Based on morphological parameters, stream classification systems include:

- Schumm's (relates straight, meandering and braided channels to sediment load)
- Montgomery & Buffington's (relates six classes of alluvial channels to sediment & bed load); and
- Rosgen's (defines eight major stream classes with about 100 individual stream types using 6 morphological measurements).

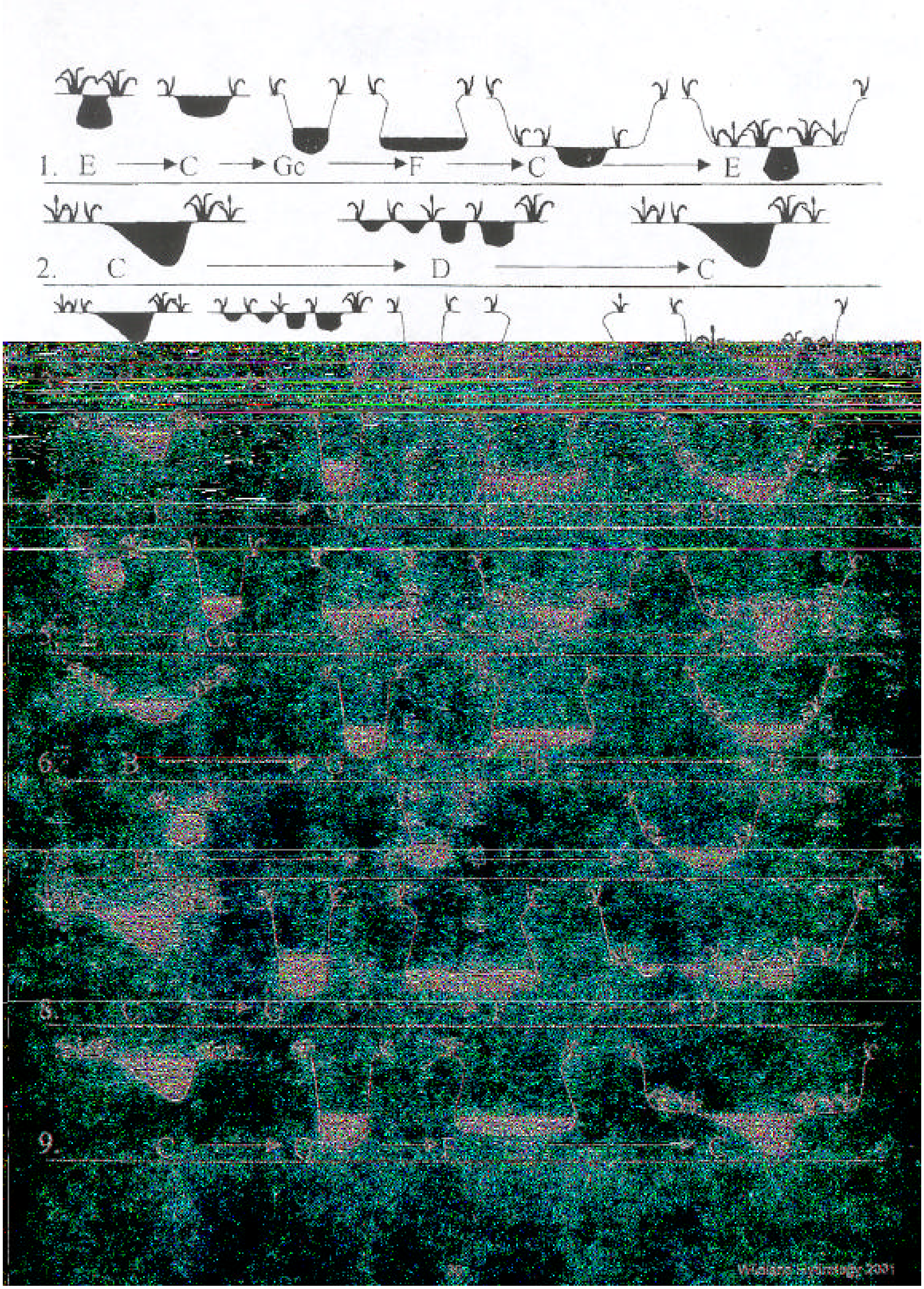
Channel evolution models are based on adjustment processes and include Rosgen's evolution scenarios (see next page) and Simon's channel evolution stages.

At the heart of each sequence in Dave Rosgen's scenario is the stream type -- when morphological changes exceed a "geomorphic threshold," stream types change and there are new quantitative values of dimension, pattern, and profile.

The only way to be certain of a stream's evolutionary stage is to quantitatively assess the degree to which the stream's existing conditions differ from its full range of operating potential. Assessment work includes comparing data for existing stream conditions to that of a similar stream type, comparing data for the same stream reach at different points in time, or comparing river conditions at different points in space.

Designs must also consider man-made watershed influences, such as upstream storm water management, agricultural activity, urban development, coal mining, road and bridge construction, and forest harvesting. Think big picture. Does your project consider

Various Stream Type Evolution Scenarios



these impacts or can your ideas fit into a larger watershed vision being developed for your area?

Another critical element of stream detective work is to think through monitoring needs early in the planning process. A monitoring plan should include pre-construction and post-construction monitoring to show success in meeting project objectives. Since funding for monitoring is often overlooked or not permitted in many government-funded projects, consider ways to use volunteer monitoring programs to measure long term success. See Chapter 9 on monitoring components. Some permitted activities require monitoring components, so it's important to comply with permit conditions.

In summary, "reading the river" involves four phases of assessment:

1) Watershed assessment (the big picture);
2) Preliminary site assessment (project area);
3) Data collection & analysis at project site (stream reaches); and
4) Monitoring for success

Watershed Assessment

Any assessment of current stream conditions should include a watershed characterization since watershed characteristics affect the volume, timing, and routing of water and sediments from upland areas into a stream and along the stream to its outlet. This evaluation includes looking at historical, landscape changes that affect the magnitude and duration of peak and base flows and the yield and character of sediments from bank and bed erosion, roads and construction sites, and surface runoff. The hydrologic response of the watershed to various rainfall amounts is important in determining the appropriate size and shape of the stream channel and floodplain.

You may not always have the dollars to collect information on all watershed characteristics. Consider the usefulness of information for your particular project's mission and goals. Don't overlook tasks that could be done by watershed association members and other community volunteers.

An example of a well-done watershed assessment is the Quittapahilla Creek watershed in Lebanon County. Contact: Rocky Powell of Clear Creeks Consulting, Jarrettsville, MD; 410-692-2164; email: rockypowell@msn.com.

■ Collect **historical, background information** to establish baseline conditions.

Historical/Background Information		
Type of Information	**Information to Look For**	**Where to Find It**
General watershed & stream/river information	watershed size, drainage area	
	classification of stream types based on valley types and land forms	Simplified stream assessments can be used to help prioritize stream problems. See Appendix II for resource information.
Hydrology	stream flow data	USGS stream gages www.pa.water.usgs.gov/pa_hydro.html For location of gages in watershed or for nearby watersheds and later 9-207 data (packet of flow information not available on the web but upon request) which is used for design and when comparing gages
	flood history	residential - anecdotal information can help establish or confirm bankfull; US Geological Survey, Federal Emergency Management Association, PA Emergency Management Association
	stormwater management plans	Stormwater Management Act (Act 167) - county, conservation district, DEP, municipality
Historical information (location/condition/pattern)	historical photos, aerial photos	PA Historical and Museum Commission (PHMC) www.phmc.state.pa.us landowners, sportsmen groups, county, PA DEP, USGS, USDA Farm Service Agency
	past projects (relocations, channelizations, flood protection - successes & failures)	
Geological Information	physiographic region (changes in rock structure)	USGS maps www.dcnr.state.pa.us/topogeo/indexbig.htm
	soils information	soil survey -- identify hydrologic groups, erodibility potential; county conservation district office
Biological Information	fishery management survey reports	PA Fish & Boat Commission www.fish.state.pa.us
Water Quality Information	water quality network stations	PA DEP Susquehanna River Basin Commission - www.srbc.net

	Citizens' Volunteer Monitoring Program	Bureau of Watershed Management, DEP (717) 772-5807 www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/cvmp.htm
	local Total Maximum Daily Load data	PA DEP www.dep.state.pa.us/watermanagement_apps/tmdl/
	USGS Water Quality Data Warehouse	www.water.usgs.gov/nawqa/data
Land use and land cover	land use maps	county or regional plans, DEP
	identify areas that have influence on discharge, sediment regimes, channel stability, or overall water quality	
	DEP policy considering land use plans and zoning ordinances in issuing DEP permits	(General Information Forms include land use information as it relates to proposed projects permitted by DEP) www.dep.state.pa.us
Geographic Information Systems/ Watershed Assessment Information	Environmental Resources Research Institute (Penn State University)	www.environment.erri.psu.edu
	County Conservation Districts	
	PA Spatial Data Access (PASDA)	www.pasda.psu.edu/
	County planning departments	

Key Watershed Contacts	
DEP Watershed Managers	Regional DEP Offices
County Watershed Specialists	County Conservation District Offices
Erosion & Sediment Pollution Control Technicians	County Conservation District Offices
Local watershed organizations/ Sportsman Clubs	
DEP Watershed Notebooks	www.dep.state.pa.us
EPA Surf Your Watershed	www.epa.gov/surf
Fish and Boat Commission	www.fish.state.pa.us
Susquehanna River Basin Commission	www.srbc.net
Interstate Commission for the Potomac River Basin	www.potomacriver.org
Delaware River Basin Commission	www.drbc.net
Chesapeake Bay Program - Watershed Profiles	www.chesapeakebay.net

- Collect most **current** watershed information, planning information, and technical data from sources such as:

Watershed management plans - river conservation plans - watershed management plans funded by the state
Fish & Boat Commission Division of Fisheries Management and Division of Environmental Services (Pleasant Gap)
DEP water quality network stations
River Network's Clean Water Projects (www.rivernetwork.org/library/librivcwastate.intro.cfm) - includes state contacts for water quality standards, NPDES permits, TMDLs, and designated uses)
Greenway plans
Regional curve data to provide bankfulls and channel dimensions (for gage sites only; cross-sections will most likely be upstream of OR downstream of gage) See Appendix II for USGS report information.
Chapter 93 classification (www.dep.state.pa.us/dep/deputate/watermgt/Wqp/WQStandards/wqstandards)
Land use projections for the future (contact county or municipality)
FEMA flood map (if available) (contact municipality)
PA Natural Diversity Inventory (www.dcnr.state.pa.us/forestry/pndi/pndiweb.htm)
PA Scenic River status www.dcnr.state.pa.us/rivers
National Scenic River status (National Park Service) www.nps.gov/rivers/
TMDLs (www.dep.state.pa.us/watermanagement_apps/tmdl/)
303(d) listing (Assessed Waters program) (www.dep.state.pa.us/dep/deputate/watermgt/Wqp/WQStandards/wqstandards)
Current photos

Preliminary Site Assessment

A preliminary analysis of the proposed project area will help guide discussions over specific information that will be needed to design a project that fits within a particular watershed. This preliminary analysis is more qualitative than quantitative and relies heavily on visual assessment work and professional judgment. It's an important step to take, however, in identifying a stream's problems, and its results will be beneficial when meeting with the area's stakeholders to discuss the proposed restoration effort.

A preliminary site assessment should include the following evaluation:

1) Identify stream reaches within your project area. Reach breaks occur where stream changes dramatically -- e.g., below a bridge, through a farm pasture, upstream or downstream of dam (or recent removal of dam), through changes in valley type and slope.

2) Take photos of key stream reaches that show signs of degradation.

3) Conduct physical & habitat assessments of identified stream reaches.

Make sure multi-disciplinary people are involved in data collection. To ensure consistency in assessment work, walk the site with assessors with data collection forms in hand. Review parameters for healthy stream conditions in your project area. This team approach helps eliminate individual interpretations of a stream's conditions. Where there exists a local watershed organization, consider employing its assistance in conducting this preliminary site assessment.

Methodologies: Select a commonly accepted methodology for the physical and biological condition of your project area. Methodologies include the following and forms can be found in Appendix I or where referenced:

- **Simplified stream assessment form** (bank stability, channel stability, riparian vegetation, and aquatic habitat). This form was used by Skelly & Loy, Inc. in Codorus Creek watershed to prioritize problems.
- **Stream Visual Assessment Protocol**, USDA/NRCS, 1998
  An easy-to-use assessment protocol to evaluate the condition of aquatic ecosystems associated with streams; does not require expertise in aquatic biology or extensive training; least-impacted reference sites are used to provide a standard of comparison; states may modify the protocol based on a system of stream classification and a series of reference sites.
  www.nhq.nrcs.usda.gov/BCS/aqua/svapfnl.pdf
- **Stream Classification Worksheet** - example of stream classification worksheet used with Rosgen methods (*Stream Corridor Restoration: Principles, Processes, and Practices, page 7-33; 1998)*
  www.usda.gov/stream_restoration
- **USDA Stream Corridor & Inventory Assessment Techniques** - A guide to site, project and landscape approaches suitable for local conservation programs *(Technical Report, January 2001, revised)* -
  www.wcc.nrcs.usda.gov/watershed/products.html

Based on an analysis of both watershed and site-specific information, begin to analyze the causes of impairment and draft a conceptual design of your restoration project. Special consideration should be given to managing causes as opposed to treating symptoms, as well as determining whether a passive, nonstructural alternative is appropriate or whether a more active restoration alternative is needed. Identify any gaps in information that may be critical to justifying a thorough evaluation of the stream's impairment.

Chapter 3
MEETING WITH THE WATERSHED COMMUNITY____________

Prior to developing a final design and submitting a permit application for a natural stream design project, it's important to involve all interested parties and persons who have a stake in the outcome of your proposed restoration. Two opportunities are suggested: 1) a Watershed Community Meeting, and 2) a Pre-application Meeting (before permit application -- see Chapter 5).

These early meetings will help build inter-disciplinary support for your project and broaden the knowledge base for applying FGM principles to stream restoration designs. Hold these meetings as early as possible in the planning process to allow for ample time to air all concerns and evaluate all the options.

Watershed Community Meeting

Invite all interested parties and members of the community to a stakeholder meeting to discuss issues and problems and introduce your ideas for a stream restoration project. If a watershed organization is involved, hold this early planning meeting before a preliminary site assessment is done to ensure broader participation in this assessment phase. Professionals engaged in stream restoration work can serve as your technical team in providing advice on data collection and design ideas.

<u>Some points to consider when organizing and meeting with your watershed community</u>:

- Include county, state and federal agency representatives; local watershed/sportsmen's group representatives; and interested landowners to hear different perspectives on need and degree of intervention.
- Confirm DEP representation at the table to help clarify any permitting questions. A subsequent pre-application meeting will serve to resolve detailed permitting issues (see Chapter 5).
- Discuss causes of stream failure and conceptual solutions. Include explanation of different philosophies or approaches to stream correction/restoration/remediation and how they relate to the goals of the watershed community. Be prepared to answer questions by bringing to the table basic stream data as outlined above under *Watershed and Preliminary Site Assessment* work.
- Use historical and current watershed information to support your ideas for a conceptual plan.
- Meet in the field, if possible, to see problems first hand.
- Involve conservation district watershed specialists and erosion and sediment technicians in the planning of any public meetings.

Points to Address at the Community Watershed Meeting

- What are the **causes of the observed problems**? Are there relationships between channel stability and watershed changes?

- How does your project support the **overall vision for watershed health**? Is the project **compatible with concurrent or planned activities** within the watershed? Can priorities be established? Is there a sequence of interventions that make sense?

- **What are the options**? The selection of a preferred restoration approach requires consideration on a site by site basis. Openly discuss all options, including bioengineering, fluvial geomorphic, and traditional hard-engineering methods. It may be necessary to integrate geomorphology, engineering, biology and botany into the restoration solution. Many stream stabilization measures not only support natural stream geometry objectives but also provide adequate habitat objectives.

  Natural stream restoration can vary from a relatively simple approach (remove the prior interventions/alterations as feasible and allow the site to restore naturally) to highly complex and structural solutions. It's important to consider regional and local restoration goals, land use conditions and constraints affecting the site, cost considerations, and natural site evolution.

  The goal of natural stream channel design is to develop a resilient system, adapted to a range of flows. Both "active" and "passive" approaches can achieve this. Passive approaches may involve simply allowing natural erosion and sedimentation processes to gradually restore geomorphic form and function or undoing prior interventions, such as removing a river levee to allow site inundation during large floods. More active site intervention might involve major earthwork to regrade a channel and floodplain, recreate geomorphic features, create habitat structures, and revegetate riparian areas.

  For example, gravel removal in streambeds changes the slope of a stream. As the stream re-adjusts, erosion of the stream bottom takes place, a process known as head-cutting. Head cuts are incisions or forms of channel degradation that migrate upstream for potentially great distances, until the slope created by the gravel removal activity hits a natural hard point such as a rock outcrop or bedrock or until the slope of the head cut matches the valley slope. The simple act of removing gravel from a streambed can affect miles of stream and produce tons of excess sediment that gets deposited downstream.

  It must be decided whether time exists to wait for the channel to adjust on its own. During that time, direct economic effects may occur, such as property loss, increased flooding, and reduced water quality, fisheries, aesthetics, and property values. Streams may heal in one area while adjustments are transferred in an upstream or downstream direction, and those adjustments may take a lifetime to complete.

Channel evolution scenarios can also be helpful in deciding whether to target a site for restoration or leave it to heal on its own. As a stream evolves from one form to the next, the stream channel pattern, dimension, and plan form within the landscape is continually changing. Each change produces sediment that is transported downstream or head cuts that migrate upstream. Some channel evolutions toward a stable state may take less time and minimally affect the stream so natural healing may be the preferential restoration decision. (For instance, a B3 stream is less sensitive to human disturbance and should recover on its own if a disturbance is removed.) Those that cause the most damage for the longest period should be targeted for stabilization and restoration measures.

Factors that usually prompt a more active or intrusive level of intervention include:

1) The system is unstable (stream channel may be actively incising and will do so for the foreseeable future);
2) Desire to accelerate the time frame of recovery;
3) Multiple (and perhaps contradictory) site objectives;
4) Inability to sufficiently alter the prior interventions (for example, watershed hydrology or sediment regime have been so changed that passive restoration processes will not achieve the project goals);
5) The site may evolve along a different trajectory than that desired without intervention;
6) The consequences or risks to infrastructure on or near the site resulting from the uncertainty of non-managed restoration are unacceptable; and
7) The desire for priority species habitat may provide an ecological basis for the site design/construction which differs from the historical site conditions.

For incised streams (vertically contained streams that have generally abandoned their floodplains - typical of stream types A,G, and F), Dave Rosgen has developed a priority system that considers a range of options based on numerous factors. Priorities 1 and 2 use methods that reconnect incised channels with either previous or existing floodplains. Priority 3 kicks in where streams are laterally contained and physical constraints limit the use of Priority 1 and 2 techniques. This level converts a stream to a new stream type without an active floodplain, but containing a floodprone area. Priority 4 acknowledges that stabilization is the only approach that can be taken given site constraints, such as adjacent roads, homes and historic features. See Appendix II for the citation of an article explaining the four priority approach.

- Consider the **ecological and economic benefits** of the project, as well as all costs associated with different solutions. Determination of costs and benefits can be useful in permitting and in justifying temporary environmental impacts, such as erosion and sedimentation. Weigh any immediate or short-term cost benefits against long-term benefits and maintenance costs. Consider the longevity of design methods being evaluated.

- What is the cost/benefit ratio?
- What kinds of risks are associated with each alternative? What are the environmental impacts of each alternative? Are the net environmental impacts of the project positive?

  It's important to stress that construction of NSCD projects often necessitates work in the stream channel that results in temporary sediment disturbances. This temporary turbidity must be weighed against permanent, long term improvements to the stream which, without NSCD controls, could add tons of sediment to the stream system due to repeated bank failure and the destruction of an existing riparian area adjacent to the project site.

- What are the long-term maintenance requirements?

➢ **Emphasize the FGM approach to natural stream design as it relates to data collection & analysis**. Discuss the scale of intervention and the degree of data collection needed for FGM-based projects. Restoring streams to their "natural" condition requires the collection of data that provides for design dimension, so intensive data collection is critical to designing a project that will succeed.
  - What types of data are needed to support the objectives of the project?
  - What data exists to support your project and gaps exist?
  - What types of monitoring data should be collected?

➢ What **site constraints** exist? Consider restrictions imposed by easements, sanitary sewer lines, gas lines, right-of-ways, railroads, large trees, overhead utility lines, storm drain outfalls, unwilling landowners access, and existing concrete channels. (See section above under *What are the Options?* for more on working with site constraints for incised channels.)

➢ Identify **permit requirements** and seek permit guidance.

➢ **Is the project compatible** with existing agency policies and/or other jurisdictional regulations?
  - Does the project significantly reduce the risk to the public health and safety and/or fish and wildlife resources?
  - Is this an emergency stabilization project? For emergency projects, encourage NSCD alternatives to hard engineering stabilization; encourage search of data if it exists.
  - Are there maintenance issues with flood control projects (reduction of sediment transport)? Incorporate bankfull channel to minimize maintenance needs.

➢ Will the project be **technically feasible**?

- ➢ What contingencies can be developed for **safety measures** if future land use changes? Write this into the assessment and make local officials part of the process.

Define and Communicate your Project's Objectives

Based on the results of this early planning meeting, summarize your findings and determine the strongest conceptual approach. Include the following in written form and circulate to those who were in attendance and to any stakeholders who may have an interest in the project.

- ☑ Summary of findings.
- ☑ Definition of priorities.
- ☑ Clear description of your project's objectives and scope of work, including the approach to data collection & analysis and plans to evaluate all proposed alternatives.
- ☑ Identification of partners and stakeholders involved in project.
- ☑ Note that there will be a second meeting before applying for a permit to allow for final stakeholder input. (See section on pre-application meeting - Chapter 5).
- ☑ Request for feedback to your report within ten days.

Chapter 4
DATA COLLECTION & ANALYSIS

The intent of the FGM-based approach is to design stream channels that will maintain themselves. The only way to arrive at a sound design is to quantitatively evaluate the principal morphological features of a stream type and valley type nearby that is natural or stable (the reference reach) and restore the natural combination of dimension and form -- slope, width, meander, etc. -- to the impaired channel.

Reference reaches should be located within your project's watershed; however, if not possible, select a site in a neighboring watershed that's within the same hydro-physiographic region, has the same general land use as your project area, and has the same stream type and valley form as the proposed stream. The reference reach characterizes the stable morphology but does not necessarily require a "pristine" reach; procedures exist to verify the stability of the reference reach and aerial photographs can be used to provide additional evidence of stability over time. Reference reaches should have at least two full meander wavelengths or 20 widths of length of consistency for measurements.

Collecting the information to make this comparative evaluation requires a system of checks and balances that is integral to natural stream channel design. It's critical to cross-verify data that is collected at the study site and at reference sites with information from gage stations, regional curves, and published reports. Multiple data sources help to justify your final project design.

The following guidelines for data collection will assist with permit approval from the Department of Environmental Protection. These parameters focus on physical restoration of the stream channel, which will lead to habitat improvements and some chemical improvements. Specific habitat objectives must assimilate other tools in data collection and monitoring.

It is important to avoid applying book values to your specific project. Every site is unique, which is why communication between professionals is critical to reaching an understanding on what depth of data analysis is required. Data collection can be time consuming -- don't take shortcuts. Complex projects need to use advanced surveying techniques including total station survey and aerial digital mapping.

Increasingly, designers are embracing Rosgen's methodology to natural stream channel design (often referred to as his "40-step process"). While this process is not intended to be a cookbook for restoration designs, it does a good job of presenting a sequence of steps that provide for the calculation of design specifications. Calculations are based on proposed stream types, verified using reference reach data, regional curve data, gaging station data, and empirical formulas, and checked against the limitations of Rosgen's stream classification values. The system presents checks and balances for just about every calculation, and model calculations are verified using field data. Designers are encouraged to apply this methodology in the collection and analysis of stream data, but only with adequate training on how to properly use this methodology.

Designs in natural channel restoration encompass three different approaches: 1) "analog" meaning reference or template, 2) "empirical" meaning a reliance on equations derived from universal data sets, and 3) "analytical" which involves using hydraulic models and sediment transport functions to determine equilibrium conditions.

Each of these approaches has strengths and weaknesses, as well as limited applications. In practice, designers usually employ elements of each of these approaches in channel design. Because NSCD is still evolving, it's important to discuss observed limitations and embrace the value of each.

To assist with data collection, Rosgen has developed procedures for collecting data from surveying reaches. Appendix II includes *Field Survey Procedures for Characterization of River Morphology* (Dave Rosgen 1996), which illustrates a process for characterizing the dimension, pattern, and profile of selected stream types. In addition to this tool, Rosgen has also developed a *Procedure for Development and Application of Dimensionless Hydraulic Geometry*. This procedure assists in restoration design by helping to define the shape of the channel based on various stages of flow.

If using alternative methodologies to design, be aware of their limitations in providing for sediment transport and base or low-flow conditions and adjust accordingly. Many "traditionally-designed" channels attempt to put all the flows into a common width in order to handle high flows; they are constructed "over-width" which leads to sediment deposition and bar formation. The width-depth ratio is missing which will provide for in-stream habitat and sediment transport.

Recommendations for Data Collection

Whatever methodology applied, data collection should include the following sets of information. The number of cross-sections needed will depend on the length of reach, stream types, and degree of riffles, pools, and meanders of the surveyed reaches. See Appendix I for data collection worksheets.

Project site information:

1) Identify bankfull cross-sectional areas by visual assessment and measurement of indicators (break in slope on bank, change in vegetation, scour line or stain marking on abutments or rocks, small bench on streambank, or top of point bar or mid-channel bars for entrenched streams; if not entrenched, bankfull is near or at top of the bank.). You should avoid relying on only one indicator -- use a combination of all these indicators and remember that bankfull is often underestimated. Take the opportunity to conduct your assessment of the stream in collaboration with other professionals to expand the understanding and application of bankfull determinations.

   In extremely unstable streams, it may be impossible to identify bankfull by visual indicators. An assessment may have to determine what should be there vs. what is there, including the application of regional curve information.

Reference: *North Carolina River Course Fact Sheet Number 3-- see Finding and Verifying Bankfull Stage in the Field.* *www5.bae.ncsu.edu/programs/extension/wqg/sri/factsheets.htm*

2) Collect data for the dimension, pattern, profile, and bed materials as outlined in the Morph Chart (Appendix I).
3) Determine stream type based on above information.
4) Fulfill other data requirements as dictated by applicable permit.

Reference reach information: Sufficient cross-sections need to be surveyed to provide a range of pool and riffle characteristics.

1) Collect data for the reference reach dimension, pattern, profile, and bed materials as outlined in the Morph Chart (Appendix I).
2) Determine stream type based on above information. Articulate what the stream condition should be in impacted area.
3) Convert the morphological measurements into dimensionless ratios by dividing the dimension, pattern, and profile variables by the bankfull values of the same feature. The purpose of the dimensionless ratios is to convert design values to scale for the project area. Ratios are used to calculate actual design measurements for width, depth, meander length, radius of curvature, pool depth, pool slope, cross-sectional area of riffles and pools, riffle slope, maximum riffle depth and many other channel properties. As many as 19 ratios can be computed from the parameters measured or computed using the table of morphological characteristics in Appendix I.

Gage site information:

1) Validate your field observations for bankfull discharge by calibrating your findings against known stream flow data, if available. Perform USGS gage calibration procedure. If a gaged site is not located within your site's watershed, locate several gages representative of your project site in nearby watersheds within the same hydro-physiographic region.

   Field data is collected at the gage site, including bankfull width, depth, cross-section, entrenchment ratio, channel gradient, sinuosity, and the particle size distribution of the bed and bank material. Use the same worksheet as used for project site and reference reach information.
2) Classify the stream type at the streamgage location.

Regional curve information:

Regional curves show the relationship between drainage area and discharge and channel characteristics. The primary purpose for developing regional curves is to aid in identifying bankfull stage and dimension in ungaged watersheds and to help estimate the bankfull dimension and discharge for natural stream channel designs.

In ungaged watersheds, regional curves and regression equations developed at USGS gaging stations can be used to validate field observations of bankfull discharge. These curves are also used to assist in bankfull determinations in highly unstable systems where field evidence of bankfull is extremely difficult to detect (particularly in the case of incised streams). It's critical that you use only those regional curves developed for the same ecoregion (same soils, rainfall patterns, runoff patterns, etc.).

Pennsylvania is in the early stages of developing new regional hydrology curves for the state's physiographic regions. Presently, USGS has completed one new regional curve for the Piedmont Lowlands (see Appendix II for contact information). Over the next three years, USGS will develop curves for the Piedmont Uplands and proceed across the state. These regional curves are being developed for rural areas only (less than 20% urbanization). In using these regional curves, the following criteria should be followed:

- only apply them to watersheds with similar runoff characteristics;
- don't use them where stream flow is regulated by more than 20 percent (i.e., dams);
- there should be at least ten years of records at a gage site; and
- if site has been discontinued, make sure it's no older than 1985.

Use of hydrology models, such as TR-20 and PSU-4, can be used to estimate flows; however, they must be calibrated to bankfull. Exercise caution in using runoff models and use field-collected data. Experience shows that accurate field observations of channel characteristics are required to accurately calibrate and corroborate modeling output.

<u>Data collection worksheet(s) --</u> see Appendix I:

- *Morph Chart* (Rosgen 1996).
- *Field Survey Procedures for Characterization of River Morphology by Dave Rosgen* (9/96)
- *Stream Classification Worksheet* - page 7-33 of *Stream Corridor Restoration: Principles, Processes, and Practices* (1998); www.usda.gov/stream_restoration

<u>Data collection and analysis references</u> – see Appendix II

- *The Reference Reach Field Book* (Wildland Hydrology 1998)
- *The River Field Book* (Western Hydrology)
- *Procedure for Development and Application of Dimensionless Hydraulic Geometry* (Dave Rosgen, Wildland Hydrology)
- *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*, USDA Forest Service, General Technical Report RM-245

Bankfull and its Role in Stream Classification

Regardless of project size and scope, the linchpin of natural stream channel design is the bankfull discharge of the watershed. Bankfull discharge is the stream flow at which channel maintenance is most effective -- the flow generally doing the work that results in the average morphological characteristics of channels. Bankfull discharge has also been defined as the discharge that fills a stable alluvial channel to the elevation of the active floodplain. Bankfull discharge corresponds to a discharge with a recurrence interval between 1 and 2 years.

Bankfull discharge is key to stream classification. From bankfull, one can then determine stream type, which can then be used to characterize stream channel cross sections, profile, and plan geometry. Over the past 100 years, there have been about twenty published stream classification systems, including those designed by Schumm, Montgomery & Buffington, and Rosgen.

Because Rosgen's classification system uses quantitative measurements to predict how a river or stream will respond to certain variables, its usefulness continues to gain acceptance among professionals working to restore the biological function and stability of degraded streams. In Pennsylvania, it is the preferred method of stream classification and its application is encouraged through stream restoration projects funded by the Commonwealth.

Bankfull stage is the basis for measuring the cross-sectional area, width/depth ratio and entrenchment ratio, the most important delineative criteria. Therefore, it is critical to correctly identify bankfull stage when classifying streams and designing stream restoration measures.

The Keystone Stream Team advises caution in identifying and veryifying bankfull. There is no substitute for field identification of bankfull with a USGS regional curve (the Dunne & Leopold 1978 curve if no other is available). It's important to learn the value and limitations of other tools (e.g., rating curves, frequency distribution plots, & database calculations). Also, do not ignore the effect of vegetation on a stream's hydrology. Studies have shown that for similar soils, drainage areas, and channel grades, the width of a channel can vary significantly depending whether it is located in grassland or forest. See related article citations in Appendix II.

Preliminary Conceptual Design

The collected data will help you most accurately evaluate your design alternatives and answer questions raised at earlier planning meetings with the watershed community. This detailed data will be used to justify the environmental impact of the activity, as well as the associated economic costs (funding). The problems have been qualified and quantified, and the solutions have been evaluated in terms of economic and environmental benefits.

Using the reference reaches as a template, regime data from regional sources, and hydraulic modeling, develop a preliminary design for the cross-section, planform, and profile of the project reaches. This preliminary design will be short of actual design but provide sufficient detail in order for everyone to understand the project. It's also a good idea to share preliminary work plans with local planning, zoning, or building authorities to learn of any local ordinances or applicable state and federal requirements.

At this point, all permitting issues need to be addressed. The next step is to meet with representatives of the permitting authorities.

Chapter 5
PERMITTING

Pre-Application Meetings

Prior to developing a final design and submitting a permit application, a pre-application meeting should be held to review a preliminary or conceptual design -- its costs, impacts, management, etc. Hold the meeting in the field to see the problems first-hand.
Data collected and analyzed up to this point will help answer questions and justify your design approach. Pre-application meetings can go a long way toward speeding up the permitting and approval process. They can also help build interdisciplinary support for the project and broaden the knowledge base for applying FGM principles to stream restoration designs.

Send your proposal, plan outline, and sketch of plan to a pre-application team, which should include the Department of Environmental Protection's Regional Soils & Waterways Section, the Army Corps of Engineers, Fish & Wildlife Service, PA Fish & Boat Commission, and county conservation district. It may also be beneficial to invite the county watershed specialist, DEP regional watershed manager, Pennsylvania Historical & Museum Commission, Pennsylvania Natural Diversity Index, and the Natural Resources Conservation Service (if they are involved). This meeting will be an opportunity to resolve any questions or requirements related to permits or any approvals required by the local zoning or planning commissions.

At this time, also discuss the role of the pre-construction meeting -- who should attend and whether a pre-construction conference should be a condition of the permit.

Record all comments during the field visit and provide a written summary to all participants after the meeting for their review and concurrence. Share this feedback with all project sponsors.

The following guidelines provide general advice on the types of permits that apply to natural stream channel designs. All stream restoration projects require federal authorization whether issued through a Pennsylvania State Programmatic General Permit (PASPGP-2, based on a PA-DEP 105 Permit), Nationwide Permit 27, or Department of the Army Individual Permit.

State Permits: Phased Watershed Permitting

At the time of publishing this document, the PA Department of Environmental Protection is in the process of advertising for public comment permit guidelines for phased watershed projects. Following public comment and revisions, the Department anticipates that these permit guidelines will become effective July 2002. See Appendix IV for a complete copy of the draft guidelines.

Federal Permits

Projects that involve the discharge of dredged or fill material (33 CFR 323) into areas subject to Federal jurisdiction (wetlands or below the ordinary high water mark (OHWM) of a stream) will require Federal authorization. Federal authorization can be issued by the following permits:

Note: Be advised that Federal authorizations are not valid until the Commonwealth issues or waives the 401 WQC.

A.) Pennsylvania State Programmatic General Permit 2 (PASPGP-2):

- Can be utilized for impacts up to 1 acre.
- A project less than 250 linear feet does not require notification to USACE (provided that there are no Section 106 or Section 9 concerns). In these cases, PADEP can attach PASPGP-2 to the State's authorization.
- Projects over 250 linear feet are reported to the Corps. After reviewing the project and determining that the project meets the terms and conditions of the PASPGP-2, USACE either notifies PADEP that issuance of PASPGP-2 is appropriate or the USACE can issue PASPGP-2 directly from their office (this generally occurs when the DEP permit has already been issued.)
- For complete terms, conditions and project applicability visit http://www.nab.usace.army.mil/Regulatory/Permit/PASPGP-2.pdf

B.) Nationwide Permit 27 (NP27) – Stream and Wetland Restoration Activities:

- Covers activities in waters of the United States associated with the restoration of former waters, the enhancement of degraded tidal and non-tidal wetlands and riparian areas, the creation of tidal and non-tidal wetlands and riparian areas, and the restoration and enhancement of non-tidal streams and non-tidal open water areas. See 33 CFR 320-330 for complete listing of Nationwide Permits and General Conditions.
- Utilized for projects with limited public involvement
- No impact acreage limitation
- Requires Corps notification as per General Condition 13.
- Project must comply with Pennsylvania Regional Conditions; See http://www.nab.usace.army.mil/Regulatory/Permit/PASPGP-2.pdf for Regional Conditions applicable to NP 27.

C.) Department of the Army Individual Permit (IP):

- Issued for activities with greater than 1 acre of impact or in special circumstances
- Public Notice issued with 15/30 day comment period
- Public Notice issued to resource agencies (PAFBC, PAGC, NMFS, PHMC, EPA and USFWS), adjacent property owners, municipalities, post offices, newspapers, and other interest groups
- Review not usually less than 60 days
- Alternative analysis required for impacts to special aquatic site (40 CFR 230 Subpart E)

The Keystone Stream Team offers the following additional guidance in issues related to ensuring a good project:

- If federal assistance is provided, the federal agency must comply with:
  - National Environmental Policy Act
  - Clean Water Act (Section 401, 402, 404)
  - Endangered Species Act
  - Rivers and Harbors Act of 1899 (Section 10)
  - executive orders for floodplain management and wetland protection
- Any work in floodplains delineated for the National Flood Insurance Program might require participating communities to adhere to local ordinances and obtain special permits.
- Remember to notify PA's One-Call System to identify underground utility lines. Call three days before you dig (1-800-242-1776).
- Remember to run search with PNDI to determine if site is home to any protected plant or animal species.
- Check with the State Historical Preservation office (Section 106 of Historical Preservation Act) for known preservation sites.
- It is the ultimate responsibility of the permitting agency to decide who must sign-off on design plans. Be aware that projects involving public health or safety issues may require that registered engineers and/or geologists sign-off if work involves engineering and geological calculations. This guidance document encourages professional peer reviews of design plans. It's important to involve those professionals who are trained and experienced in FGM design work.

Chapter 6
CREATING THE FINAL DESIGN

Cross-Checking Designs

Whether applying Rosgen's methodology or other design approaches, it's critical that your final design is checked against traditional equations and analyses (refer to *the River Field Book*). The table below indicates how different types of analyses are needed, depending on the boundary characteristics, hydraulics, and the destabilizing problem. Field data verification provides final design dimensions for bankfull channel widths, depths, width/depth ratios, and other hydraulic geometry patterns, as well as sediment transport capability for the stream types being constructed.

Checklist of Procedures for Solving Bed-Material Transport Problems

	Analysis Procedure			
	Tractive Stress [1]	Comparative Hydraulics [2]	Bed Material Formulas	Field Evaluation
<u>Problem characteristics</u>				
Erodibility of bed	x			x
Erodibility of bed and banks	x			x
Erodibility of banks	x			x
Channel aggradation		x	x	
Volume of bed material			x	x
Effects of channel change		x	x	x
<u>Channel boundary characteristics</u>				
Cohesive soils	x			x
Cohesive soils or rock with intermittent deposits of sand or gravel	x			x
Sand ≤1.0 mm	x	x	x	x
Sand ≤1.0 mm with <10 % gravel	x	x	x	x
Gravel, gravel mixed with sand	x		[3]	x
Gravel and boulders	x		[3]	x
<u>Hydraulic characteristics</u>				
In problem reach:				
Steady state or slowly changing	x	x	x	x
Rapidly changing	x	x		x
Cross section-slope upstream vs problem reach:				
About the same	x	x	x	x
Steeper slope	x	x	x	x
Wider channel	x	x	x	x
Narrower channel	x	x	x	x

[1] For cohesive soil boundaries, analysis may include tractive power (tractive stresg times mean velocity).
[2] Comparison of relationships between depth, velocity, and unit discharge in two or more reaches.
[3] Special situations, see page 4-19 of NRCS Technical Guide.
Source: USDA,NRCS. National Engineering Handbook (NEH), Washington, D.C.

For certain projects, run HEC-RAS to check if the proposed channel will handle different flow conditions. The final design must clearly explain why a design is proposing to do something a little different than what the numbers say to do -- for example, you may want to promote more bankfull flows to enhance wetlands on flood plains. If combining natural channel features with hard engineering techniques, be sure to explain the rationale.

The Keystone Stream Team highly encourages the peer review of final designs as a way to ensure quality assurance and control.

Reference documents for application of structures:

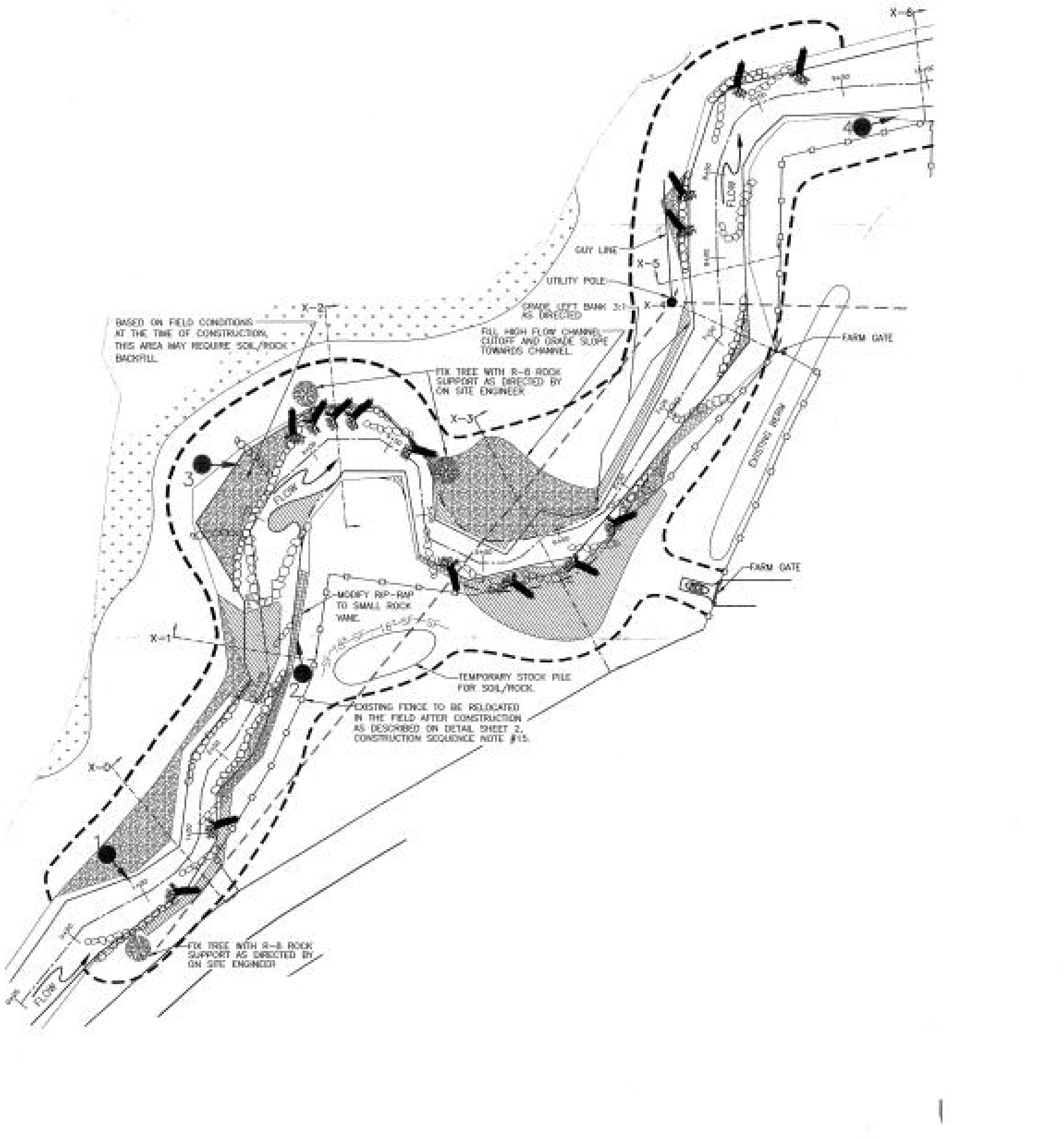
1) As a point of reference, the Maryland Department of the Environment has developed a set of guidelines for waterway construction that identifies the effective uses and limitations of common restoration and stabilization practices. It can be accessed at www.mde.state.md.us/wetlands/guide/mgwc.pdf.
2) Chapter 8 of *Applied River Morphology* (Dave Rosgen,1996); and
3) Appendix A in *Stream Corridor Restoration: Principles, Processes and Practices* (1998). www.usda.gov/stream_restoration.

Erosion and sediment pollution control is an important component of design and construction. See Chapter 8 for information on what to consider in the development of the Erosion & Sediment (E&S) control plan. E&S notes should be included on your design drawings.

Sample Site Plan

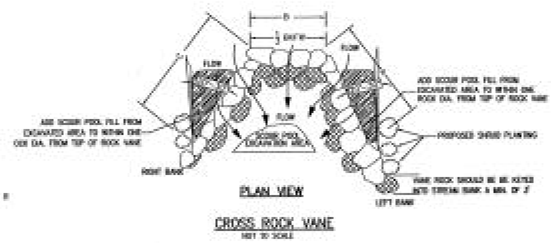
The following site plan is an excellent illustration of the design details that should appear in permit application packages. As explained in detail under Chapter 5 on permitting, applications should include a scaled plan view drawing showing the location and type of structure or activity within the project limits.

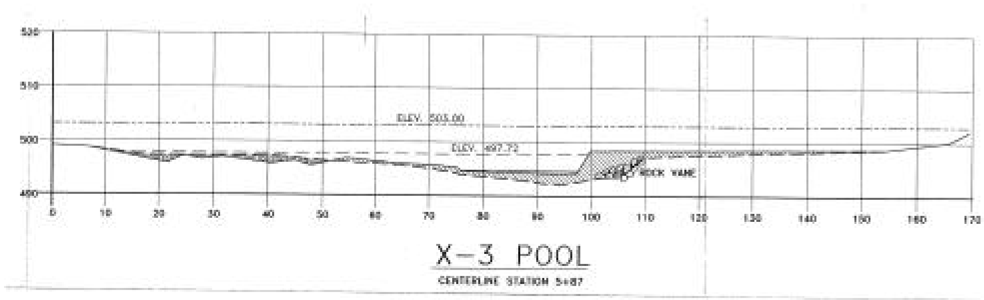
SAMPLE SITE PLAN DRAWING



Source: Site Plan, East Branch Codorus Creek, York County; Izaak Walton League of America - York Chapter #67; Skelly & Loy, Inc.

SAMPLE PLAN VIEW & CROSS-SECTION





Source: Site Plan, East Branch Codorus Creek, York County; Izaak Walton League of America - York Chapter #67; Skelly & Loy, Inc.

Chapter 7
SELECTING A QUALIFIED CONSULTANT

Because natural stream channel design integrates many disciplines (geomorphology, engineering, biology, hydrology, and botany) and requires a combination of field experience and formal training, finding competent consultants can be particularly challenging. Registered engineers are not automatically qualified to design natural channels, nor those who've taken the recommended coursework without field experience. Selecting a consultant who is simply interested and available and who professes to know the field is not enough. Competency, reputation, training, technical support, references, and having a good track record with similar projects are all critically important.

Whether you're looking to hire a consultant for stream assessment, design, or construction work, there are a number of steps you can take to ensure that you are selecting the best person to get the job done right. It's important to ask the right questions and to consider all your options in the selection process.

Know Your Options

Your identity as a non-governmental organization (NGO) or governmental agency will determine to a large extent the options open to you when procuring services for a project. In general, local governmental agencies (county conservation districts, county agencies, and local municipalities) must adhere to local regulations in the awarding of subcontracts, while non-governmental organizations have more flexibility in the process. However, both governmental agencies and NGO's should be aware of state and/or federal subcontract conditions when both applying for and awarding grants. When planning a project and developing a grant proposal, NGOs should learn all they can about fiscal agents' rules and construct their proposals accordingly. Each grant program has its own set of requirements. Under state-funded projects, for instance, subcontractors must be presented to the Commonwealth for review and approval. In some cases, the Pennsylvania Prevailing Wage Act applies (see Appendix II for listing of helpful websites).

NGO's that do not hold 501-C-3 non-profit status often look to local governmental agencies to receive grant monies for a local project. An alternative to running a grant through a governmental agency would be to run it through a non-profit grant administrator, which, for an administrative fee, can manage the financial matters of the project and sub-contract the management and implementation of the project to a watershed organization and/or private consultants.

Government funding agencies encourage competition in the selection process. The Commonwealth procures services competitively in two ways: Invitation for Bids and Request for Proposal.

1) **Invitation for Bids** (IFB) - IFBs are used when a project is well-defined and the awarding agency can describe precisely what it's looking for in a project. Bids are submitted in response to the IFB solicitation document issued by the governmental agency. The award is made to the lowest responsive and responsible bidder -- in other

words, the lowest bidder that is considered responsible in carrying out the work. Cost is generally the overriding factor in evaluating submissions.

2) **Request for Proposals** (RFP) - RFPs are used when the project is less well-defined. The funding agency may be soliciting novel or creative ideas, or the project may be more complex and open to broader interpretations. Proposals are submitted in response to the RFP solicitation document issued by the governmental agency. The award is made to the highest scoring proposal, in accordance with a set of criteria for selection of which cost is just one factor.

Non-competitively, a third option is sole-source procurement. Under sole-source, the funding agency must justify the award being made to one recipient rather than following a competitive process. Chapter 6, Subpart E of the *Commonwealth Procurement Code*, outlines nine circumstances that justify sole-source awards. Sole source procurement may be used when the contracting officer determines that one of the following conditions exists:

1) Only a single contractor is capable of providing supplies, services, or construction.
2) A state or federal statute or regulation exempts supplies, services, or construction from a competitive procedure.
3) It is clearly not feasible to award the contract for supplies or services on a competitive basis.
4) The services are to be provided by attorneys or litigation consultants selected by the Office of General Counsel, Office of Attorney General, Department of Auditor General, or the Treasury Department.
5) The services are to be provided by expert witnesses.
6) The total cost for services involving the repair, modification, maintenance, or calibration of equipment and are to be performed by the manufacturer of the equipment or by the manufacturer's authorized dealer, is more than $10,000, and the purhcasing agency head or designeee determines bidding not be appropriate under the circumstances.
7) The contract is for investment advisors or managers selected by the Public School Employees' Retirement System, the State Employee's Retirement System or a state-affiliated entity.
8) The contract is for supplies or services is in the best interest of the Commonwealth.

See www.dgs.state.pa.us/comod/handbook/Part1.pdf - page 33.

The funding source for your particular project may specify which approach to take in awarding subcontracts. The three options noted above are simply guidance based on part of the Commonwealth's procurement protocol.

Know What You're Selling

The better you know what you're asking for on a project, the better you can judge the competency of prospective consultants.

Make a public announcement explaining the nature of your project and what you're looking for from a consultant or construction contractor. Be specific as to what functions must be conducted under assessment work, design, and/or construction and monitoring. This can be in the form of a RFP or IFB as explained above.

Some invitations for work will be highly detailed if the individuals preparing the document are experienced in NSCD and know exactly what needs to be done. Specific methodologies might be required. Others may request conceptual plans based on preliminary assessment work or request up front assessment work to be accomplished.

Instructions to Prospective Consultants/Contractors

Clearly articulate any procedures which your organization is obligated to follow. Consider explaining the following elements to design consultants and construction contractors as applicable:

1) Process for submitting proposals.
2) Process for evaluating proposals and the timeframe for selecting and notifying all candidates of the final selection.
3) Timeframe for work (when and how long work is expected to last; contingency plans for seasonal delays)
4) Process and schedule for payment of work; payment conditions if installation unsatisfactory. It may be necessary to include a provision explaining that payment will be made within a specified number of days after reimbursement is made to the project sponsor from a government grant source. This will help avoid cash flow problems for those watershed organizations that cannot pay a subcontractor until grant monies are reimbursed.
5) Inspection and certification of work
6) Exceptional permit conditions
7) Construction details & Work Plan:
    - construction details and specifications for structures if possible -- eg., channel dimensions, locations and dimensions of structures; cost estimates for specific components make for easier adjustments to finalized work plan and contract
    - soil erosion & sedimentation control plan (if already developed)
    - rock quantities
    - cut & fill estimates
    - stream access points -- existing, to be built, number to be restored
    - erosion controls -- seed and mulch; number of square feet; plantings
    - sources of material (fill & topsoil) -- trucking distance, permits needed, access points
    - stock pile locations for rock; transportation of rock
    - equipment needs and specifications
    - fuel for equipment -- sources, cost
    - disposal of spoil material (trees, debris, etc.)
8) Change Order and Delays - Additional work or changes to scope of work may be made through a written change order, which should be approved by both the contractor and project administrator.

    Ask for a rate schedule from the contractor to be used for the determination of costs related to needed changes. Categories to be included in rate schedule: laborer, project management, excavator with thumb, wheel loader, dozer, per diem, survey crew, mobilization, and other anticipated categories.

    Bid instructions should explain the following about change orders:
    - explain who is authorized to make changes in the field;
    - set dollar amount not to be exceeded for agreed-to changes;.
    - set per diem cost rates charged to the contractor if the contractor is delayed in starting or completing its work due to causes within its control;

- set per diem cost rates charged to the project administrator if the contractor is delayed in starting or completing its work due to causes within the project administrator's control;
- Acts of God - If the project is delayed due to adverse weather or stream conditions, an Act of God, or other conditions beyond the control of the contractor or project administrator, then the contract completion date will be adjusted to reflect the new completion date without additional cost to either party. Adverse stream conditions may be defined as those that exceed 3/4 of the depth of the designed bankfull. Reserve the right to determine when weather or other unforeseen circumstances warrant a delay or suspension to the project administrator. Contractors should not be held responsible for any damage to portions of the project that have already been completed and approved by a project inspector. Consider language that calls for a written "change order" if significant delays create more than a 10% increase or decrease in the work.

Offer to walk the site with interested candidates. Different scientific backgrounds often provide different perspectives on the source of stream problems as well as solutions. Consultants will also have a clearer idea of expenses associated with hauling materials for the job.

Interviews

After receiving proposals, conduct an in-depth interview process to screen prospective consultants. Be sure to cover the following in the interview:

- Credentials (ask for a resume)
- Track Record (ask to see photos and reports of similar projects completed)
- References (ask for contact information from past projects; ask for references for sub-contractors as well)
- Training (specific to FGM and NSCD projects)
- Experience and qualifications of personnel assigned to the project
- Rates & Work Schedule (ask for estimates of how much time a consultant would expect to devote to the described assessment, design, or construction work)
- Proof of insurance coverage (workers compensation, public liability and property damage, automobile bodily injury and property damage)
- Performance Bonds (for construction work; can potentially add to project cost)

As experience builds in NSCD, consultants will be able to provide more consistent cost estimates, and the job of selecting qualified consultants should grow easier.

Chapter 8
CONSTRUCTION CONSIDERATIONS

To ensure an effective project, the project designer should be on-site during construction! The Keystone Stream Team strongly recommends that a project designer or a person knowledgeable and accountable for the project be on-site during key construction periods. Experience in natural stream channel design is limited among construction contractors, so it's critical to provide direct oversight by someone who understands the project and has knowledge of the structures being installed. The key is to work with contractors so that experience and competency will grow in this evolving field. Where possible, encourage peer learning opportunities.

Communication between the designer, contractor, and landowners is critical to the success of the construction phase. Walk the site together and discuss access, local availability of rock materials, and use of fill. Ensure landowners that site will be adequately cleaned up after construction is completed. Satisfied landowners upstream may mean a greater acceptance by landowners downstream for future construction work.

Pre-construction conferences

A pre-construction meeting should be held on site to ensure that all aspects of the plan are understood by the contractor and construction crew. Include the designer, contractor, construction crew, construction inspector (if have one), landowner, conservation district, and agency representatives. Send notification of the pre-construction meeting to the Corps of Engineers.

Points to consider at the pre-construction meeting:

- recognize most sensitive areas of the site
- review sequence and schedule of implementing control measures
- review mechanisms for emergency response
- note any changes to the erosion & sediment control plan
- review any changes made to final copies of plans and permits
- reviewing right of entry agreements on private properties
- review any public utility locations and related concerns
- review the staging and transportation plan (consider access to project site in terms of landowner concerns and how to transport materials and equipment)
- review records and reports that will be needed to provide necessary documentation for progress on site

Erosion and Sediment Control

With any project, the goal is to minimize secondary erosion impacts associated with construction. Therefore, be sure to limit the time of disturbance to the stream and corridor.

The Erosion & Sediment Pollution Control Plan should include a written analysis of various alternatives explaining why work will be done in the stream or from its banks. *This narrative should be part of a permit application*. Reference the cost/benefit ratio to help justify approach if necessary. Analyses will vary across different physiographic regions of the state. Be sure to consider and include a "NO ACTION" alternative as part of your analysis.

If concerns exist with regard to sediment and turbidity during construction, use sediment and bedload sampling prior to construction and throughout the construction period. A study underway on Big Bear Creek by Dr. Mel Zimmerman of the Lycoming College Clean Water Institute is showing that benthic macroinvertebrates are returning four to eight-times their original numbers after the implementation of a natural stream channel design. The current phase is documenting turbidity and bedload data, and fish populations will be measured.

The Keystone Stream Team offers the following tips on controlling erosion and sedimentation during and after construction, selecting the best construction periods and locations, and choosing the right equipment:

E&S Stabilization Tips:

- All work should be done from the bank where possible. Minimize the amount of time and extent of disturbance in the channel as much as possible.
- Oftentimes, working from within the stream itself with excavating equipment is the most effective way to install structures such as rock vanes or cross rock vanes. Working from within a stream will also protect any riparian vegetation. Depending on stream size, it is more effective to allow equipment in the stream as needed and then retreat up the bank slope to properly key structures into the stream bank. Equipment should work from the side of the stream where in-stream structures are being installed. Avoid the installation of in-stream structures from opposing stream banks as soil may be pulled toward the channel.
- Stabilize all disturbed areas concurrently with restoration activities. Seed, mulch or geo-mulch with jute mat, and then add live stakes, plants, or seed. Seed and mulch/mat areas from bankfull to the water's edge (active stream channel). The design will stabilize an active stream channel.
- Point bars should be stabilized by seeding rye grass (if fairly flat stream). If there's a medium for growth, take the effort to re-seed area for added measure of stabilization.
- Depending on soil types, consider using erosion blankets especially on non-cohesive soils that are more prone to erosion. This practice is particularly useful along meanders.
- Avoid the use of silt fence along the immediate stream bank area during construction (it will be in the way and is not practical). The installation of

silt fence may also disturb the bank area during installation. In most situations where limited disturbance occurs, silt fence is not needed.

- Everything over design bankfull should be permanently stabilized.
- Consider the environment. Limitations will be different for Spring Creek and Letort Run compared to Codorus or Bentley creeks due to differences in geology.
- Consider requirements imposed by Special Protection status of some streams. Situations may require pumping or costly E&S controls in order to get projects permitted -- this may cause a project to never be completed.
- Collect pre/post construction information on turbidity and bank erosion.

When and where to construct?

- Identify specific windows for construction.
  - In-channel construction activities should take place during low-flow periods.
  - Sometimes frozen ground is an asset for access to a stream.
  - With regard to fish spawning and stocked trout constraints, no work should be done in wild trout streams between 10/1 and 12/31; stocked trout streams between 3/1 and 6/15; Lake Erie tributaries between 9/1 and 4/30; and warm water streams between 4/15 and 6/15.
- It may be necessary to move equipment or work within the stream with minimal movement to avoid destroying sensitive riparian areas or mature forests. Streams can rejuvenate themselves faster than a riparian forest.
- Begin stream restoration work upstream and proceed downstream. The installation of in-stream structures will change flow patterns within the channel and, therefore, any required adjustments to restoration activities can be made downstream as needed.
- Using natural stream channel design and fluvial geomorphic principles, it is advantageous to construct in-stream structures with normal to low flow in the channel to observe the reaction of channel flow to the installed structure. Therefore, consider avoiding the use of coffer dams or the diversion of flow around the work area. Doing so will add to construction delays and increase project costs.
- For newly constructed channels or stream channel relocations, consideration should be given to constructing the new channel in dry conditions. The new channel can then be seeded and planted and allowed to become stabilized before water is diverted into the new channel. Construction of a new stream channel in dry conditions can be completed in a shorter time frame, and it’s easier to navigate installation. The one disadvantage to this option is that flow conditions and the reaction of flow vectors to in-stream structures cannot be observed. This option may require adjustments to the channel and structures after water is diverted into the new channel. Soil removed from the newly excavated stream

channel will need to be stockpiled and stabilized until the old channel is ready for backfilling. Upon completing channel construction, the abandoned channel may need to be at least partially backfilled (if it's hydraulically critical), vegetated, and stabilized.

- Abandoned mine reclamation projects: Impervious liner must be placed to prevent stream flow loss to abandoned underground mines or fill areas. It is essential to place the liner and construct the natural stream channel in the dry.
- Bankfull rain events truly test the design. Such storms can be beneficial from a design standpoint during construction. You can observe how the new stream channel functions during high flow events and modify construction techniques to improve the overall design.
- Wetlands within the limits of disturbance must be clearly identified on the drawings and flagged at the project site prior to start up. Disturbance of wetlands or other soft wet riparian area should be avoided.
- Avoid impacts to existing woody vegetation and their root masses along stream banks.
- Carefully select staging areas for equipment and materials. Stockpile an adequate amount of materials on site prior to construction to avoid project delays and additional hauling while under construction.
- Identify any soil disposal areas which may be required as a result of regrading steep bank slopes. Soil requiring disposal should be "feathered out" in thin layers (less than 3 inches) across the floodplain in the work area especially in pasture areas. This will not apply to wetland areas which should be avoided. This soil should be seeded concurrently with grading activities.
- When fording a stream, select areas with a stable bottom and where channel is not entrenched to minimize the amount of disturbance.

Choice of equipment

- Match the size of construction equipment to the size of project and materials. Undersized equipment can mean staying in the stream longer and creating more disturbance, which can ultimately mean more time and money. Larger excavators can handle working from bank if mandated to do so. However, where useable, smaller equipment may disturb less area.
- Excavators with thumb attachment can greatly improve the handling of large material such as root wads and vane rocks. For wheel loaders, a four-yard bucket is best for moving large rocks.
- Ensure that the contractor has liability insurance.
- Encourage the use of biodegradable fluids in construction equipment.
- Prepare for and use the right equipment for wet conditions.
- Have a spill kit on site to handle accidental spills of hazardous materials.

Chapter 9
MONITORING: PRE- AND POST- CONSTRUCTION________

Monitoring is conducted to measure success, and success in the field of natural stream channel restoration can be two-fold in purpose: 1) to meet permit conditions and measure the success of a project's specific objectives, and 2) to measure the performance of natural stream channel designs over the long term. Monitoring also provides baseline conditions and a measurement of change over pre-construction conditions.

A natural channel develops a particular form over a long period of time. It makes continual adjustments in width and depth as it experiences a wide range of storms and low flow events. Monitoring for short periods of time (only one or two years) implies that stability is established or should be established the day the channel is built. Therefore, monitoring over a period of at least five years is recommended to provide time for the stream channel to become more fully established.

In measuring project success, objectives expressed in terms of measurable stream conditions provide the basis for monitoring the success of the project. Define monitoring parameters to match your objectives and make sure your objectives are both achievable and measurable.

It's important to build monitoring components into the assessment phase of your project. Establish pre-construction monitoring components and locations. Monitor the poorest sections early on -- aim to document before and after construction and those conditions at the worst sections of impacted stream reaches.

Remember that the three main objectives of natural stream channel design are sediment transport, habitat restoration, and bank and channel stabilization. Determine ways to monitor for each of these three objectives, keeping in mind that there will be varying degrees to which these objectives are sought. Identify your MAIN objectives and plan to monitor accordingly.

Remember also that the reference site establishes baseline conditions to provide an accurate basis for measuring change.

Your monitoring plan should include pre-construction, as-builts, and post-construction monitoring to show whether the project was successful in meeting stated objectives. The plan should define monitoring parameters, sampling frequency, sampling locations and analytical procedures. Documentation on structures (their size, length, slope, rock size, etc.) should be part of your monitoring strategy. It's a good idea to involve the project designer in the selection of monitoring parameters.

Reference worksheet: - Morph Chart (Appendix I) includes a column for as-builts.
- Field Survey Procedures for Characterization of River Morphology (Appendix I)

Take an adaptive management approach -- monitoring and evaluation teaches us new things in natural stream channel design. Unforeseen problems may require midcourse corrections either during or shortly after implementation.

Use volunteers from watershed organizations, sportsman clubs, and senior volunteer organizations, such as the Enviromental Alliance for Senior Involvement (EASI) to assist with short and long term monitoring tasks.

Monitoring Recommendations

- Duration of monitoring period: minimum of five years
- As Built Surveys: As Built surveys, which are now required by DEP, should be done within 60 days post-construction. Following construction, an as-built site plan should show:
  1) Any field adjustments in plan -- additions/deletions
  2) Post-construction cross-sections (monumented) and longitudinal profile
  3) Elevations and placement of structures
  4) Constructability -- discuss access to project, utilities, selection of equipment
  5) Breakdown of costs (optional: materials, construction, design, construction management)
  6) Photos: take at monitoring stations and cross-section areas, upstream and downstream of project.

     Reference documents: Morph Chart (Appendix I) and Field Procedures for Characterization of River Morphology (Appendix I)
- Frequency of monitoring: During first year post-construction, a minimum of two times/year plus several bankfull storm events (as-built plus one more time unless there is not a bankfull event). For 2-5 years post-construction, a minimum of 1x/year plus several bankfull storm events.
- Monitoring reports: Long term monitoring reports should include comments on structures (erosion at structures, narrative on any tweaking done), survivorship or percent cover of riparian vegetation or wetlands (this is often specified in the 404 permit special condition), and an evaluation of whether goals/objectives have been met. Note any monitoring requirements as part of required permits.
- Monitoring components: Parameters should reflect those measures needed to meet the project's objectives. It's also important to consider the capability and dedication of people who will be involved in conducting the monitoring activities.

  Channel characteristics:
  - Monumented cross-sections (required by DEP)
  - Longitudinal profile
    - slope
    - riffle/pool characteristics

- Pebble Count
  - bed particle size distribution
- Pattern
  - sinuosity, meander lengths, radius of curvature
- Bank stability (optional)
  - bank pins
  - scour chains for measuring aggrading or degrading streambed
  - BEHI (bank erodibility index)
  - bank stability (Pfankuch Stability Rating)

Biological characteristics:

- RBP (Rapid Biological Assessment Protocol) assessment form

Currently, the Citizen Volunteer Monitoring Program under DEP is developing monitoring guidance for natural stream channel restoration projects. For an update, contact CVMP at 717-772-5807.

APPENDIX I

HELPFUL TOOLS AND FORMS

I - i **Watershed Assessment: Stream Reach Prioritization**

I - ii **Morph Chart**
- Morphological Characteristics of the Existing and Proposed Channel with Gage Station, Reference Reach and As-Built Data (modified for PA)

I - iii **Field Survey Procedures for Characterization of River Morphology**

Watershed Assessment
Stream Reach Prioritization

Date: ________________ **Overall Score: __________**

Assessed by: __________ **Priority Ranking:** **1** (4 to 8) **2** (9 to 12) **3** (13 to 16)

Stream Identification:

Watershed ID: ____________ Reach ID: _____________ Stream Type: _____________

Predominant Land Use: *(Circle)*: Agricultural, Rural Open, Residential, Commercial, Industrial, Forested

Cause of Impairment: *(Circle all that apply)*: Not impaired, stormwater runoff, pasture impacts, unstable conditions upstream, channel downcutting, floodplain alteration, lack of riparian vegetation, high sediment loads (in-stream or overland)

Stream Assessment: *(Circle descriptive elements that apply to overall stream reach)*

Bank Stability

Priority
1__ Severe (Banks sloughing, undercut or vertical, exposed soils, evidence of property damage)
2__ Moderate (Banks unstable, some bank sloughing, bank slopes 60 to 80 degrees)
3__ Minor (Some bank erosion, slopes < 60 degrees)
4__ Stable (Well vegetated, gently sloping or low banks)

Channel Stability

Priority
1__ Severe (Numerous or large unvegetated channel bars, channel dredged, straightened or bermed, no active floodplain, downcutting and/or widening)
2__ Moderate (Degradation or aggradation noticeable, some evidence of over-bank overflow)
3__ Minor (Some channel scouring or sediment buildup, migration appears minor, floodplain feature present)
4__ Stable (Channel appears natural with no evident migration, point bars well vegetated, active floodplain)

Riparian Vegetation

Priority
1__ Severe (No woody vegetation with high banks, predominately grasses, buffer < 10’, canopy < 20% closed)
2__ Moderate (Sparsely vegetated banks, buffer 10’ to 20’ wide, canopy 20% to 40% closed)
3__ Minor (Some woody diversity and density, buffer 20’ to 60’, canopy 40% to 60% closed)
4__ Good (Good density and diversity of woody species, or low banks with grasses, buffer > 60’, canopy > 80%)

Aquatic Habitat (Features = riffles, runs and pools) (Cover = woody debris, large boulders, roots)

Priority
1__ Severe (No habitat present, uniform substrate or silt, no in-stream cover, uniform stream features)
2__ Moderate (Limited aquatic habitat, some substrate particle gradation, limited mix of stream features/cover)
3__ Minor (Aquatic habitat noticeable throughout reach, some mix of stream features and cover but not optimal)
4__ Good (Good in-stream cover, good mix of features, high variability of substrate particle size)

COMMENTS:____
____

SOURCE: Aquatic Resource Restoration Company

MORPH CHART

In order to collect the data in a consistent way that can be used to build a Pennsylvania database, please complete this chart and return it to your DEP project advisor. If you have questions please contact Fran Koch 717-783-2289 or email fkoch@state.pa.us

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION, REFERENCE REACH AND AS BUILT DATA*
(Rosgen, 1996)

Restoration site (Name of stream & location):
USGS Station (No. & location):
Reference Reach (Name of stream & location):

VARIABLES	**EXISTING CHANNEL**	**PROPOSED REACH**	**USGS STATION**	**REFERENCE REACH**	**AS BUILT**
1. Stream type					
2. Drainage area (sq. mile)					
3. Bankfull width (W_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:
4. Bankfull mean depth (d_{bkf})		Mean: Range:		Mean Range:	Mean: Range:
5. Width/depth ratio (W_{bkf}/d_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:
6. Bankfull cross-Sectional area (A_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:
7. Bankfull mean velocity (V_{bkf})					
8. Bankfull discharge, cfs (Q_{bkf})					

9. Bankfull Maximum depth (d_{max})		Mean: Range:		Mean Range:	Mean: Range:
10. Max d_{riff}/d_{bkf} ratio		Mean: Range:		Mean: Range: .	Mean: Range:
11. Low bank Height to max. d_{bkf} ratio		Mean: Range:		Mean: Range:	Mean: Range:
12. Width of flood prone area (W_{fpa})		Mean: Range:		Mean: Range:	Mean: Range:
13. Entrenchment ratio (W_{fpa}/W_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:
14. Meander length (L_m)		Mean: Range:		Mean: Range:	Mean: Range:
15. Ratio of meander length to bankfull width (L_m/W_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:
16. Radius of curvature (R_c)		Mean: Range:		Mean: Range:	Mean: Range:
17 Ratio of radius of curvature to bankfull width (R_c/W_{bkf})		Mean: Range:		Mean: Range	Mean: Range:
18. Belt Width (W_{blt})		Mean: Range:		Mean: Range:	Mean: Range:
19. Meander width ratio (W_{blt}/W_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:

20. Sinuosity (stream length/valley distance) (k)					
21. Valley slope (ft/ft)				.	
22. Average slope (S_{avg})=(S_{valley}/k)				.	
23. Pool Slope (S_{pool})		Mean: Range:		Mean: Range:	Mean: Range:
24. Ratio of pool slope to average slope (S_{pool}/S_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:
25. Maximum pool depth (d_{pool})		Mean: Range:		Mean Range:	Mean: Range:
26 Ratio of pool depth to average bankfull depth (d_{pool}/d_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:
27. Pool width (W_{pool})		Mean: Range:		Mean: Range:	Mean: Range:
28. Ratio of pool width to bankfull width (W_{pool}/W_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:
29. Ratio of pool area to bankfull area		Mean: Range:		Mean: Range:	Mean: Range:
30. Pool to pool spacing (p-p)		Mean: Range:		Mean: Range:	Mean: Range:

31. Ratio of p-p spacing to bankfull width (p-p/W_{bkf})		Mean: Range:		Mean: Range:	Mean: Range:
MATERIALS:					
1. Particle Size distribution of channel material					
D_{16}					
D_{35}					
D_{50}					
D_{84}					
D_{95}					
2. Particle Size distribution of bar material					
D_{16}					
D_{35}					
D_{50}					
D_{84}					
D_{95}					
Largest size particle at the toe (lower third) of bar					

SEDIMENT TRANSPORT VALIDATION (Based on Bankfull shear Stress	**Existing**	**Proposed**
Calculated value (mm) from curve		
Value from Shield Diagram (lb/ft^2)		
Critical dimensionless shear stress		
Minimum mean d_{bkf} calculated using critical dimensionless shear stress equations		

Remarks: using bedload data adjusted shields relation
***Modified for Pennsylvania with Dave Rosgen's permission. If you have any questions contact Fran Koch email fkoch@state.pa.us.**

Please follow this procedure to establish monumented cross sections that can be used for follow up monitoring of your project. If you have questions/suggestions please contact Fran Koch 717-783-2289 or email fkoch@state.pa.us

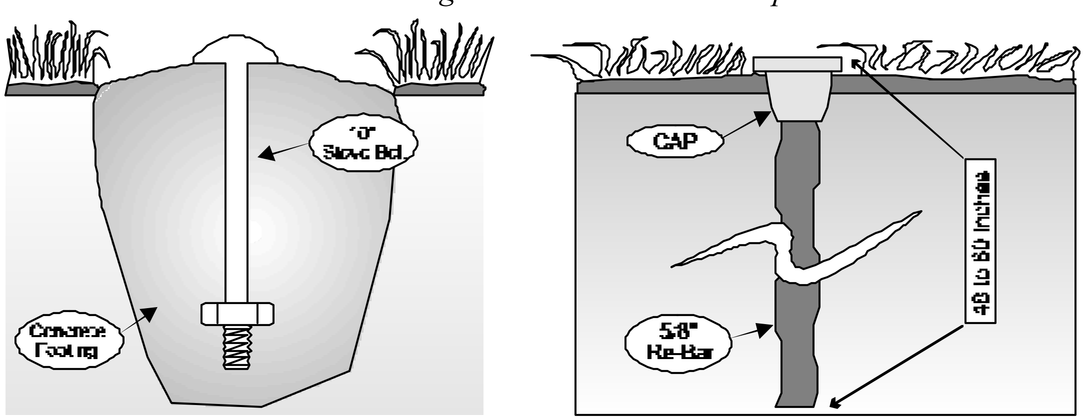
Field Survey Procedures for Characterization of River Morphology by Dave Rosgen 9/96

- Locate a reach for a minimum of 20 channel widths (Two Meander Wavelengths).
- This reach should characterize or represent the dimension, Pattern, Profile, and materials of the stream type you select.
- Select the reach starting point for the survey at the upstream location. Locate reach on aerial photo and map.

A. Dimension

1) Establish a cross-section at the start of the survey reach.
Establish a Permanent Benchmark to tie Both Cross-Section and longitudinal profile to an elevational control for future comparison. The Benchmark should be located a sufficient distance from the edge of the bank to prevent loss of the reference elevation by lateral erosion. The benchmark should be of a permanent installation using Sackrete with Stove Bolt into a "cone hole". Another alternative is to drive 5/8" rebar 4' into the ground and place a cap over the rebar, flush with the ground surface (Figure 1).

Figure 1. Benchmark Examples



2) The cross-section needs to show:
-Benchmark elevation and location
-Terraces and floodplain
-Flood prone area width and depth

-Bankfull stage (Both left and right banks)
-Existing left and right edge of water
-Variability in shape of cross-section
-Thalweg

3) Start Cross-Section with the zero end of tape on left bank (looking downstream)

4) The following information is obtained from the cross-section (Figure 2):

a. Bankfull width (W_{bkf})
b. Mean Bankfull depth (d_{bkf}) (cross sectional area (A_{bkf})/(W_{bkf})
c. Width/depth ratio W_{bkf} /d_{bkf}
d. Entrenchment ratio = W_{FPA}/ W_{bkf}
[Flood prone Area width (W_{FPA}) = (width at an elevation2x maximum bankfull depth)]
e. Cross-sectional area at the bankfull stage (A_{bkf})
Cross-sectional area is obtained by computing the sum of the products of the intervals of width times depth across the section.
Wetted perimeter @ the bankfull stage
f. Wetted perimeter @ the bankfull stage (WP)
   a) measure from from plotted cross section or ;
   b) approximate by computation:

$$WP = \left(2d_{bkf}\right) + \overline{W}_{bkf}$$

$$Where: \overline{W} = \frac{\left(W_{top} + W_{bottom}\right)}{2}$$

OR:

$$WP = W_{bottom} + 2\sqrt{\overline{d}^2_{bkf} + \left(\overline{W}_{bkf} - W_{bottom}\right)^2}$$

$$Where: \overline{W} = \frac{\left(W_{top} + W_{bottom}\right)}{2}$$

g. Compute bankfull hydraulic radius (R_{bkf} = mean hydraulic depth):

$$R_{bkf} = \frac{A_{bkf}}{WP}$$

h. Estimate mean bankfull velocity (U_{bkf}) in ft/sec.
i. Estimate bankfull discharge (Q_{bkf}) = A_{bkf} x U_{bkf}.
j. Obtain drainage area (mi^2) from topographic map. Compare regional curves at the bankfull stage for; cross-sectional area, width, depth, velocity and discharge by drainage area.

B. PROFILE

1) Start the longitudinal profile from first cross-section and tie- into a permanent elevation control for replicate measurements (Figure 3).

2) Obtain the following elevations on the longitudinal profile:

* Bed surface
* water surface
* Bankfull stage
* Bank height (note left and /or right bank) (Optional)

3) Measure Thalweg position, stationing and distance, i.e. maximum depth. Make sure to measure changes in elevation that indicate the shape, depth, and length of pools and other features to accurately define the bed features along the profile.

4) Locate other cross-sections with longitudinal stationing as reach identifiers i.e. cross-section 3+50 is located 350 feet down from start of profile.

5) The number of points (elevations) obtained along the profile should be sufficient to describe the show the length and depth of pools and well as other bed features such as runs and glides.

6). The following data is obtained from the longitudinal profile.

*average slope (S) (using water surface)
*Bankfull slope (S_{bkf}) (for certain hydraulic and sediment computations.)
*Maximum riffle depth
*Ratio of maximum riffle depth/average depth (d_{maxrif} / d_{bkf})
*Riffle slope
*Ratio of riffle slope to average water surface slope (S_{riff} /S)
*Pool slope
*Ratio of pool slope to average water surface slope (S_{pool} / S)
*Maximum pool depth (d_{pool})
*Ratio pool depth to average bankfull depth (d_{pool} / d_{bkf})
* Riffle/pool spacing or pool to pool distance (r-p / W_{bkf})

C. Pattern

From aerial photos or from field survey obtain the following information:

1) Radius of curvature (R_c) Obtain for minimum, maximum and average values. Besides measuring on aerial photo or in field, another technique for field measurement is the Chord length/mid-ordinate method where $R_c = C^2/8M + M/2$ (Figure 4).
2) Meander wavelength (Lm) Obtain minimum maximum and average values (Figure 4).
3) Ratio of meander wavelength to bankfull width (L_m / W_{bkf}).
4) Meander width ratio (belt width/ bankfull width, or lateral containment) (W_{BLT} /W_{bkf}) Measure minimum, maximum and average meander width ratios (Figure 4).
5) Arc length (L_{arc}).
6) Sinuosity (Stream length/ Valley distance, or valley slope/ channel slope) (Figure 5).

D. General Information

1) The location, elevation, and type of each cross section is tied to the longitudinal profile as shown in Figure 6.

Figure 2. Channel Cross Section

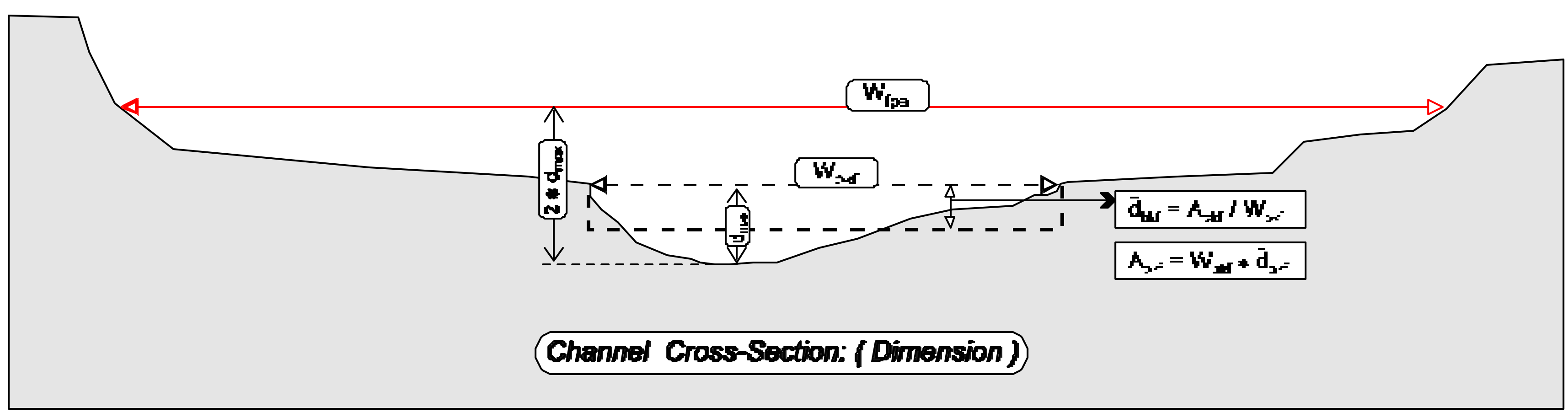


Figure 3. Longitudinal Profile

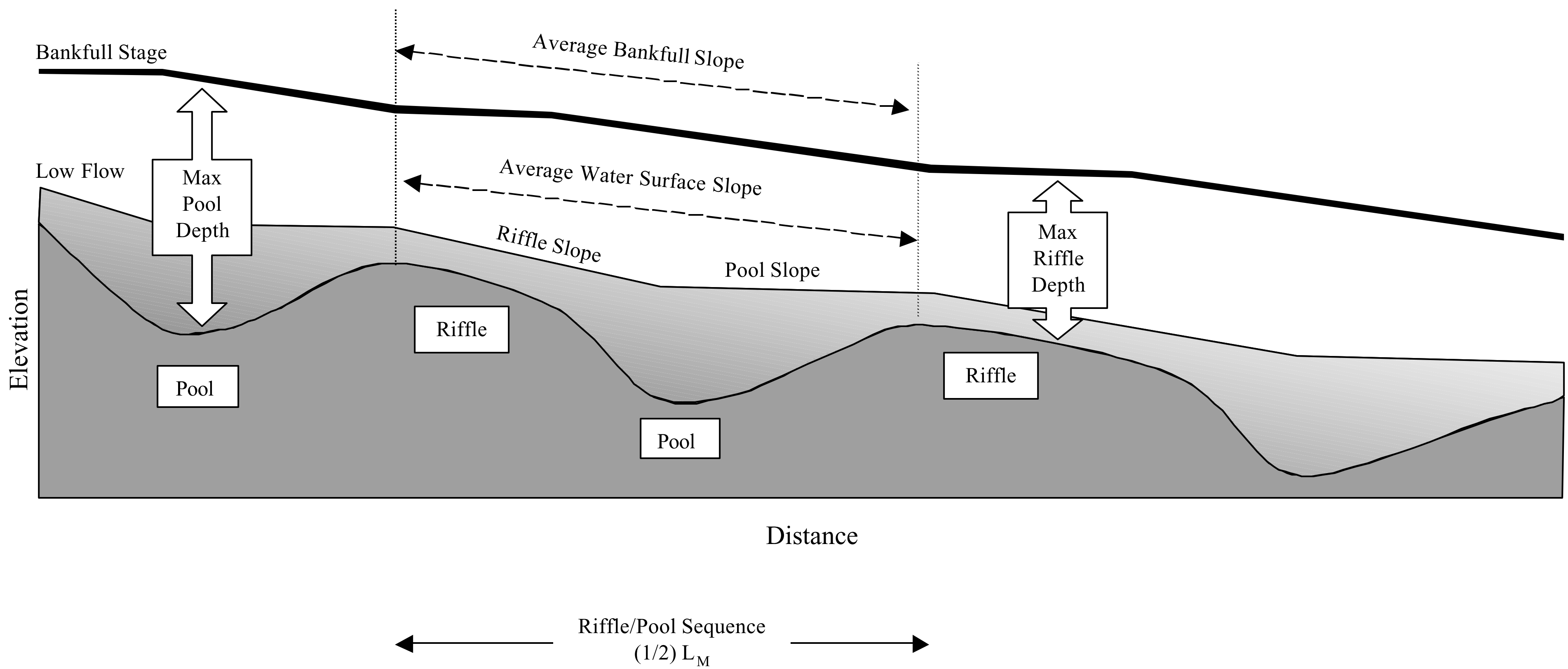
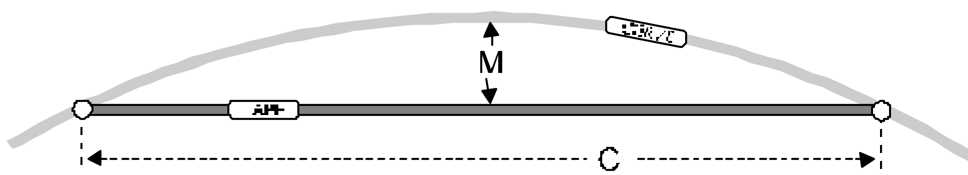


Figure 4. Pattern

Determining RADIUS of CURVATURE (R_c) for a Existing Curve

Extend a known length of tape between two points on a curve, to form a chord (C).

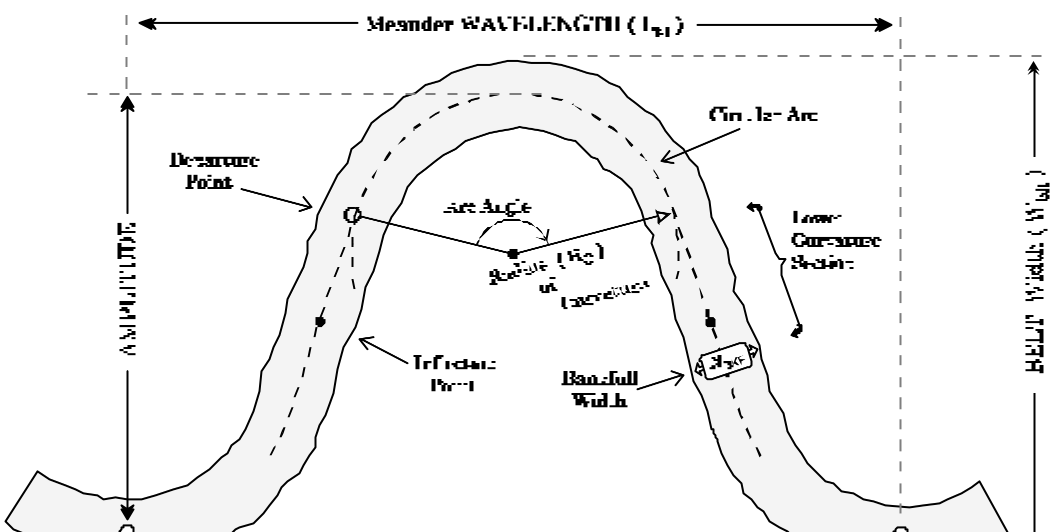
Determine the mid-point of the chord and measure the length of the perpendicular middle ordinate (M).



Where: C – CHORD length, and M = Middle Ordinate distance,...then:

$$R_c = C^2/8M + M/2$$

Curve RADIUS Ft.	Table of MIDDLE ORDINATES.....with Data in Feet									
	CHORD LENGTH....FEET									
	20	25	30	40	50	60	70	80	90	100
20	2.7	4.4	6.8							
30	1.7	2.8	4.0							
40	1.3	2.0	2.9	5.4	8.8	13.5	20.6			
50	1.0	1.6	2.3	4.2	6.7	10.0	14.3	20.0	28.2	
70	.7	1.1	1.6	2.9	4.6	6.2	9.4	12.6	16.4	21.0
80	.6	1.0	1.4	2.5	4.0	5.8	8.1	10.7	13.9	17.6
90	.5	.9	1.3	2.3	3.5	5.1	7.1	9.4	12.1	15.2
100	.5	.8	1.1	2.1	3.2	4.6	6.3	8.4	10.7	13.4
110	.5	.7	1.0	1.8	2.9	4.2	5.7	7.5	9.6	12.0
130	.4	.6	.9	1.6	2.4	3.5	4.8	6.1	8.0	10.0
140	.4	.6	.8	1.4	2.3	3.3	4.5	5.9	7.4	9.2
150	.3	.5	.8	1.3	2.1	3.0	4.1	5.4	6.9	8.6
160	.3	.5	.7	1.3	2.0	2.8	3.9	5.1	6.5	8.0
180	.3	.4	.6	1.1	1.7	2.5	3.4	4.5	5.7	7.1
200	.3	.4	.6	1.0	1.6	2.3	3.1	4.0	5.1	6.4
250	.2	.3	.5	.8	1.3	1.8	2.5	3.2	4.1	5.1
300	.2	.3	.4	.7	1.1	1.5	2.1	2.7	3.4	4.2



***Meander Width Ratio* = BELT Width / BANKFULL Width**

***M W R* = W_{BLT} / W_{BKF}**

Figure 5. Sinuosity

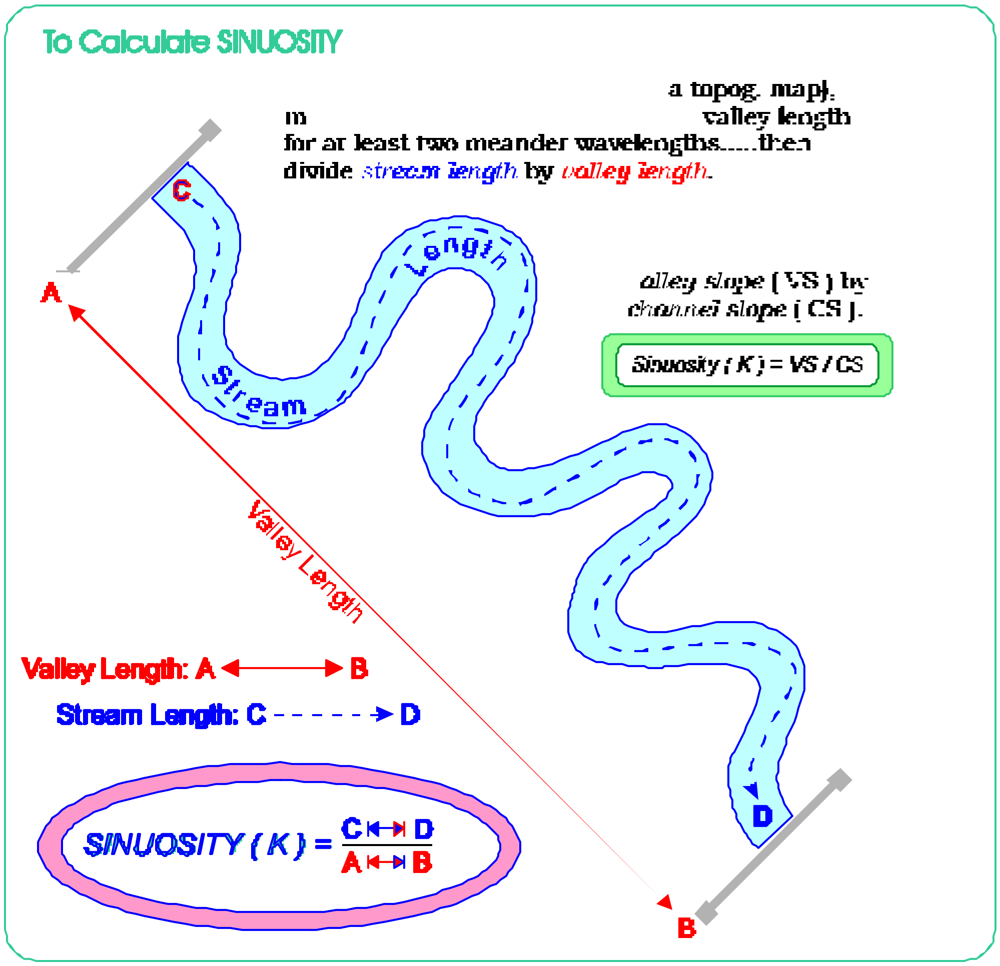
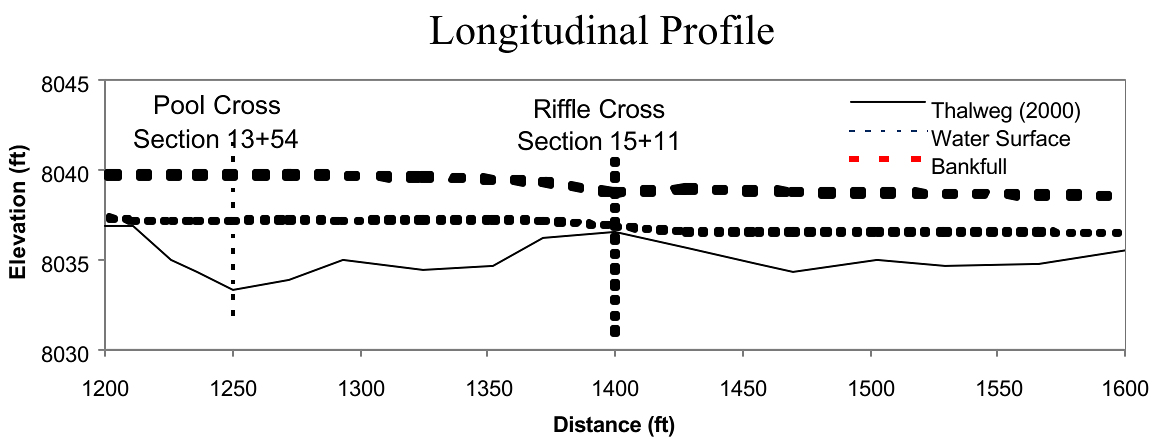
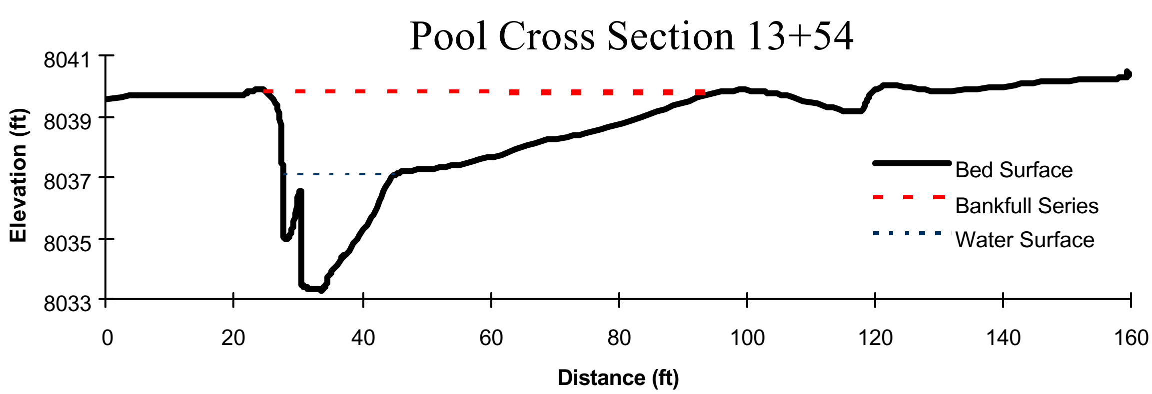
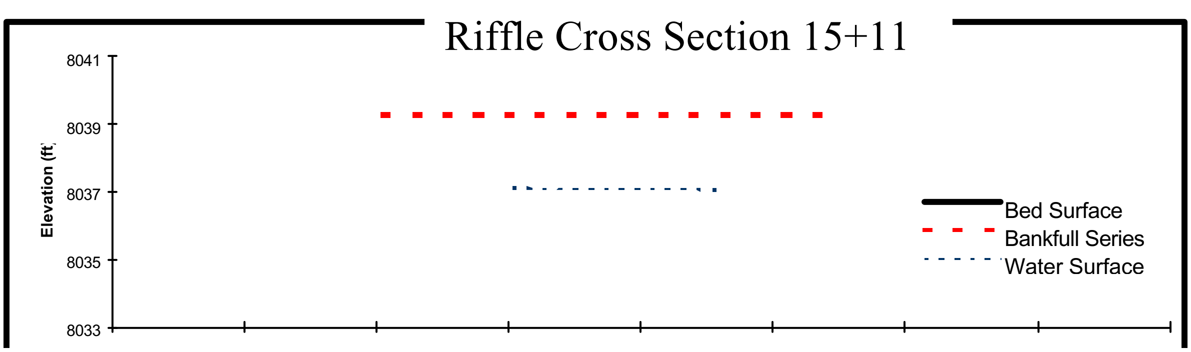
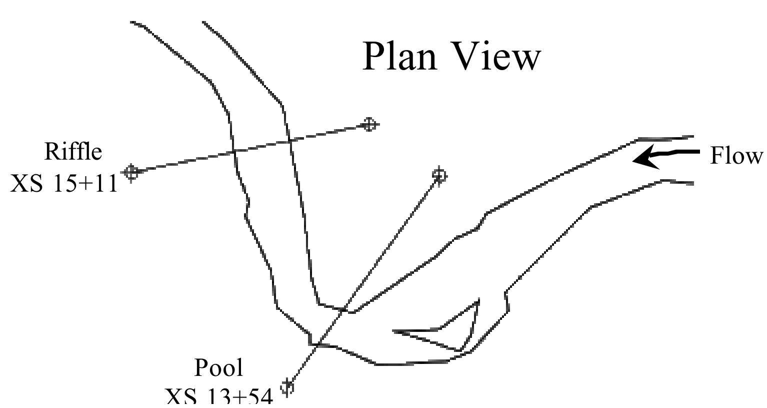


Figure 6. Profile, Dimension, and Plan View









APPENDIX II

RESOURCE INFORMATION ON NATURAL STREAM CHANNEL DESIGN

Guidebooks & Manuals

- The Reference Reach Field Book
  Wildland Hydrology, Inc. Research and Educational Center for River Studies, Pagosa Springs, CO 81147; 970-731-6100; www.wildlandhydrology.com
- The River Field Book
  Available from Lee Silvey, Western Hydrology; 303-986-9200; email at hlsilvey@msn.com
- River Restoration and Natural Channel Design Field Book
  (only available through Rosgen training coursework)
- Stream Corridor Restoration Principles, Processes, and Practices
  Federal Interagency Stream Restoration Working Group; 10/09
  www.usda.gov/stream_restoration
- Maryland's Guidelines to Waterway Construction
  www.mde.state.md.us/wetlands/guide/html
- Channel Restoration Design for Meandering Rivers
  (US Army Corps of Engineers)
  Philip J. Soar and Colin R. Thorne
  http://libweb.wes.army.mil/uhtbin/hyperion/CHL-CR-01-1.pdf
- Hydraulic Design of Stream Restoration Projects
  (US Army Corps of Engineers)
  Ronald R. Copeland, Dinah N. McComas, Colin R. Thorne, Philip J. Soar
  http://libweb.wes.army.mil/uhtbin/hyperion/CHL-TR-01-28.pdf
- River Engineering for Highway Encroachments
  - *a major rewrite of Highways in the River Environment*

  HDS 6, FHWA-NHI-01-004
  www.fhwa.dot.gov/bridge/hydpub/htm
- Maryland's Streams - Take A Closer Look
  Maryland Department of Natural Resources, Watershed Restoration Division, Tawes Building, E2, Annapolis, MD 21401; 410-260-8799
- Restoring Streams in Cities: A Guide for Planners, Policy Makers, and Citizens
  Ann L. Riley, Island Press, 1998
- Montana Stream Management Guide for Landowners, Managers and Stream Users
  - a 33-page, full-color document that provides basic information on stream characteristics, stream types, and steps to stream restoration.
  Department of Environmental Quality, PO Box 200901, Helena, MT 59620-0901; 406-444-2406
- Stream Restoration in Pennsylvania: Ten Case Studies
  Delaware Riverkeeper Network, 2001; 215-369-1188

Helpful Websites

- North Carolina Stream Restoration Institute
  www5.bae.ncsu.edu/bae/programs/extension/wqg
- Greene County Soil & Water Conservation District, NY
  www.gcswcd.com/stream
- Wildland Hydrology, Inc., 1481 Stevens Lake Road, Pagosa Springs, CO 81147; (970)264-7120;
  www.wildlandhydrology.com
- Urban Stream Restoration Video
  - highlights six urban stream restoration sites; order at www.urbanstreamrestoration.com
- FGM Projects in Pennsylvania
  www.dep.state.pa.us
- Watershed Science Institute
  www.wcc.nrcs.usda.gov/watershed/
- Pennsylvania Prevailing Wages and PA Prevailing Wage Act
  www.dli.state.pa.us
  www.dli.state.pa.us/landi/CWP/view.asp?a=185&Q=58229
  (Davis-Bacon Act) www.dol.gov/dol/esa/public/programs/dbra/index.html

Articles/ Publications of Interest

- *A Geomorphological Approach to the Restoration of Incised Rivers* (provides an overview of Dave Rosgen's four levels of priorities for incised river restoration)
  David L. Rosgen, Director, Wildland Hydrology, 1481 Stevens Lake Road, Pagosa Springs, CO 81147
- *A Classification of Natural Rivers*
  David L. Rosgen, Wildland Hydrology, Inc. 1481 Stevens Lake Road, Pagosa Springs, CO, 81147; 970-731-6100
- *Regional Curve Development and Selection of a Reference Reach in the Non-Urban, Lowland Sections of the Piedmont Physiographic Province, Pennsylvania and Maryland*
  (USGS in cooperation with PA DEP)
  Water Resources Investigations Report 01-4146; USGS Branch of Information Services, Box 25286, Denver, CO 80225-0286; 1-888-ASK-USGS
- *The Impact of Afforestation on Stream Bank Erosion and Channel Form*
  A.L. Murgatroyd, J.L. Ternan, 1983, Earth Surface Processes and Landforms, Vol. 8, 357-369.
- *Streamside Forests and the Physical, Chemical, and Trophic Characteristics of Piedmont Streams in North America*
  Bernard W. Sweeney, 1992, Wat.Sci.Tech. Vol. 26, No. 12, pp 2653-2673.
- *Natural Channel Design: How Does Rosgen Classification-Based Design Compare with Other Methods?*
  Dale E. Miller and Peter B. Skidmore, Inter-Fluve, Inc., 2001 ASCE River Restoration Conference, Reno, NV, (Dale Miller - 406-586-6926)
- *Urban Stream Restoration Practices: An Initial Assessment*
  Kenneth Brown, Center for Watershed Protection, 8391 Main Street, Ellicott City, MD 21043, October 2000

APPENDIX III

KEYSTONE STREAM TEAM	
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APPENDIX IV

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

PERMIT GUIDELINES FOR PHASED PROJECTS

NPDES STORMWATER CONSTRUCTION
EROSION AND SEDIMENT CONTROL
AND
WATERWAY RESTORATION

This draft policy is available on the DEP website at www.dep.state.pa.us (choose "Participate" then "draft technical guidance." Paper copies of the proposed policy are also available by contacting Shirley Rodrock of the Division of Waterways, Wetlands, and Erosion Control at 717-787-6827.
Persons wishing to make comments on the proposed policy are invited to submit comments by May 13, 2002 to Ken Reisinger, Chief, Division of Waterways, Wetlands, and Erosion Control, PO Box 8775, Harrisburg, PA 17105-8775; email: kereisinge@state.pa.us. Comments should contain the name, address, and telephone number of the person commenting and a concise statement of the comments, objections, recommendations and suggestions.

March 27, 2002

TITLE: Permit Guidelines For Phased NPDES Stormwater Construction Permits, Erosion and Sediment Control Permits, and Waterway Restoration Project Permits

DOCUMENT NUMBER: 363-2134-013

ANTICIPATED EFFECTIVE DATE: July 2002

AUTHORITY:

Pennsylvania Clean Streams Law (35 P.S. §§ 691.1-691.1001); Dam Safety and Encroachments Act (32 P.S. §§ 693.1-693.28); Federal Clean Water Act (33 U.S.C.A § 1342 and 40 CFR 122.26).

POLICY:

It is the policy of the Department of Environmental Protection to ensure projects requiring DEP permits are reviewed as single and complete projects and meet all public health, safety and environmental requirements. The Department is also committed to the implementation of an effective, efficient, and flexible permit application and review process that eliminates redundant processing procedures and ensures public notice, while meeting its commitment to the public interest and the environment.

PURPOSE:

The Department's approach to permit phased construction and waterway restoration activities uses existing authority to promote the development of comprehensive project plans, provide for a single and complete project review, ensure impacts from construction and waterway restoration activities are minimized, allow for more efficient use of grant money, provide implementation flexibility for long range planning, and minimize delays in project implementation.

APPLICABILITY:

This policy applies to the individual Erosion and Sediment Control Permits, individual and general NPDES Stormwater Discharges from Construction Activity Permits processed by the Department or a delegated Conservation District, and individual Water Obstruction and Encroachments Permit Applications for waterway restoration as defined herein and are processed by the Department.

DISCLAIMER:

The policies and procedures outlined in this guidance document are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements. The policies and procedures herein are not adjudications or regulations. There is no intent on the part of DEP to give the rules in these policies that weight or deference. This document establishes the framework, within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.

PAGE LENGTH: 13

LOCATION: Volume 34, Tab10

EXECUTIVE SUMMARY

Some projects that require DEP permits are long term or large scale projects that may take several years to complete. These projects are commonly referred to as *phased projects* and are funded, planned, or designed in phases or stages to facilitate project implementation. Phased projects are often dependent upon available financial and staff resources, technical support, design or construction grants, and other factors. Traditional permitting approaches to these types of projects can result in high costs for detailed up front data collection, analysis and project design for projects that may not come into fruition for a number of years.

Traditional front-loaded permitting approaches can also be a disincentive for watershed organizations involved in developing and implementing waterway restoration projects. These watershed organizations, typically funded by private donations, or grants such as Growing Greener, often have limited funds and staff resources. A phased approach to these projects allows those limited resources to be targeted towards immediate stream restoration within the context of a broad based project goal.

The purpose of this guidance is to provide flexibility in the permitting process to minimize the administrative burdens on applicants and DEP permit processors, provide an effective public review and notice process for projects, and ensure projects meet the public health, safety, and environmental requirements of the Commonwealth.

A phased project approach promotes the development of comprehensive project plans, provides for a single and complete project review, allows for the efficient use of grant money, reduces permit processing time, and provides implementation flexibility for long term projects. Under the phased project approach, a permit application can be submitted that explains the goals and scope of the project, and the general types and locations of anticipated activities for the entire project site without the requirement for detailed construction plans and drawings for all phases of the project up front.

Permit applicants will provide detailed construction drawings, plans, erosion and sediment control plans, and other required information for review and approval for the initial phase of the project that will be constructed, along with more generalized plans for the subsequent phases under consideration. The entire project, initial phase along with subsequent phases, is advertised through the *Pennsylvania Bulletin* to provide landowners, municipalities, and other interested persons with an opportunity to comment on the overall goal and scope of the project, and proposed activities. Implementation of the first phase may not commence until the public comment period closes, all required information is received, reviewed, and approved, and the permit is issued. Prior to the implementation of subsequent phases, detailed construction drawings, plans, Erosion and Sediment Control plans, and other required information as described in this policy must be submitted to the Department for review and approval prior to commencing work. The approval of a subsequent phase will be published in the *Pennsylvania Bulletin* as an approved action under the previously issued permit.

Applicants are not required to use this phased permit approach for all projects. If circumstances preclude the use of a phased approach, or applicants believe it will not suit their needs, they may choose to submit detailed construction drawings, plans, erosion and sediment control plans and the other required information for the entire project for a one time review and permit decision.

TABLE OF CONTENTS

OVERVIEW

A phased project approach promotes the development of comprehensive project plans, provides for a single and complete project review, allows for the efficient use of grant money, minimizes delays in project implementation and provides flexibility for long term projects. Under the phased project approach, the permit application is submitted with the scope, locations and types of anticipated activities for the entire project site provided. The activities proposed are evaluated to ensure environmental impacts are minimized, and that environmental, public health, and safety issues are satisfied.

For the initial phase of the project, applicants will provide detailed construction drawings, plans, Erosion and Sediment Control Plans, and other required information for review and approval. Implementation of the first phase may not commence until all required information is received, reviewed, approved, and the permit is issued. Prior to the implementation of subsequent phases, detailed construction drawings, plans, Erosion and Sediment Control Plans, and other required information must be submitted to the Department for review and approval prior to commencing work.

This phased approach is not mandatory. Applicants may submit detailed construction drawings, plans, Erosion and Sediment Control Plans and other required information for a one-time comprehensive review if they choose to do so.

DEFINITIONS

Erosion and Sediment Control (E&S) Permit - A permit required for earth disturbance activities of 25 acres (10 hectares) or more where the earth disturbance is associated with timber harvesting or road maintenance activities.

Erosion and Sediment Control (E&S) Plan - A site-specific plan identifying BMPs to minimize accelerated erosion and sedimentation.

Initial Phase - The first phase of a project site for which implementation approval is being requested in the permit application.

NPDES Permit for Stormwater Discharges Associated With Construction Activities (NPDES Stormwater Construction Permit)[1] - A permit required for the discharge or potential discharge of stormwater into waters of this Commonwealth from construction activities, including clearing and grubbing, grading and excavation activities involving 5 acres (2 hectares) or more of earth disturbance, or an earth disturbance on any portion, part or during any stage of, a larger common plan of development or sale that involves 5 acres (2 hectares) or more of earth disturbance over the life of the project.

[1] This definition reflects the Federal Phase I NPDES Program and may change upon final implementation of the Federal Phase II NPDES Program.

Phased Project - A project site that is divided into different stages to facilitate efficient project development and implementation.

Project Site – the entire area of activity, development or sale including:

- the area of an earth disturbance activity;
- the area planned for an earth disturbance activity; and
- other areas which are not subject to an earth disturbance activity.

*Subsequent Phas*e(s) - All other phases after the initial phase that are generally identified in location and scope in the permit application, but not specifically designed and not approved for construction under the initial phase of the project. Subsequent Phase(s) will be approved after detailed construction drawings, plans, erosion and sediment control plans, and other required information is submitted and approved by the Department.

Chapter 105 Waterway Restoration Permit - An individual Chapter 105 water obstruction and encroachment permit, typically issued to a watershed organization for a project with a primary purpose of waterway restoration, using standard protocols, assessment procedures, and designs to support the re-establishment of natural stream flow, dynamics, and environmental conditions.

PHASED NPDES STORMWATER CONSTRUCTION AND E&S PERMIT PROCESS

- **Applications**

General NPDES Permits - A Notice of Intent (NOI) for coverage by a NPDES General Permit for Stormwater Discharges Associated with Construction Activities involving a Phased Project must contain the following information.

1. Notice of Intent for General Permit;
2. Permit application fee;
3. Act 14 notification letters and proof of receipt from the municipality and c county;
4. PNDI Supplement No. 1 for Project Site (all phases);
5. Erosion and Sediment Control Plan (E&S Plan) containing the following information:

   a. For the Project Site:

   1) The existing topographic features for the Project Site and immediate surrounding area.

   2) The types, depth, slope, locations and limitations of the soils.

   3) A narrative description identifying the characteristics of the earth disturbance activity including past, present, and proposed land uses, and a

description of the planned physical alterations, earth disturbances, and other construction activities, as well as a description of anticipated BMPs, including BMPs for special protection waters.

4) The location of all surface waters which may receive runoff within or from the project site, and their classification pursuant to Chapter 93.

5) Procedures to ensure the proper handling, storage, control, disposal and recycling of wastes or other materials that have a potential to cause pollution;

6) A narrative description and a map (USGS topographic quadrangle or equivalent) of the project area that identifies the location and characteristics of sensitive areas or areas of environmental concern for the project site. Sensitive areas or areas of environmental concern include but are not limited to: wetlands, special protection waters, historic or cultural resource areas and areas where threatened or endangered species or critical habitat may be present.

b. For the Initial Phase of the project:

1) A detailed description identifying the specific BMPs that will be used, plan details, drawings, specifications, and a sequence of BMP installation.

2) The amount of projected runoff and supporting calculations for each BMP.

3) E&S Plan drawings identifying the location and boundaries of the phase, the locations of BMPs that will be used, construction details, specifications, and a legend. Typical sketches may be used but must provide sufficient detail to illustrate critical dimensions and construction requirements.

4) Maintenance program including the inspection of BMPs on a weekly basis and after each measurable rainfall event, and the type of maintenance required for each BMP to ensure effectiveness.

Individual NPDES or E&S Permit - Individual NPDES or E&S Permit applications must include all of the information identified for General Permit NOIs, plus the following**:**

1. Individual NPDES Permit for Stormwater Discharges Associated with Construction Activities or E&S Permit application form.

2. General Information Form (GIF).

3. Act 67, 68, and 127 Notifications and proof of receipt.

4. Cultural Resource Notices when the earth disturbance for the Project Site is 10 acres or more.

- **<u>Permit Processing Guidelines</u>**

<u>General NPDES Permit</u> **-** General Permit NOIs are reviewed for administrative and technical completeness. Upon approval of the Initial Phase E&S Plan, notice is published in the *Pennsylvania Bulletin* authorizing the use of the general permit. Approval of Subsequent Phase(s) will be published in the *Pennsylvania Bulletin* and will identify the specific phase of a project being approved for construction. Earth disturbance activities associated with the Initial Phase and Subsequent Phase(s) may commence when the permittee receives written authorization of the Departments approval for that phase.

<u>Individual NPDES or E&S Permit</u> - Individual permit applications are reviewed for completeness. A public notice of the individual permit application will be published in the *Pennsylvania Bulletin* for a 30-day comment period after the application is deemed administratively complete. Upon the approval of the individual permit application and Initial Phase E&S plan, the Department will publish a second notice in the *Pennsylvania Bulletin* informing the public of its decision. Approval of Subsequent Phase(s) will be published in the *Pennsylvania Bulletin* and will identify the specific phase of a project being approved for construction. Earth disturbance activities associated with the Initial Phase and Subsequent Phase(s) may commence when the permittee receives written authorization of the Department's approval for that phase.

- **<u>Subsequent Phase Approvals</u>**

Before initiating any earth disturbance activities on Subsequent Phases, the permittee or co-permittee must submit the following information for review and approval before project implementation of the phase:

1. A detailed description identifying the specific BMPs that will be used, plan details, drawings, specifications, and a sequence of BMP installation.

2. The amount of projected runoff and supporting calculations for each BMP.

3. E&S Plan drawings identifying the location and boundaries of the phase(s), the locations of BMPs that will be used, construction details, specifications, and a legend. Typical sketches may be used but must provide sufficient detail to illustrate critical dimensions and construction requirements.

4. Maintenance program including the inspection of BMPs on a weekly basis and after each measurable rainfall event, and the type of maintenance required for each BMP to ensure effectiveness.

The Department will publish a notice, in the *Pennsylvania Bulletin*, of approval for the Subsequent Phase(s) as an action under the previously authorized permit. Approval of a Subsequent Phase is not considered a permit modification.

- **<u>Post Construction Stormwater Management</u>**

Best Management Practices are used to minimize the potential for accelerated erosion and sedimentation during and after construction. The applicant is required to identify post-construction stormwater BMPs as part of the Individual NPDES Stormwater Construction Permit application or Notice of Intent for the General NPDES Stormwater Construction Permit. In addition, both the Individual and General NPDES stormwater Construction Permits require compliance with local ordinances developed under an Act 167 Stormwater Management Plan. Permanent stormwater management BMPs must be operated and maintained in accordance with the approved maintenance plans.

PERMIT AND E&S PLAN MODIFICATIONS FOR NPDES STORMWATER CONSTRUCTION PERMIT OR E&S CONTROL PERMIT

- **<u>Minor Permit and Plan Modifications</u>**

The Department may approve minor modifications or corrections to the NPDES or E&S Permit to allow for minor changes. These minor modifications may be used to correct typographical errors, require more frequent monitoring or reporting by the permittee or co-permittee, change in an interim compliance schedule, allow for change in ownership, or delete a point source outfall from which a discharge is terminated. Minor modifications do not require a, new permit, or public notice and comment period. The Department may approve field adjustments on-site to BMPs and locations that are within the scope of the approved plan and that do not constitute a major modification of the permitted activity, by noting and initialing changes on the E&S Plan that is available at the site.

- **<u>Major Permit and Plan Modifications</u>**

A new NPDES or E&S Permit shall be obtained for a new or increased discharge, or change of the waste stream, including any new or increased pollutant not identified in a previous permit application. Major modifications require a new permit application meeting all procedural and E&S Plan requirements identified above for either General or Individual Permit Applications, including the publication of a notice in the *Pennsylvania Bulletin*.

Example of changes that require a major permit and plan modification include but are not limited to: adding an industrial waste discharge, adding a point source discharge, and expanding the project site from that area approved in the permit.

CHAPTER 105 WATERWAY RESTORATION PERMIT PROCESS

- **Applications**

General Information - Before beginning the application process, a pre-application meeting between the project sponsors (watershed organization), designers and permitting agencies is recommended to familiarize everyone with the project scope and goals, exchange ideas, and discuss the permitting process. This pre-application meeting should include appropriate staff from the DEP regional office, US Army Corp of Engineers (USACOE), Pennsylvania Fish and Boat Commission (PF&BC), County Conservation District, US Fish and Wildlife Service (USFWS), as well as representatives of the watershed group, project designers, and others involved with the project. The regional DEP Soils and Waterways Section normally serves as the initial point of contact for permit applicants.

At the pre-application meeting, the project designers should have preliminary plans available that depict the overall project goal and planned phases of the project including an estimate of the total length of stream to be affected, sequence of phases, scope and length of each phase, anticipated BMPS to be used, and anticipated channel modifications, or realignments necessary for each phase. Detailed drawings and supporting documentation is not required for the pre-application meeting, however there should be a sufficient level of detail in order for everyone to understand the project in order to provide technical comments and specific recommendations.

After the pre-application meeting, the project sponsor will commence with the detailed analysis, design, and work plan, supported by written documentation and analysis, for the initial phase of project. In order for a permit to be processed in a timely fashion it is important that the application reflect the results of the pre-application process, and provide the appropriate level of environmental and engineering information necessary to ensure a sound project and facilitate effective and efficient permit decisions. Construction activity under a phased permit may be authorized for time periods greater than the normal three construction seasons for standard projects. The specific construction window and other terms of the permit will be based on the scope of the project.

Waterway Restoration Permit Requirements - The following information must be provided for all individual permit applications for phased waterway restoration projects:

1. For the entire project site:

    a. Completed and Signed GIF and Chapter 105 Permit Application form.

    b. The Application must be accompanied by a check in the amount of $300.00, payable to the "Commonwealth of Pennsylvania". This is a one-time fee. There is no Chapter 105 permit fee for additional phases.

c. Act 14 notifications to the county(ies) and municipality(ies) and proof of receipt.

d. Completed PNDI form and search receipt(s) for all phases of the project.

e. Cultural Resource Notice and PHMC response letter for all phases of the project.

f. A location map of a scale factor of 1:24000 (standard U.S.G.S. Topographic Map). The location map shall show:

   1) The entire project limits, including the identification of the initial phase and all subsequent phases.

   2) All natural features including the names and boundaries of regulated waters of this Commonwealth, natural areas, wildlife sanctuaries, natural landmarks.

   3) Political boundaries.

   4) Locations of public water supplies.

   5) The contributory drainage area.

   6) Other geographical or physical features including cultural, archeological and historical landmarks within 1 mile of the site.

g. Project description. A narrative of the project shall be provided which includes:

   1) The project purpose.

   2) A written narrative that clearly identifies the stream's problems and describes the scope and objectives of the project.

   3) Alternatives analysis – A detailed analysis of alternatives to the proposed action, including alternative locations, routings or designs to avoid or minimize adverse environmental impacts.

   4) The upper and lower limits of the project using standard latitude and longitude reference coordinates.

   5) A written description of the activities, structures, BMPs and implementation methods, including a rationale for selected alternatives, that will be utilized throughout all phases of the project.

6) The effect the project will have on public health, safety or the environment.

7) A statement on water dependency. A project is water dependent when the project requires access or proximity to or siting within water to fulfill the basic purposes of the project. For purposes of waterway restoration activities, it is presumed the activities are water dependent.

8) A detailed impact analysis of the potential impacts, to the extent applicable, of the proposed project on water quality, stream flow, fish and wildlife, aquatic habitat, Federal and State forests, parks, recreation, instream and downstream water uses, prime farmlands, areas or structures of historic significance, streams which are identified candidates for or are included within the Federal or State wild and scenic river systems and other relevant significant environmental factors. If a project will affect wetlands the project description shall also include:

    a) A narrative of the delineation process supported by the appropriate data sheets and copies of appropriate soil maps and descriptions from soil conservation service soil surveys. Soil conservation service soil surveys may be obtained from the county conservation district offices.

    b) An analysis of whether the wetland is exceptional value as classified in § 105.17 (relating to wetlands).

    c) A statement on water dependency. A project is water dependent when the project requires access or proximity to or siting within water to fulfill the basic purposes of the project.

9) An application for a project which will affect less than 1 acre of wetland where the wetland is not exceptional value wetland shall also include a description of functions and values of the existing wetlands to be impacted by the project, as defined in § 105.1 (relating to definitions).

10) An application for a project which may have an affect on an exceptional value wetland or on 1 or more acres of wetland shall also include an assessment of the wetland functions and values using a methodology accepted by the Department and a survey, conducted by a licensed professional land surveyor, of the wetland boundary as delineated and of the property lines of the parcel where the project is located.

11) A mitigation plan to mitigate any adverse impacts to wetlands that are incidental to the waterway restoration project.

h. Stormwater management analysis. If a stormwater management plan has been prepared or adopted under the Stormwater Management Act (32 P.S. §§ 680.1-680.17), an analysis of the project's impact on the Stormwater Management Plan and a letter from the county or municipality commenting on the analysis shall be included.

i. Floodplain management analysis. If the proposed dam, water obstruction or encroachment is located within a floodway delineated on a FEMA map, include an analysis of the project's impact on the floodway delineation and water surface profiles and a letter from the municipality commenting on the analysis.

j. Risk assessment. If the stormwater or the floodplain management analysis conducted in subparagraphs (h) and (i) indicates increases in peak rates of runoff or flood elevations, include a description of property and land uses which may be affected and an analysis of the degree of increased risk to life, property and the environment.

k. For projects that incorporate fluvial geomorphology methodology (FGM) principals, a reference stream reach or regional curve data must be provided.

l. Environmental Assessment Form, Part 1 items 1-7, Part 2 and Part 3 for the entire project including the initial phase and all subsequent phases.

m. Limits of project disturbance should be clearly shown on the drawings. Wetlands within the limits of disturbance must be clearly identified on the drawings and flagged at the project site prior to start up.

n. A monitoring plan.

2. For the initial phase:

a. Photographs of the initial phase of work and a photo location map depicting the area where work will be accomplished.

b. Detailed restoration plans and construction drawings that include:

1) A plan view at a scale of 1" = 30' or larger showing the location and type of structure or activity within the initial phase of the project, depicting at least 100 feet upstream and downstream and the immediate area of the stream and the adjacent floodway. Details such as roads, utilities, buildings, and other man-made structures and natural feature such as contours and drainage patterns must be identified.

2) A complete demarcation of the floodplains and regulated waters of this Commonwealth on the site. The wetlands shall be identified and delineated in accordance with the Department's Wetland Delineation Policy as published at § 105.451 (relating to identification and delineation of wetlands – statement of policy).

3) A north arrow.

4) A scaled longitudinal profile of existing and proposed stream channel conditions for initial phase of the project area, depicting at least 100 feet upstream and downstream and the immediate area of the stream and the adjacent floodway.

5) Detailed cross sections showing the existing and proposed conditions of the initial phase of the project. These cross sections should be taken where the more extensive cuts and fills are proposed. Drawings should clearly identify cut and fill areas, i.e. cuts: shaded; fills: crosshatched.

6) Cross sections upstream and downstream of work area. The supporting hydraulic information at these sections must clearly indicate that there will be no change of water surface elevations and velocities at bankfull flow and the flow related to the flood prone area.

7) A completed morphological chart for FGM or Natural Stream Channel Design (NSCD) Projects that includes the sections of the stream that have been surveyed, stream type, stream sinuosity, bank-full flow width, flood prone areas, belt width, and other relevant information.

8) Critical engineering calculations that prove the competency of the designed channel.

c. Verification by the applicant that landowner consent/permission has been obtained to conduct activities on private property.

d. In FEMA study areas where a detailed floodway has been identified, include an analysis of the Q100 flood elevations in both existing and proposed conditions, using the Q100 flood flow identified in the narrative of the flood insurance study. This step will help justify that your design can handle all flows.

e. The name of the person who prepared the restoration plan, and the date and name of the applicants.

f. Proof of an application for a NPDES Stormwater Discharge From Construction Activity Permit application or an approved Erosion and Sediment Pollution Control Plan, whichever is applicable.

- **Permit Processing Guidelines**

Permit applications are reviewed for administrative and technical completeness. A public notice of the permit application will be published in the *Pennsylvania Bulletin* for a 30-day comment period. Upon the approval of the permit application for the Initial Phase, the Department will publish a second notice in the *Pennsylvania Bulletin* informing the public of its decision. Approval of Subsequent Phase(s) will be published in the *Pennsylvania Bulletin* as an approved action under the previously issued permit, and will identify the specific phase(s) of a project being approved for construction.

- **Subsequent Phase Approvals**

Before initiating any earth disturbance activities on subsequent phases, the permittee must submit the following information for review and approval before project implementation:

1. Photographs of the initial phase of work and a photo location map depicting the area where work will be accomplished.

2. Detailed restoration plans and construction drawings that include:

    a. A plan view at a scale of 1" = 30' or larger showing the location and type of structure or activity within the initial phase of the project, depicting at least 100 feet upstream and downstream and the immediate area of the stream and the adjacent floodway. Details such as roads, utilities, buildings, and other man-made structures and natural feature such as contours and drainage patterns must be identified.

    b. A scaled longitudinal profile of existing and proposed stream channel conditions for initial phase of the project area, depicting at least 100 feet upstream and downstream and the immediate area of the stream and the adjacent floodway.

    c. Detailed cross sections showing the existing and proposed conditions of the subsequent phase of the project. These cross sections should be taken where the more extensive cuts and fills are proposed. Drawings should clearly identify cut and fill areas, i.e. cuts: shaded; fills: crosshatched.

    d. Cross sections upstream and downstream of work area. The supporting hydraulic information at these sections must clearly indicate that there will be no change of water surface elevations and velocities at bankfull flow and the flow related to the flood prone area.

e. A completed morphological chart for FGM or Natural Stream Channel Design (NSCD) Projects that includes the sections of the stream that have been surveyed, stream type, stream sinuosity, bank-full flow width, flood prone areas, belt width, and other relevant information.

f. Critical engineering calculations that prove the competency of the designed channel.

3. Verification by the applicant that landowner consent/permission has been obtained to conduct activities on private property.

4. In FEMA study areas where a detailed floodway has been identified, include an analysis of the Q100 flood elevations in both existing and proposed conditions, using the Q100 flood flow identified in the narrative of the flood insurance study. This step will help justify that your design can handle all flows.

5. The name of the person who prepared the restoration plan, and the date and name of the applicants.

6. A current PNDI search form and search receipt for the phase proposed for construction.

7. Proof of an application for a NPDES Stormwater Discharge From Construction Activity Permit application or an approved Erosion and Sediment Pollution Control Plan, whichever is applicable.

MODIFICATIONS FOR WATERWAY RESTORATION PERMITS

- **Minor Project Modifications**

The Department may approve minor modifications or corrections to the Chapter 105 permit to allow for minor changes to the project that are within the scope of the approved plan and do not constitute a major modification of the permitted activity, by noting and initialing changes on the project site plan shall be reflected in the post construction as-built plans. Minor modifications also include correction of typographical errors and other administrative corrections to the plans or permit. Minor modifications do not require a new permit, or a public notice and comment period.

- **Major Project Modifications**

An amended or new Chapter 105 permit shall be obtained for new additions to the project area, a change in project scope, change in the nature of restoration activities, new discharges, any new direct or indirect impacts to wetlands, or any other change to the project beyond those activities identified in the initially approved permit. Major modifications require a new permit application meeting all procedural requirements identified under Waterway Restoration Permit Applications, including the publication of a notice in the *Pennsylvania Bulletin*.

APPENDIX V

Glossary

Aggradation -- the excessive accumulation of sediment that results in raising the streambed elevation

Bankfull discharge - the stream flow that transports the majority of a stream's sediment load over time and thereby forms the channel; the discharge that fills a stable alluvial channel to the elevation of the active floodplain; bankfull discharge is the basis for measuring width/depth ratio and entrenchment ratio

Cross vanes -- rock structures that extend across a stream from bank to bank; they are keyed into the bankfull elevation in order to control the channel carving flow.

Dimension - a stream's width, mean depth, width/depth ratio, maximum depth, floodprone area width, and entrenchment ratio

Degradation -- the lowering of a streambed by scour and erosion

Entrenchment -- the degree to which a channel is incised

Incised stream - a stream in which scouring causes the channel to degrade or down cut to a point where the stream is no longer connected to its floodplain

Fluvial Geomorphology (FGM) - the study of a stream's interactions with the local climate, geology, topography, vegetation, and land use; the study of how a river carves its channel within its landscape

Head cuts -- incisions or forms of channel degradation that migrate upstream for potentially great distances; head cuts are created when materials are removed from the streambed at a depth sufficient to cause the stream to adjust its slope in an upstream direction

Pattern - a stream's sinuosity, meander wavelength, belt width, meander width ratio, & radius of curvature

Profile - the mean water surface slope, pool/pool spacing, pool slope, & riffle slope

Natural stream channel design - a fluvial, geomorphic-based restoration method that uses data collection, modeling techniques, and stable or reference channels in the design of ideal channel configurations

Reference reach - a section of a stream that provides a target for a river restoration project; a reference reach must be located within the same hydro-physiographic region, have the same general land use, and the same stream type and valley form as the proposed stream.

Regional curve -- hydraulic geometry relationships that relate bankfull channel dimensions to a stream's drainage area; regional curves aid in identifying bankfull stage and dimension in ungaged watersheds and to help estimate the bankfull dimension and discharge for natural channel designs

Rip Rap -- loose rock generally about 6 to 10 inches in diameter

Rock Vanes -- rock structures used in FGM-based restoration projects; slope and shape of the rock vane reduces the velocity of the water as it flows up the vane and accelerates the flow as it rolls water away from the bank towards the center of the stream; the net effect is to protect the bank from erosion and to direct the force of the water into the center of the stream for sediment transport.

Root wads -- used to control erosion on outside bends; involves tree trunk embedded in a trench in the streambank and angled upstream with the root mass facing the flow; serves to dissipate energy by receiving the brunt of the stream energy.

Stream enhancement -- the process of implementing certain stream rehabilitation practices in order to improve water quality and/or ecological function; typically conducted on the stream bank or in the flood prone area but may also include the placement of instream habitat structures; however, they should only be attempted on a stream reach that is not experiencing severe aggradation or erosion.

Stream restoration -- the process of converting an unstable, altered, or degraded stream corridor, including adjacent riparian zone and flood-prone areas to its natural or referenced, stable conditions considering recent and future watershed conditions. This process also includes restoring the geomorphic dimension, pattern, and profile as well as biological and chemical integrity, including transport of water and sediment produced by the stream's watershed in order to achieve dynamic equilibrium.

Stream stabilization -- the in-place stabilization of a severely eroding streambank and stream bed. Stabilization techniques which include "soft" methods or natural materials (such as root wads, rock vanes, vegetated crib walls) may be considered part of a restoration design. However, stream stabilization techniques that consist primarily of "hard" engineering, such as concrete lined channels, rip rap, or gabions, while providing bank stabilization, will not be considered restoration or enhancement in most cases.