# Post-Flood Emergency Stream Intervention

# Training Manual

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**Prepared by:**
**Delaware County Soil and Water Conservation District**
**Delaware County Planning Department**

**In cooperation with:**
**The New York City**
**Department of Environmental Protection**
**Bureau of Water Supply**
**Stream Management Program**

# ~ Table of Contents ~

# ~ I. Foreword~

After a flood event, streams may look unraveled with gravel and debris strewn all over the place. Our first reaction is to put everything back to the way it was and maybe do some extra work. Typically this extra work consists of widening and dredging the channel to increase capacity. While the pressure to get into the area and move material to protect the public is understood, it is important to understand how the stream has changed as a result of the flood. Quick assessment can give the contractor or highway superintendent valuable information that will help determine how much work needs to be done and how the problem can be best resolved. Because the damage is widespread, the objective is to do the most good with the least effort. This is accomplished by addressing the most pressing problem areas and phasing the work so more complex work is left to the later stage of flood recovery. The process is akin to First Aid where the first responder must assess the scene, decide who the priority for treatment is and only do what is required to stabilize the situation until additional assistance arrives. This training material will provide information on how to assess the situation, decide where to work and what the right approach to be under and emergency response condition.

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# ~ II. Introduction to Streams ~

Understanding the stream mechanics is important when conducting stream management practices because there can be an impact upstream and downstream of your project site. In the course of transporting water from the tops of mountains to the ocean, streams also transport sediment scoured from their own beds and banks. Streams and rivers are never constant, and it is important to understand how and why streams change. An understanding of how streams work is essential when approaching stream management at any level. This section is intended to serve as an overview of stream science, as well as its relation to management practices past and present.

## Watershed

Streams reflect the regional climate, biology and geology. The water flowing through the drainage system reflects the watershed characteristics that influence the hydrologic cycle (**Figure 2.1**). These characteristics include the climate of the drainage basin, geology, topography, land use/land cover, infrastructure and vegetation.

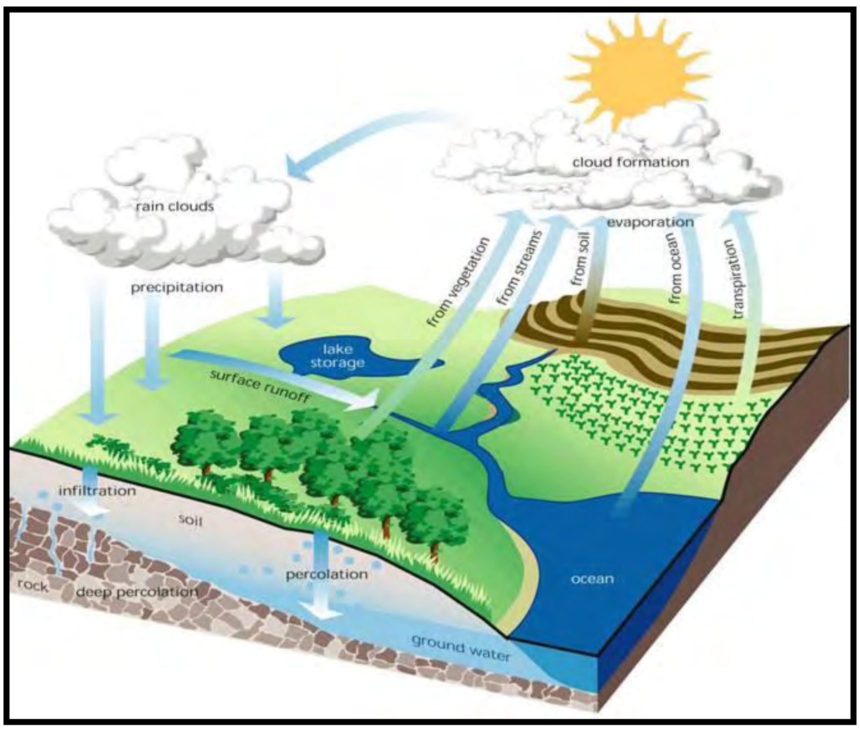



**Figure 2.1 The Hydrologic Cycle (USDA-NRCS, 1998)**

Drainage area or watershed size is part of the physical characteristics of the watershed. The size of the watershed is defined by the amount of land area that has the potential to drain stormwater runoff into the stream network. The shape of the watershed also plays a key role in the stream network; if two watersheds have the same size but different shapes, they will have different peak discharges and times of concentration resulting from the same storm event. Travel time for runoff to move through the stream network varies with watershed topography. A steep watershed typically exhibits a higher peak discharge than a flatter watershed. Climate, geology, topography, vegetation, etc. affect timing and amount of stream flow, referred to as the stream's hydrologic regime. **Figure 2.2** is a drainage area map for Chambers Hollow in the Town of Hamden using StreamStats program created by United States Geological Survey (USGS).

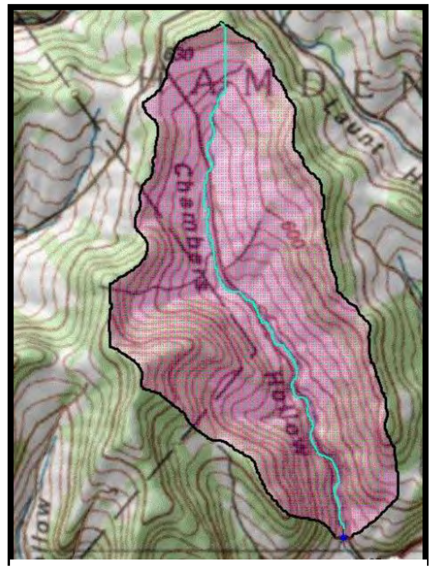



**Figure 2.2 Drainage area map from USGS StreamStat**

## Stream Flow

Streams flow at many different levels over the course of a year, ranging from the small trickle of a dry summer to the raging torrent associated with the rapid thaw of a thick snowpack. There are essentially three basic types of stream flow: base flow, storm flow, and flood flow. Base flow sustains stream flow between storms, during subfreezing, or during drought periods and is largely the water flowing into the stream from groundwater springs and seeps. Storm flow, also known as bankfull flow, appears in the channel in direct response to precipitation and/or snowmelt. Flood flow is water that gets outside of the streambanks. **Figure 2.3** shows an illustration basic stream flows in a typical stream cross section.

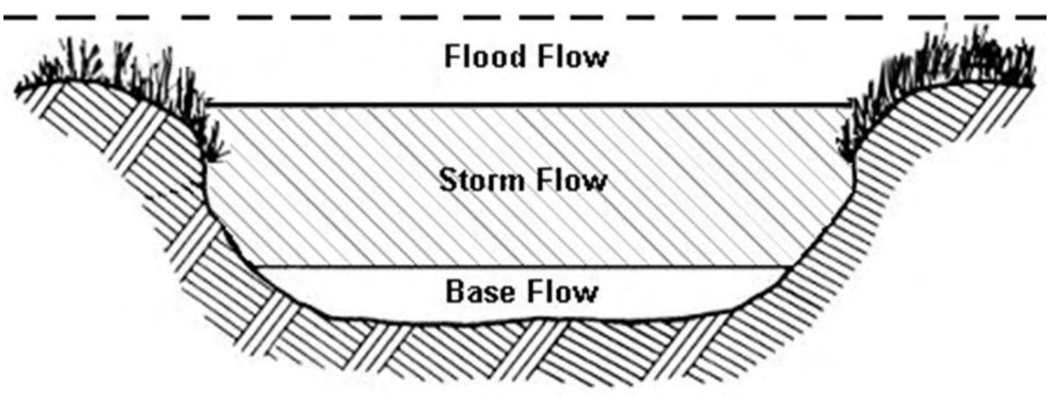



**Figure 2.3 Illustration of a typical stream cross section showing stream flows.**

**Figure 2.4** is an example of a daily mean discharge curve for the stream gage at Margaretville, NY for the period from September 2006 to August 2007. Note that the brown line indicates the average daily mean discharge (stream flow measured in cubic feet per second) for the 69 years of gage records, and the light blue line shows the daily mean discharge for the 2006-2007 period. United States Geological Survey (USGS)[1] graph also shows that most of the runoff for the watershed occurs between mid March and mid May, with a second period of runoff in the fall in November and December. This is a period when the ground is often bare and evapo-transpiration from plants is low. The precipitation that falls during this period quickly runs off and the streams are full.

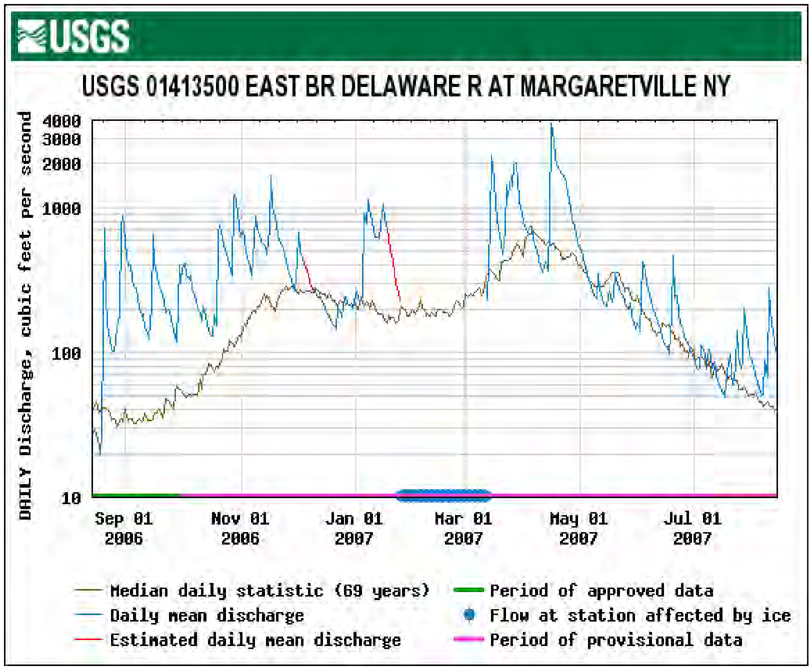



**Figure 2.4 Daily Mean Discharge Curve**

## Stream Stability

The definition of a stable stream used by Delaware County SWCD: "The tendency of a stream to maintain its cross-section, plan form and profile geometry over time, effectively transporting its water and sediment supply without aggrading (building up), degrading (down cutting), or adjusting laterally (eroding its banks)." (Rosgen)

Streams that are in balance with their landscape adapt a form that can pass the water and sediment through both small and large floods, regaining their previous form after the flood passes. In many situations, however, stream reaches become unstable when some management activity has upset that balance, altering the stream's ability to move its water and sediment effectively.

The form of a stream that is considered "stable" varies with topography. When it is in balance with mountainous terrain, a stable stream will look different than one that is in balance with rolling hills or broad floodplains. Stable streams are less likely to experience bank erosion, water quality and habitat problems. A number of factors can change the stability of streams such as changes in flow input, sediment, and land use. Channelization of the stream, berms, culverts and bridges can also have a negative impact on stream stability.

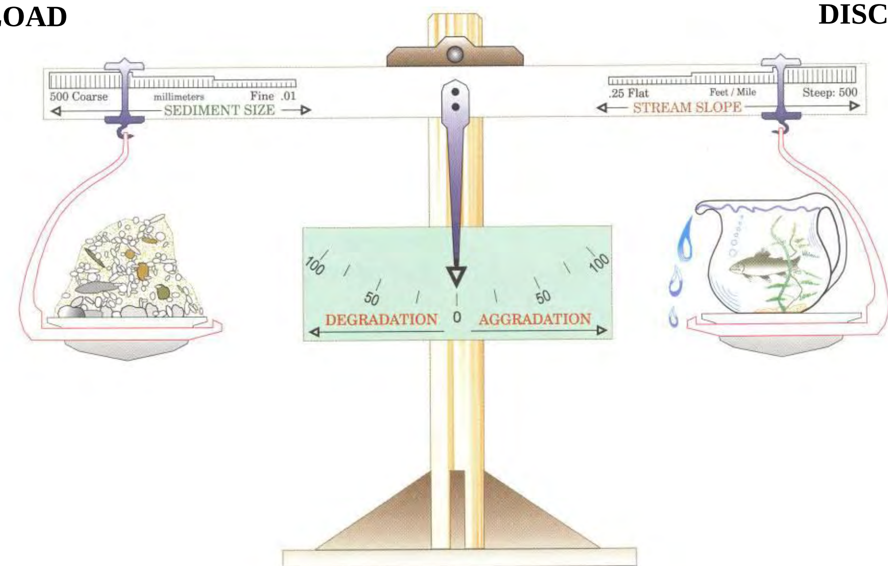
## Sediment Balance

Sediment discharge has long been recognized as one of the primary variables that determine the characteristics of a stream. **Figure 2.5** below illustrates the relationship between a set of four primary physical variables (sediment size, sediment load, stream discharge and stream slope) and two opposing processes (stream bed aggradation and degradation) that determine stream sediment and channel characteristics and balance. The figure suggests that a change in one of

[1] USGS stream gage information can be found on their website http://nwis.waterdata.usgs.gov/ny/nwis/rt

four physical variables will trigger a response in the two process variables. This in turn creates changes in stream characteristics. See **Figure 2.5a** and **Figure 2.5b**. Streams are said to be in equilibrium when the volume of water is enough to transport the available sediment without building up in the channel (also known as aggradation) or cutting down the channel bed (known as degradation). Streams will adjust their shape, size, and slope in order to transport the sediment.

**LOAD** **DISCHARGE**




**STREAM EFFECT**

**(Sediment LOAD) x (Sediment SIZE) is proportional to (Stream SLOPE) x (Stream DISCHARGE)**
**Figure 2.5 Sediment Balance (Rosgen, 1996)**

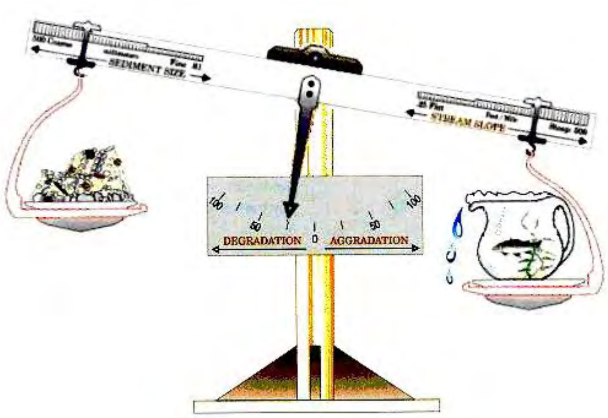



**Figure 2.5a If the supply of sediment decreases or the supply of water increases, the stream will begin to erode the stream bed or degrade. (After Rosgen, 1996)**

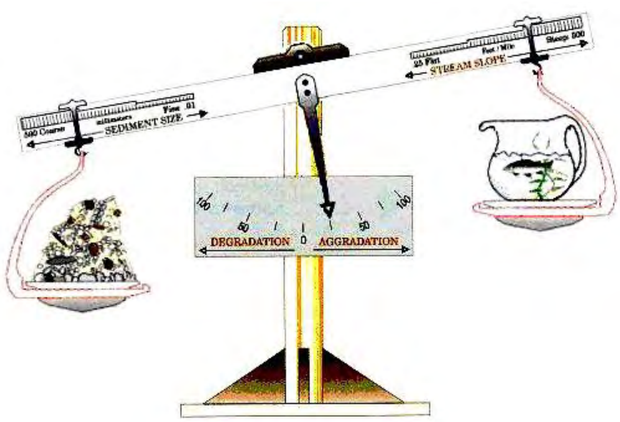



**Figure 2.5b If the supply of sediment increases or the supply of water decreases, the stream will begin to fill in with gravel or aggrade. (After Rosgen, 1996)**

## Stream Features

The features of a stream are described in terms of their planform dimensions, their longitudinal dimensions, and their cross-sectional dimension.

The overhead or "planform" view of the stream focuses on the path that the stream follows within its valley (**Figure 2.6**). Stream managers speak of a stream's sinuosity as they describe the coverage the stream meanders across the valley. Sinuosity is related to slope and energy. A stream that has sinuosity has a longer distance than a stream that is straight. The associated elevations will also differ whereas the greater the sinuosity the lower the average slope. The sinuosity of a stream is generally greater at the lower end of the valley closer to the mouth of the watershed.

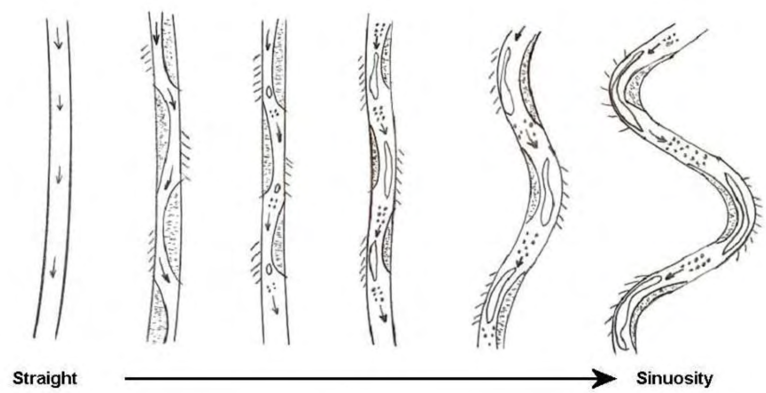



**Figure 2.6 Planform of a Stream with Increasing Sinuosity (After Keller, 1972)**

Longitudinal dimensions of a stream are used to describe how the stream changes from the top of the watershed to the mouth of the stream. The most important factor is the slope of the stream. Slope is a critical contributor to the energy of the stream. The energy of water flowing down a slope is needed to move sediment. A stream's slope can vary from high gradient (slope greater than 4%) to medium gradient (2%-4%) to low gradient (less than 2%). The slope of the stream typically is greatest at the top of the watershed (high gradient stream) and gradually declines as the stream flows down the valley (medium gradient stream) and makes its way to the bottom of the watershed (low gradient streams).

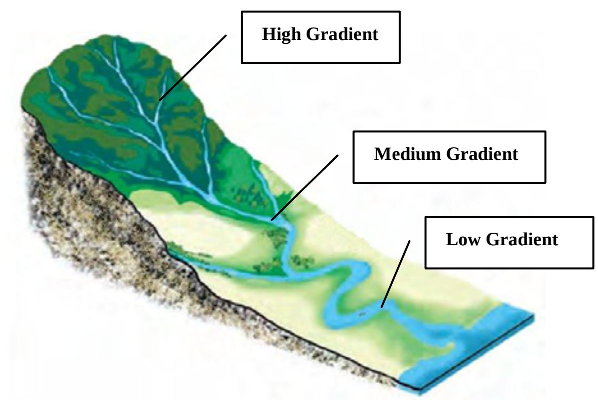



**Figure 2.7 Stream's slope from high gradient to low**

In terms of its cross-sectional dimension, a stream has a primary channel that conveys most of the flow throughout the year. Secondary conveyance of flow is the floodplain. Floodplains are the flat area of a stream system located above the top of the stream bank that is inundated with slower flowing water during and following flood flow events. Flood flows in some streams sections may not rise over the top of the banks and therefore may lack or are disconnected from their historic floodplain. Such stream channels are commonly called entrenched channels (**Figure 2.8**). Maximum depth is the distance from the top of the water at bankfull elevation to the deepest part of the channel. If at twice maximum depth the stream cannot access it's floodplain it is considered to be entrenched.

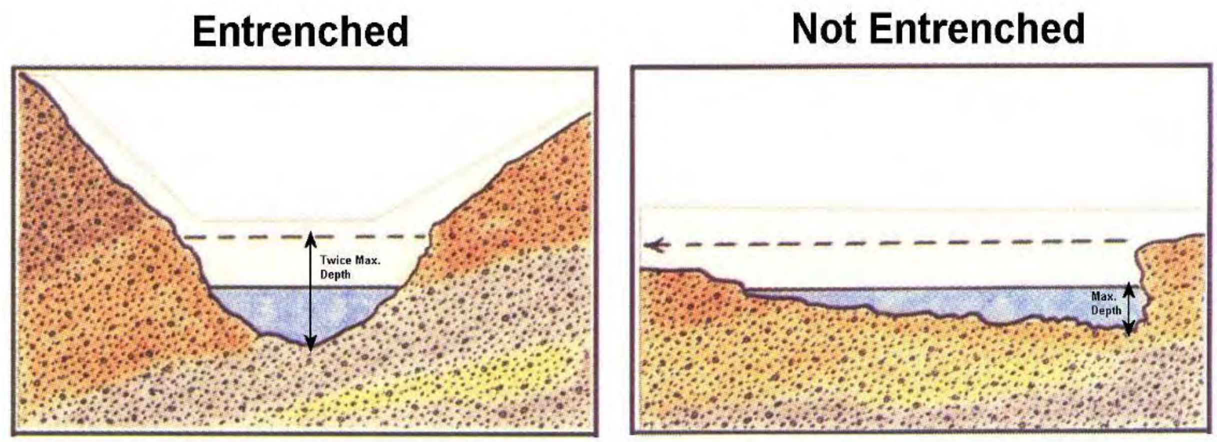



**Figure 2.8 Shows entrenched channel (After Rosgen, 1996)**

"The floodplain is defined as the flat area bordering a stream, constructed by the river in the present climate and inundated during periods of high flow" (Leopold, 1997). The floodplain is a critical component of stream function. The floodplain serves as an energy dissipater and depository of finer sediments during high flows. **Figure 2.9** shows a typical cross section of a stream system with bankfull and floodplain. Notice that a bankfull event is not considered a flood event until it over tops the banks. Bankfull happens on average, every 1.2 to 2.0 years. This discharge, from relatively frequent storms, is largely responsible for the shape of the stream channel within the floodplain.

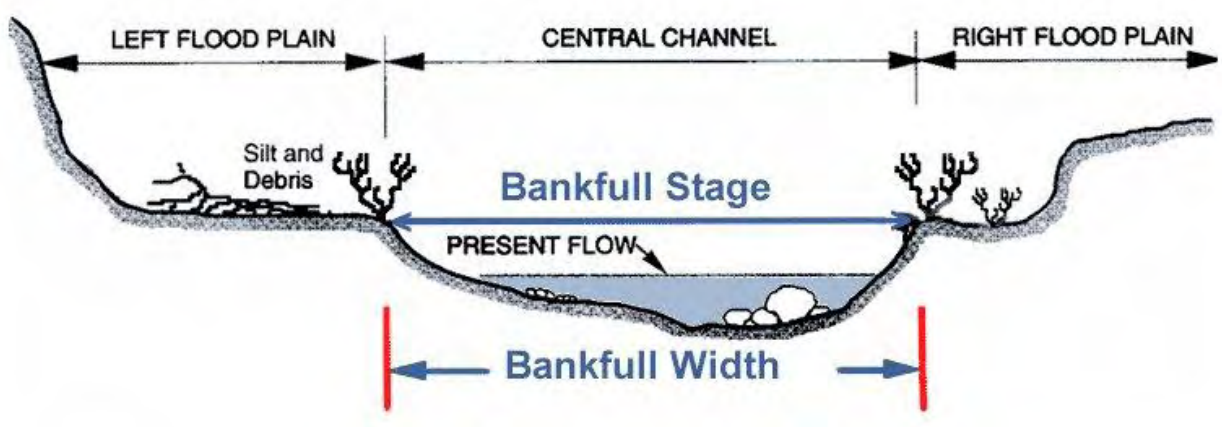



**Figure 2.9 Shows a typical cross section of a stream system (After Newbury & Gaboury, 1993))**

## Stream Type

There are two basic stream types that can be identified in the field. One is the riffle-pool sequence illustrated in **Figure 2.10**. Typically a stable stream reach will maintain a balance in the ratio of the length of riffles to the length of pools. This balance helps regulate the velocity of water when it speeds up in riffles and slows down in the pools. Pools are important features in the stream since their low slope acts to slow the velocity (hence reduce the energy of the stream). Pools are found on the stream bends and the water enters the bend into a vortex pattern dissipating the energy in the deep water. Gravel can be found on the inside of the bend (point bar), which is a characteristic of a stable stream.

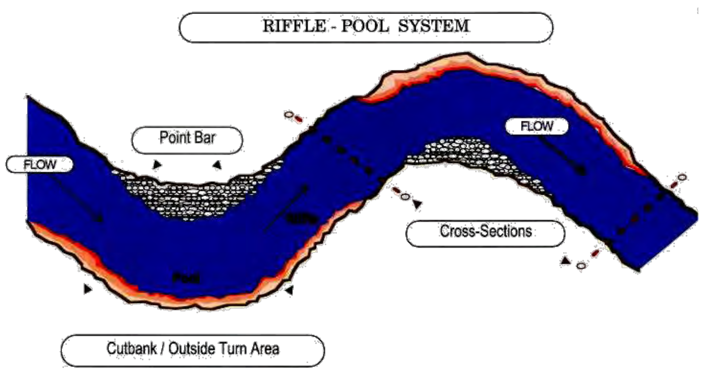




**Figure 2.10 Typical Riffle-Pool Sequence (Rosgen, 1996)**

The second stream type is called a step-pool sequence which is illustrated in **Figure 2.11**. The energy is dissipated through the stepped pools much like a series of speed bumps would slow down a car. This stream type is typically found in the headwaters or in steep narrow valleys.

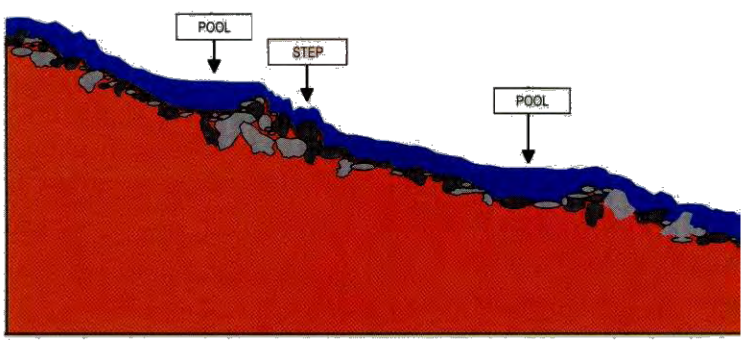



**Figure 2.11 Typical Step-Pool Sequence (Rosgen, 1996)**

## Channel Disturbance – Evolutionary Sequence

Channels that have been disturbed by dredging, incision, or channelization follow a systematic path to recovery. This process has been documented in six classes described by Simon and Hupp (1992) in **Figure 2.12**. This process can happen naturally.

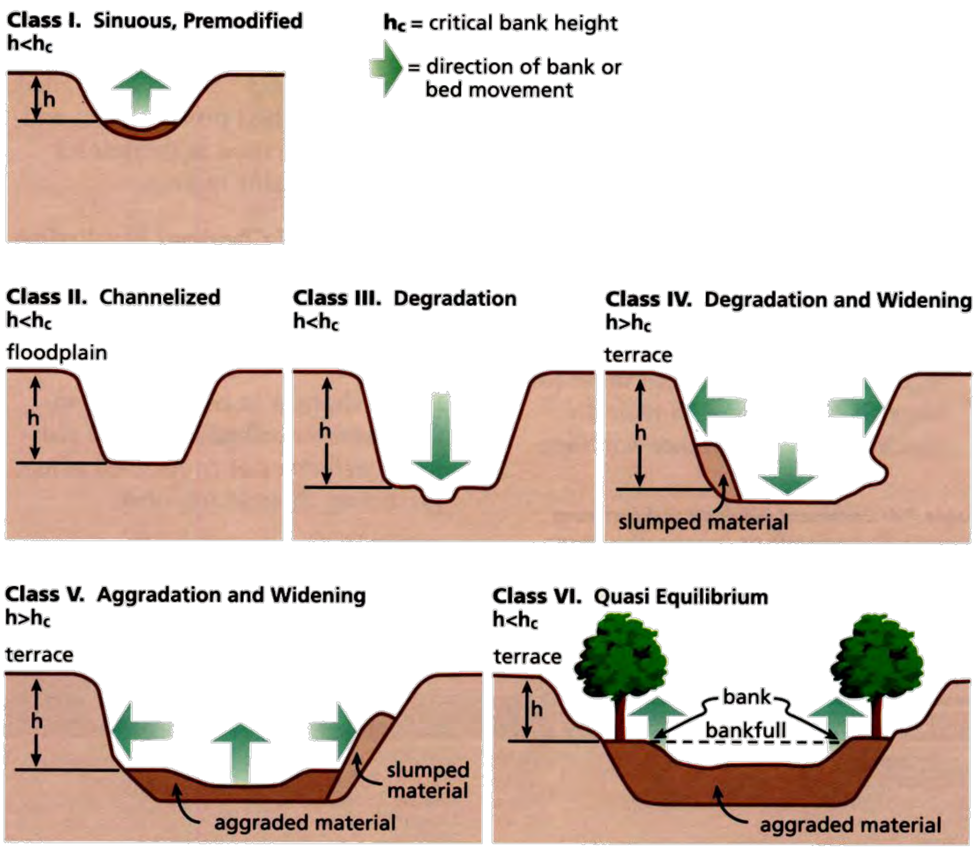



**Figure 2.12 Stream Evolutionary Sequence (Simon and Hupp, 1992)**

- Class I, is the channel in its natural pre-disturbed state.
- Class II, is the channel immediately after being disturbed (in this case, channelized, presumably straightened and steepened in addition to over-widened).
- Class III, is the channel eroding down (degrading) due to the flood waters being confined because channel is lower and out of contact with the former floodplain.
- Class IV, the channel continues to degrade, the banks become unstable, and the channel erodes laterally.
- Class V, the channel begins to deposit eroded material in the over-wide channel, and the newly developing floodplain continues to widen.
- Class VI, and a new channel is established and becomes relatively stable. A new floodplain is established within the original channel, and the former floodplain becomes a terrace (abandoned or inactive floodplain).

## Immediate Effects of Dredging

Dredging is often proposed as a means of increasing channel capacity after a flood. On the previous page we have shown the evolutionary sequence that the stream must go through when channelization occurs. The immediate consequences of dredging are illustrated below:

**Figure 2.13** (after R. Hey, 2003) shows a stream in profile view that has just been dredged. This corresponds to Simon and Hupp's Class II in **Figure 2.12**.

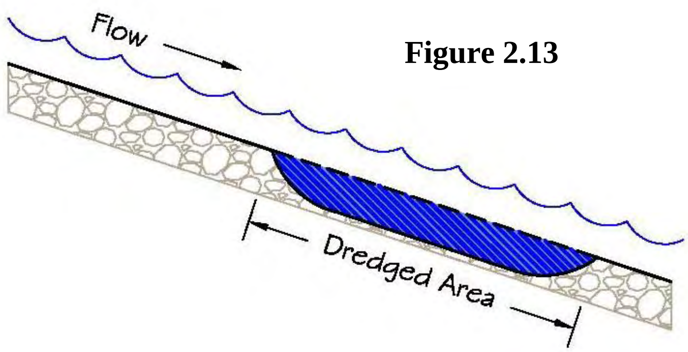



**Figure 2.13**

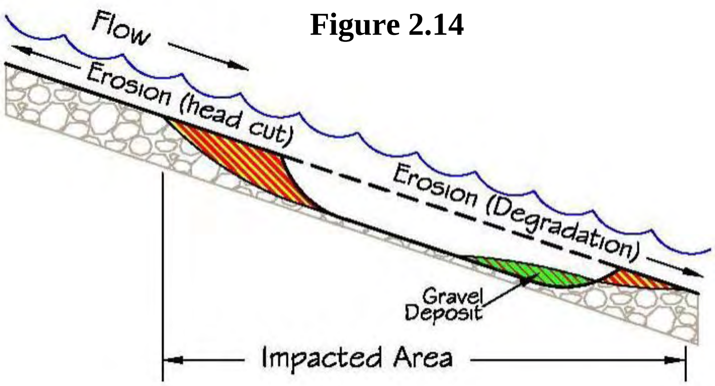



**Figure 2.14**

Within days, certainly no longer than weeks, the disturbances illustrated in **Figure 2.14** (after R. Hey, 2003) will be seen on the dredged stream.

Three things are occurring in the stream when it is dredged:

- A headcut occurs as a steep abrupt change in elevation in the stream bottom which forms upstream of the dredged area. The headcut will continue to move upstream releasing a huge amount of sediment supply from the bed and banks.
- This new sediment will be deposited at the location shown in the sketch labeled gravel deposit.
- Since the headcut is in effect lowering the elevation of the channel, erosion will occur downstream of the gravel deposit and outside of the area dredged. This occurs because the stream is trying to achieve equilibrium with a new bottom elevation and slope. In short, it is trying to match downstream with what is happening upstream. **Figure 2.15** is an illustration of a headcut that shows the instability that progresses upstream and the impacts that happen downstream.

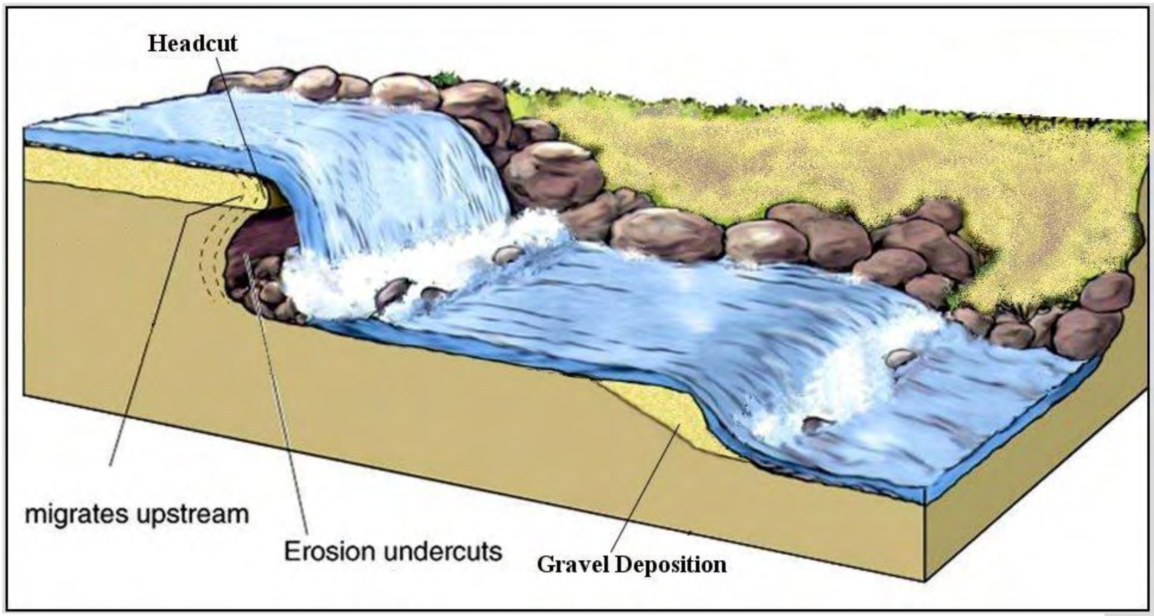



**Figure 2.15 Headcut illustration showing instability of the stream channel (after R. Christopherson, 2001)**

All of this leads to serious instabilities in the reach. Unfortunately, that is not all that can happen. The headcut, if left unchecked, will proceed upstream and destabilize more of the stream. The erosion and gravel deposition will proceed downstream and destabilize the downstream reach. If the upstream and downstream reaches are stable then this chain reaction will result in an unstable reach. If the unstable reach was further compromised with improper stream management such as dredging, the impact will further destabilized the reach resulting in steeper bank erosion. This will be greater nuisance to the municipality or landowner which may be a danger to public safety and may cost additional funding to correct the situation. **Figure 2.16** shows a headcut moving upstream on Third Brook stream Walton, NY after post-flood work using traditional deeper -wider u-shape (parabolic) stream channel was completed to repair damages from the 2006 storm event. This headcut eroded the streambed down 6 feet which has compromised existing high eroding banks within the reach. The municipality has received funding to repair some areas of the reach and is currently in the process of developing a stream management plan to address several mass slope failures within the reach.

**Figure 2.16 Headcut on Third Brook stream in Walton, NY**

## *Human Activities and Impacts on Stream Health*

The distinction between natural and human disturbances is important to understand. Human disturbances often significantly alter natural conditions and can have a longer lasting impact on the capability of the stream to function. These disturbances can include logging practices, livestock overgrazing, cropping practices, construction and maintenance of highway infrastructure, real estate development, gravel mining, dredging, channelization, berming, and introduction of non-native species in the riparian corridor. All of these practices have impacted stream stability on a watershed scale.

**Highway/Public Utility Infrastructure Influence**

Some of the most easily visible impacts to stream stability result from the construction or maintenance of highway infrastructure. Roads are commonly located close to streams, especially in the Catskill region with its narrow and winding valleys. Road encroachment has narrowed and deepened many streams, resulting in increased velocity. This causes the bed of the stream to degrade and, ultimately, to become incised, like a gully in its valley. This means that the stream reach has become unstable, which can lead to rapid streambank erosion as well as impairment of water quality and stream health. Worse yet, these local changes can spread upstream and downstream, causing great lengths of stream to become unstable.

**Figure 2.17 Culvert Conveying Holliday Brook Colchester, NY**

Roadside ditches collect stormwater runoff, carrying it away from the road and sometimes directly into streams. Roadside ditches have an impact on water quality and quantity. Without stormwater retention and/or filtration, runoff may impact streams by transporting contaminants, excess sediment, and excess nutrients as well as carrying excess water. Re-directing water away from property, fields or roads without the chance for the water to absorb into the ground results in increased runoff into the streams that will raise water levels during storm events. Ditch maintenance without re-seeding can increase sediment (turbidity) in the stream system. This can aggravate gravel deposition problems.


**Figure 2.18 Bridge with no floodplain**

Proper culvert installation and sizing is also important for stream stability. Culvert installation that utilizes improper size, slope, and headwall can lead to streambank erosion and/or gravel deposition both upstream and downstream of the culvert.

Orientation, size and approaches for bridges have had a considerable impact on stream system stability. Bridges built wider than the stream's natural dimensions will lead to the deposition of sediment under and near the structure during periods of low or base flow. Localized scour may also be present. Sediment that is deposited under the bridge may affect the designed flow capacity of the channel beneath the bridge. In many instances, the sediment must be excavated to maintain the design capacity. Bridges built narrower than the stream's natural dimensions will exhibit a depositional wedge upstream of the structure. This may lead to water to become backed up behind the bridge, resulting in local flooding upstream. Bridge approaches are usually built across floodplains in order to have a gradual transition onto the bridge. These become a floodplain block. Bridges can force water and debris that would normally be on the floodplain through a narrow opening, concentrating energy that can cause problems downstream of the bridge, such as streambank and stream bed erosion or debris plugging bridge openings. Allowing the water to convey thru floodplain culverts placed in bridge approaches will allow water to access the floodplain and reduce the risk of water backing up behind the bridge debris jams under bridges (**Figure 2.19**).


**Figure 2.19 Floodplain culverts along Delaware County Route 2 Hamden, NY**

**Residential and Commercial Development Influence**

Development of new residential and commercial districts can have a significant impact on the watershed and on the ecology of the riparian (streamside) area. Developments require access roads and utility lines that often have to cross streams. **Figure 2.20** portrays the stormwater runoff that is compared to natural versus developed landscape. Homeowners who enjoy their stream and desire to be close to it may clear all the trees and shrubs along it to provide views and access. They may replace natural conditions with an un-natural mowed lawn that provides little benefit to stream health or local wildlife. Mowed lawn will increase stormwater runoff that would normal be a slow flow and be absorbed by

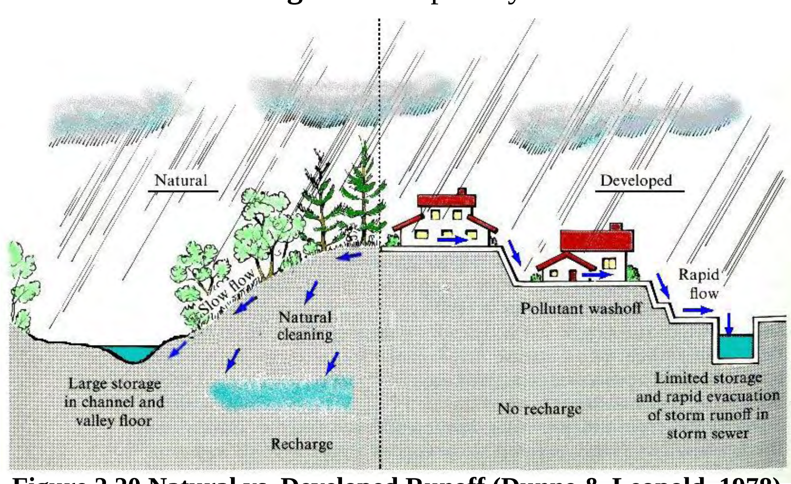



**Figure 2.20 Natural vs. Developed Runoff (Dunne & Leopold, 1978)**

the trees, shrubs and ground. This leads to increase water to the stream system that may produce new streambank erosion or increase existing erosion issues. Landowners that live close to a stream and desire access to the water can minimize the destabilization of the streambank. Careful selection of a route to the stream and locating access where the water's force on the bank is lower, a landowner can minimize disturbance to riparian vegetation and the streambank. Minimizing the disturbance in the flood prone area and promoting a dense natural buffer provide property protection, aesthetic value and wildlife habitat. Landowners should be aware of planting appropriate riparian species along the stream to maximize streambank stability.

Impervious surfaces such as houses, buildings, paved parking lots or driveways will not allow for water to be absorbed into the ground. This water will become surface water runoff that is directed into ditches or swales to be removed from the property and directed towards the stream. The increase stormwater runoff to the streams will raise water levels and will reduce groundwater recharge.

**Agricultural Influence**

The abundance of water and cold-hardy grasses have supported agricultural industries for centuries. As fields were created to obtain the most profitable land for growing crops or grazing cattle, the streams were moved to maximize property. Streams were pushed to the sides of valleys which are no longer the lowest point of elevation. These streams are traditionally maintained and reinforced to stay in place by berms, riprap or other stabilization methods. **Figure 2.21** illustrates the stream reaction to the displacement where the channel bed is filled with gravel and erosion on the streambank occurs. When water flows over the streambanks during storm events the water will flow to the lowest elevation of the valley.


**Figure 2.21 Stream that has been moved to higher elevation in a valley.**

# ~ III. Flood Response~

After a flood event, streams may look unraveled with all the gravel and debris all over the place. A first reaction is to put everything back to the way it was and maybe do some extra work. Some of these attempts at fixing the streams have been "band-aid" solutions for spot problems and have often created additional problems. Understanding the stream conditions and using stream friendly techniques can help contractors and municipalities prioritize post-flood unstable reaches for treatment. Identifying areas that are in most need of help is essential. Often looking upstream and downstream can help a contractor determine the best fit channel shape. Allowing the stream to be re-connected to the floodplain will help maintain the new constructed channel. Remember that what you do at a given site should not significantly affect areas upstream and downstream. A variety of management strategies can be provided to address post-flood issues problems on both short and long-term bases.

## *Protocol*

There is a need to develop a protocol for flood response to ensure the best results with minimal adverse impacts. Developing an emergency plan can help with organization of resources and determine where work is needed. Assessing and correcting stream channel conditions on a short-term basis can be completed with minimum adverse effect on the streams and can save time and money in the long run.

### Immediate Priority

During and after a flood certain things need to be completed and they must be done immediately. Immediate priority items include, but are not limited to:

- Opening clogged bridges
- Opening closed roads
- Keeping important installations functioning, such as:
    - Power plants
    - Fire stations
    - Rescue centers
    - Water wells and systems
    - Sewage treatment plants and systems
    - Hospitals

***Immediate priority*** *items are those facilities and infrastructure which need to be repaired and/or kept open in order that further recovery may be allowed to continue, or to prevent immediate loss of human life.*

## High Priority

High priority items are those items of work that are necessary for the first part of the cleanup process. Generally, one of the first high priority items is to get the stream channels back into some sort of a functioning condition. The reason this needs to be accomplished is to:

- Open up clogged channels so they can convey their normal flow.
- Put channels back in place to prevent continued flooding.
- Open up clogged bridges to prevent additional flooding should there be another storm.
- Stabilize streambanks to prevent erosion. If left unchecked this can lead to deposition, which in turn can lead to more localized flooding.
- Attempt to stabilize landslides, at least on a temporary basis, so they do not slide into the channel and trigger an avulsion and/or localized flooding.
- Get the channel into a condition such that the natural processes of streams can begin to return the stream to its pre-flood condition.

Other work may also qualify as high priority. This training guide is intended to describe an efficient method that may be used for the emergency repair of impaired stream channels after a flood. The material which follows concentrates primarily, although perhaps not exclusively, on post-flood emergency channel repair.

## Assess the Stream Reach

Knowing where to work and where not to work in a stream will help save time and money. Not all streams will need to have work done to them after a flood, even if at first glance, they appear to be in bad condition. In many cases the stream will have created a new, stable condition. Therefore, the first thing to do is assess the condition of the stream.

**Appendix A** is the "Problem Itemization Sheet". It is a check list of problems commonly found after a flood. It is highly recommended to take copies of this sheet out in the field, to be used in the assessment of streams. The sheet can be used to:

- Identify the number of problem sites
- Itemize the number and type of problems on a given reach
- Identify the most severely impacted reaches
- Prioritize reaches with more severe problems
- Determine manpower and equipment needs
- Serve as documentation for state or federal reimbursement
- Help document work done under an emergency permit
- Serve as documentation for additional permits

When a damaged reach is assessed, the upstream and downstream reaches should be assessed as well. For example, the upstream reach is not damaged, it is possible to measure certain physical features and then "duplicate" that reach at the damaged reach.

## Perform the Work

When the assessment is complete and priorities have been established, work can begin to restore the damaged steam reaches.

## Assess and Document Further Needs

Documentation is important for any project. This information can be used for flood aid reimbursement and/or future long term mitigation planning. A stream manager/contractor should provide the following:

- Project sketch or drawing
- Before and after photos
- Written description of work
    - Date
    - Time
    - Equipment
    - Material
    - Labor force

Note any future work that needs to be done. Even though the channel may be reformed to the approximate correct size, long term mitigation may be required. Such as:

- Vegetation that may need to be planted
- Structures that may be required to permanently stabilize the stream

A post construction assessment should be made. DCSWCD and NYCDEP can be asked to provide technical assistance and to help with a monitoring plan.

## *Improper Sizing of Channels*

Over-sizing or under-sizing a stream may create future problems for the area and should be avoided. Dredging the entire stream from top to bottom creates more problems. If the stream is disconnected from its floodplain, the stream will begin to down-cut, causing the streambanks to be taller, steeper, and more unstable. This can create a whole new set of problems that will end up costing more money in the end.

An example of improper stream sizing is the classic parabolic shape, or u-shape, channels. This technique is highly discouraged due to the fact that the parabolic shape concentrates the water flow with no energy dissipation and the smooth surface increases the water velocity. The serious of figures below show the sequence of stream evolution after the Third Brook stream located in Walton, NY was fixed after the 2006 flood event using the parabolic design.

**Figure 3.1** shows an area of stream directly after a flood event. This area appears to be in bad condition, but it is in relatively stable form. The sediment after a flood flow settles out into an overlapping or shingle-like effect wedging sediment material together. This interlocked material is less likely to move in a smaller storm event.


**Figure 3.1 Section of stream that has been flooded.**


**Figure 3.2 The classic parabolic stream channel shape.**

**Figure 3.2** is in the same location as in **Figure 3.1** after some stream construction was conducted. Notice the classic parabolic shape stream channel. Re-arranging the stream bed and banks loosened the sediment material which allows this material to be more transportable. The smooth bank and rounded streambed allows for the water to speed up.

**Figure 3.3** shows the stream channel two months later. Notice that the stream has begun to erode its streambanks and become wider. The loose sediment is easily transported downstream.


**Figure 3.3 Two months of stream channel evolution.**


**Figure 3.4 Three months of stream channel evolution.**

**Figure 3.4** shows the stream channel three months after construction. The stream has continued to adjust, further eroding its streambanks and creating a floodplain. The original floodplain is so high that it is now a terrace.

## *Proper Sizing of Channels*

To avoid situations such as described on the previous pages, it is necessary to work with the stream and to have an understanding of how streams work. The simplest solution is to do nothing and allow natural processes to do the work. But in most situations this cannot happen due to existing infrastructure such as homes, bridges, or roads that are threatened.

Various solutions are provided in the next few pages as an alternative to just going into a stream and "winging it". There is no one answer that fits all streams, and in some cases technical assistance may be needed. In these cases, contact Delaware County Soil and Water Conservation District (DCSWCD) Stream Corridor Management Program (SCMP) or New York City Department of Environmental Protect (NYCDEP) for any assistance.

There are two ways to properly size channels:

- The Stable Reach Concept
- Using Regional Hydraulic Relationship Curves

## The Stable Reach Concept:

*This is the preferred method*. In some cases only a section of stream is damaged. The simplest solution in this case is to look upstream and/or downstream of the area to find a relatively undisturbed "stable" section. Measure the width, depth, and slope of this area and duplicate these measurements at the impacted area. A suggested method of surveying the cross section is shown in **Figure 3.5**. These measurements should be checked using the Regional Hydraulic Relationship Curves as shown in **Figure 3.7**. This "duplicating" method will allow for natural processes to adjust the stream and have minimal adverse impact to the stream health. It will also give you information about the presence and size of important features of the stream, such as the floodplain benches, pool depths, or the stream's meander geometry.

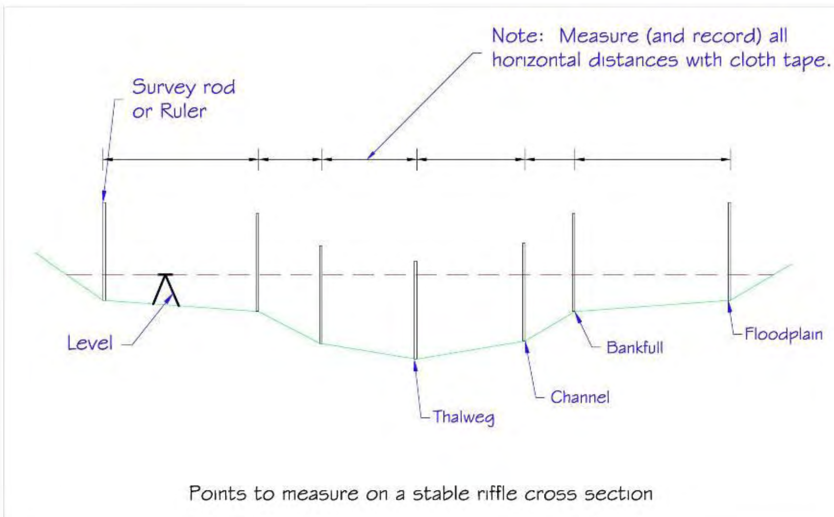



**Figure 3.5 Surveying A Stable Cross Section**

When you have finished your survey your sketch of the cross section should look something like **Figure 3.6**.

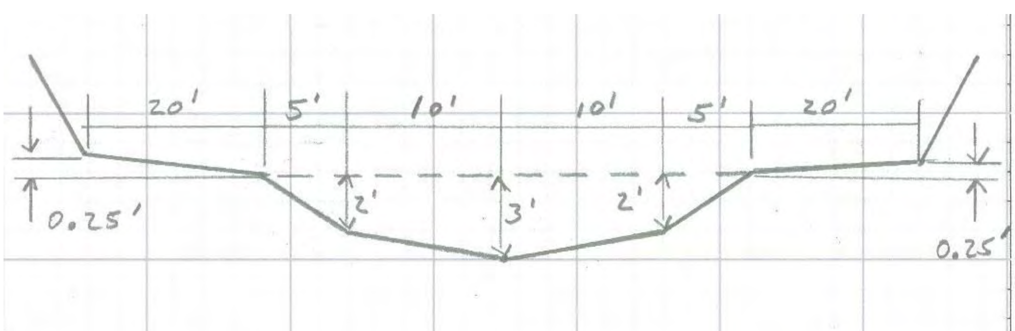



**Figure 3.6 Sketch of Stable Cross Section**

## Using Regional Hydraulic Relationship Curves:

In cases where the stream was completely devastated by a flood event, the Regional Hydraulic Relationship Curve (Regional Curves) can be used to determine stream channel dimensions. These Regional Curves for the Delaware River basin were developed by DCSWCD and NYCDEP using information gathered from USGS stream gaging stations. These curves are extremely useful when performing emergency stream mitigation. An example of how the Regional Hydraulic Curves can be used is provided below:

> A damaged section of stream with a 25 square mile drainage area has a post-flood width of 80 feet, an average depth of 1.3 feet, and a cross-sectional area of 104 square feet. By interpolating from the Regional Curves (**Figure 3.7**), the average channel width should be 56 feet, the bankfull depth should be 2.5 feet, and the cross-sectional area of 140 square feet.

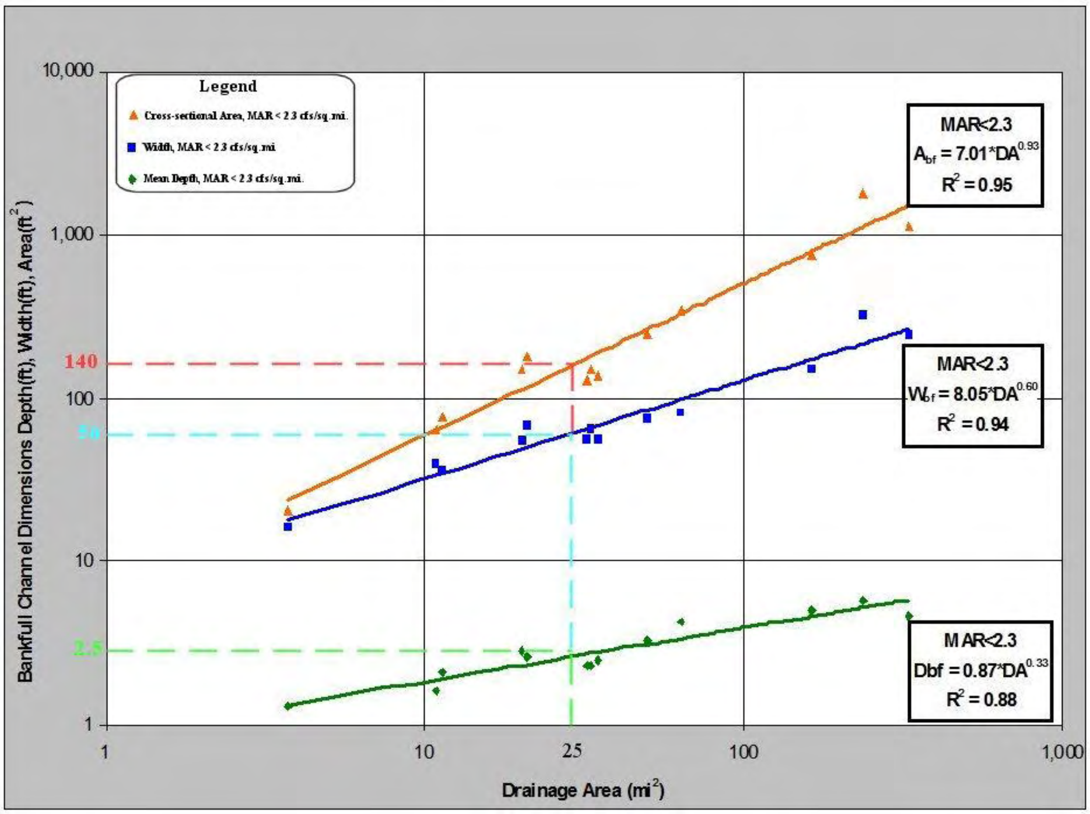



**Figure 3.7 Regional Hydraulic Relationship Curves**

This means that the reach in question is both too wide and too shallow, and it will likely aggrade, widen, and become shallower. More frequent flooding is also likely. Such a reach would be noted as being "impacted" and, as part of developing a mitigation plan, DCSWCD staff is available to further examine the watershed to determine the cause of these issues.

Based on the Regional Curve, DCSWCD staff can design a typical cross section that can be used for the emergency reconstruction of a severely damaged stream. Such a typical section would look much like the one shown below in **Figure 3.8**.

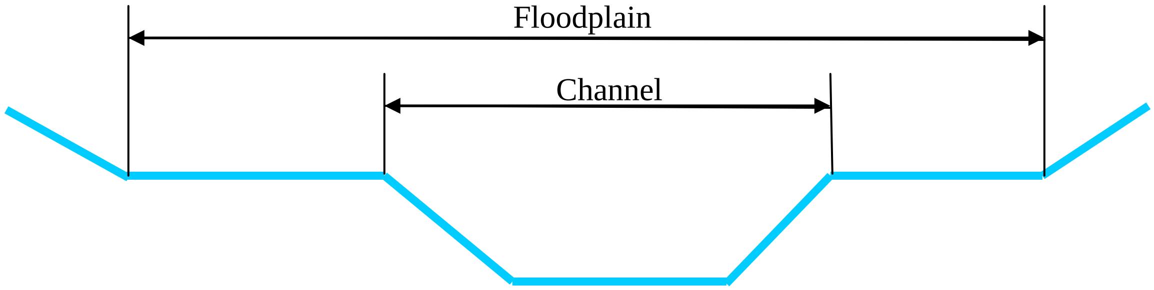



**Figure 3.8 Typical Stream Cross Section for Emergency Stream Intervention**

**Bankfull Hydraulic Geometry vs. Drainage Area for Selected Drainage Areas**

Bankfull hydraulic geometry tables have been produced that are based on the Regional curves. *If the drainage area is known*, the tables on the following pages give dimensions that can be used for the *emergency reconstruction* of stream channels.

The drainage area (D.A.) can be found by:

- Using the maps created by DCSWCD and provided to the Town Highway departments
- USGS has this website operable http://water.usgs.gov/osw/streamstats (Verified March 21, 2012). Instructions for use are found on the left side of the web page. Click on State Applications to access New York. Additional instructions for using the USGS NY State site are in **Appendix D**.

***These tables are to be used for emergencies only!***

# *EAST BRANCH DELAWARE RIVER BASIN*

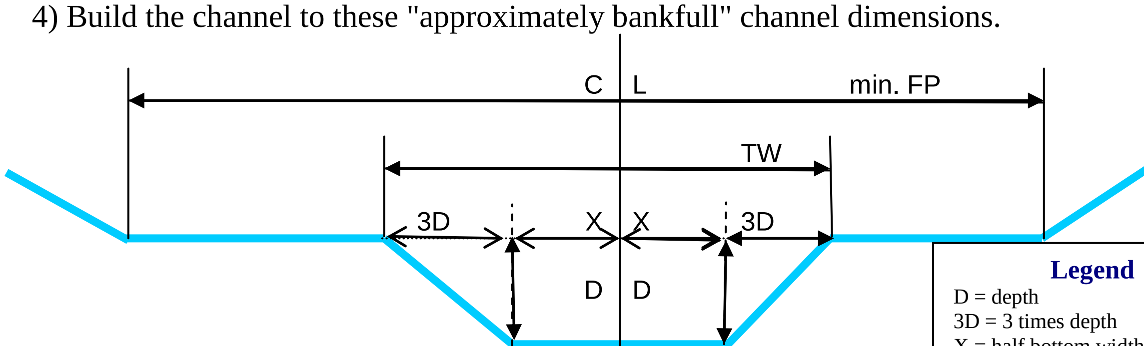
## *Bankfull Hydraulic Geometry vs. Drainage Area for Selected Drainage Areas*

| | | | | Construction Dimensions | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DA (sq. mile) | Bankfull Area (sq. ft) | Bankfull Width (ft) | Bankfull Depth (ft) | channel bank side slope | D (ft) | 3D (ft) | X (ft) | TW (ft) | Min. FP (ft) |
| 1 | 7 | 8.1 | 0.9 | **2:1** | 1.3 | 2.6 | 1.5 | 8.1 | 18 |
| 2.5 | 16 | 13.9 | 1.2 | **2:1** | 1.5 | 3.0 | 4.0 | 13.9 | 31 |
| 5 | 31 | 21.1 | 1.5 | 3:1 | 2.1 | 6.3 | 4.3 | 21.1 | 46 |
| 7.5 | 46 | 27.0 | 1.7 | 3:1 | 2.3 | 6.8 | 6.7 | 27.0 | 59 |
| 10 | 60 | 32.0 | 1.9 | 3:1 | 2.4 | 7.3 | 8.7 | 32.0 | 70 |
| 12.5 | 73 | 36.6 | 2.0 | 3:1 | 2.5 | 7.5 | 10.8 | 36.6 | 81 |
| 15 | 87 | 40.9 | 2.1 | 3:1 | 2.6 | 7.9 | 12.5 | 40.9 | 90 |
| 17.5 | 100 | 44.8 | 2.2 | 3:1 | 2.7 | 8.2 | 14.2 | 44.8 | 99 |
| 20 | 114 | 48.6 | 2.3 | 3:1 | 2.8 | 8.5 | 15.8 | 48.6 | 107 |
| 22.5 | 127 | 52.1 | 2.4 | 3:1 | 2.9 | 8.8 | 17.3 | 52.1 | 115 |
| 25 | 140 | 55.5 | 2.5 | 3:1 | 3.0 | 9.0 | 18.7 | 55.5 | 122 |
| 27.5 | 153 | 58.8 | 2.6 | 3:1 | 3.1 | 9.3 | 20.1 | 58.8 | 129 |
| 30 | 166 | 62.0 | 2.7 | 3:1 | 3.2 | 9.5 | 21.5 | 62.0 | 136 |
| 32.5 | 179 | 65.0 | 2.7 | 3:1 | 3.2 | 9.7 | 22.8 | 65.0 | 143 |
| 35 | 191 | 68.0 | 2.8 | 3:1 | 3.3 | 9.8 | 24.2 | 68.0 | 150 |
| 37.5 | 204 | 70.8 | 2.9 | 3:1 | 3.4 | 10.1 | 25.3 | 70.8 | 156 |
| 40 | 217 | 73.6 | 2.9 | 3:1 | 3.4 | 10.3 | 26.5 | 73.6 | 162 |
| 42.5 | 229 | 76.4 | 3.0 | 3:1 | 3.5 | 10.4 | 27.8 | 76.4 | 168 |
| 45 | 242 | 79.0 | 3.1 | 3:1 | 3.5 | 10.6 | 28.9 | 79.0 | 174 |
| 47.5 | 254 | 81.6 | 3.1 | 3:1 | 3.6 | 10.8 | 30.0 | 81.6 | 180 |
| 50 | 267 | 84.2 | 3.2 | 3:1 | 3.6 | 10.9 | 31.2 | 84.2 | 185 |

* From Regional Relationships of Bankfull Hydraulic Geometry to Drainage Area for 18 USGS Stream Gages in the Catskill Mts., NY - Stratified by Mean Annual Runoff (MAR) MAR<2.3

## Instructions:

1) Select the table for the drainage basin that your project is in.
2) Select the drainage area (DA) in the selected table that most closely matches the DA at your project site.
3) Under "Construction Dimensions" read the channel dimensions tabulated.
4) Build the channel to these "approximately bankfull" channel dimensions.




**Legend**
D = depth
3D = 3 times depth
X = half bottom width
TW = Top width
Min. FP = Minimum floodplain
CL = centerline

# *WEST BRANCH DELAWARE RIVER BASIN*

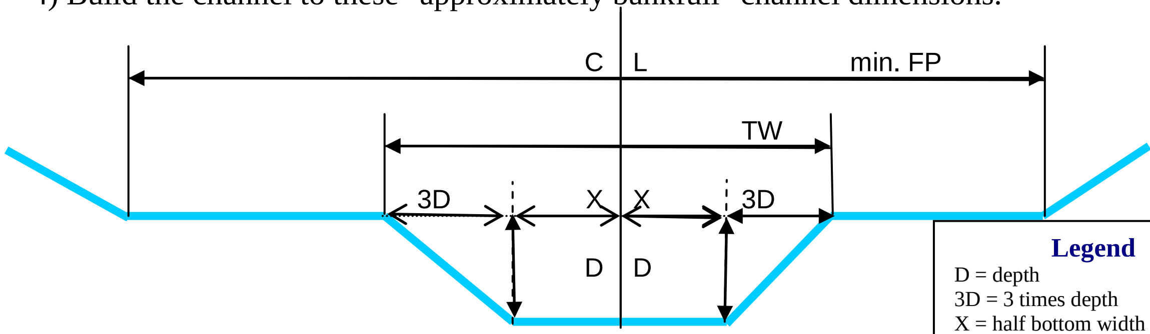
## *Bankfull Hydraulic Geometry vs. Drainage Area for Selected Drainage Areas*

| | | | | Construction Dimensions | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DA (sq. mile) | Bankfull Area (sq. ft) | Bankfull Width (ft) | Bankfull Depth (ft) | channel side slope | D (ft) | 3D (ft) | X (ft) | TW (ft) | Min. FP (ft) |
| 1 | 10 | 15.7 | 0.6 | 3:1 | 0.7 | 2.2 | 5.6 | 15.7 | 35 |
| 2.5 | 21 | 22.8 | 0.9 | 3:1 | 1.1 | 3.2 | 8.2 | 22.8 | 50 |
| 5 | 37 | 30.3 | 1.2 | 3:1 | 1.4 | 4.3 | 10.9 | 30.3 | 67 |
| 7.5 | 51 | 35.8 | 1.4 | 3:1 | 1.7 | 5.0 | 13.0 | 35.8 | 79 |
| 10 | 65 | 40.2 | 1.6 | 3:1 | 1.9 | 5.6 | 14.5 | 40.2 | 88 |
| 12.5 | 78 | 44.1 | 1.8 | 3:1 | 2.1 | 6.2 | 15.9 | 44.1 | 97 |
| 15 | 90 | 47.5 | 1.9 | 3:1 | 2.2 | 6.6 | 17.2 | 47.5 | 105 |
| 17.5 | 102 | 50.6 | 2.0 | 3:1 | 2.3 | 7.0 | 18.3 | 50.6 | 111 |
| 20 | 113 | 53.5 | 2.1 | 3:1 | 2.5 | 7.4 | 19.4 | 53.5 | 118 |
| 22.5 | 125 | 56.1 | 2.2 | 3:1 | 2.6 | 7.7 | 20.3 | 56.1 | 123 |
| 25 | 136 | 58.6 | 2.3 | 3:1 | 2.7 | 8.1 | 21.2 | 58.6 | 129 |
| 27.5 | 147 | 60.9 | 2.4 | 3:1 | 2.8 | 8.4 | 22.1 | 60.9 | 134 |
| 30 | 158 | 63.1 | 2.5 | 3:1 | 2.9 | 8.7 | 22.8 | 63.1 | 139 |
| 32.5 | 168 | 65.2 | 2.6 | 3:1 | 3.0 | 9.0 | 23.6 | 65.2 | 143 |
| 35 | 178 | 67.3 | 2.7 | 3:1 | 3.1 | 9.2 | 24.5 | 67.3 | 148 |
| 37.5 | 189 | 69.2 | 2.7 | 3:1 | 3.2 | 9.5 | 25.1 | 69.2 | 152 |
| 40 | 199 | 71.0 | 2.8 | 3:1 | 3.3 | 9.8 | 25.8 | 71.0 | 156 |
| 42.5 | 209 | 72.8 | 2.9 | 3:1 | 3.3 | 10.0 | 26.4 | 72.8 | 160 |
| 45 | 219 | 74.6 | 2.9 | 3:1 | 3.4 | 10.2 | 27.1 | 74.6 | 164 |
| 47.5 | 229 | 76.2 | 3.0 | 3:1 | 3.5 | 10.4 | 27.7 | 76.2 | 168 |
| 50 | 238 | 77.9 | 3.1 | 3:1 | 3.5 | 10.6 | 28.4 | 77.9 | 171 |

*From Bankfull Geometry vs. DA for 31 West Branch Cross Sections and 4 USGS Stream Gages with Walton at 7200cfs

## Instructions:

1) Select the table for the drainage basin that your project is in.
2) Select the drainage area (DA) in the selected table that most closely matches the DA at your project site.
3) Under "Construction Dimensions" read the channel dimensions tabulated.
4) Build the channel to these "approximately bankfull" channel dimensions.




**Legend**
D = depth
3D = 3 times depth
X = half bottom width
TW = Top width
Min. FP = Minimum floodplain
CL = centerline

## *SUSQUEHANNA RIVER BASIN*

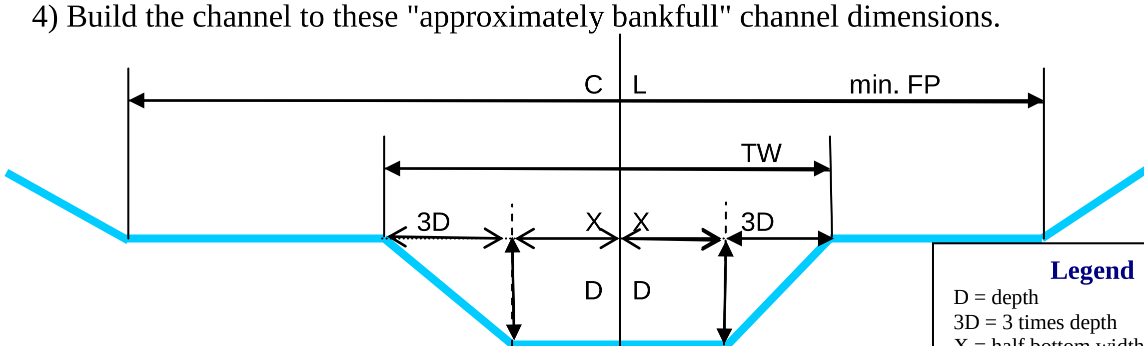
### *Bankfull Hydraulic Geometry vs. Drainage Area for Selected Drainage Areas*

| | | | | Construction Dimensions | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DA (sq. mile) | Bankfull Area (sq. ft) | Bankfull Width (ft) | Bankfull Depth (ft) | channel bank side slope | D (ft) | 3D (ft) | X (ft) | TW (ft) | Min FP (ft) |
| 1 | 11 | 13.5 | 0.8 | 3:1 | 1.1 | 3.2 | 3.5 | 13.5 | 30 |
| 2.5 | 23 | 20.4 | 1.1 | 3:1 | 1.4 | 4.3 | 5.9 | 20.4 | 45 |
| 5 | 41 | 27.8 | 1.5 | 3:1 | 1.8 | 5.5 | 8.4 | 27.8 | 61 |
| 7.5 | 57 | 33.4 | 1.7 | 3:1 | 2.1 | 6.3 | 10.4 | 33.4 | 73 |
| 10 | 72 | 38.0 | 1.9 | 3:1 | 2.3 | 7.0 | 12.0 | 38.0 | 84 |
| 12.5 | 86 | 42.0 | 2.1 | 3:1 | 2.5 | 7.5 | 13.5 | 42.0 | 92 |
| 15 | 100 | 45.5 | 2.2 | 3:1 | 2.7 | 8.0 | 14.7 | 45.5 | 100 |
| 17.5 | 114 | 48.8 | 2.3 | 3:1 | 2.8 | 8.5 | 15.9 | 48.8 | 107 |
| 20 | 127 | 51.8 | 2.4 | 3:1 | 3.0 | 8.9 | 17.0 | 51.8 | 114 |
| 22.5 | 140 | 54.6 | 2.6 | 3:1 | 3.1 | 9.3 | 18.0 | 54.6 | 120 |
| 25 | 153 | 57.3 | 2.7 | 3:1 | 3.2 | 9.6 | 19.0 | 57.3 | 126 |
| 27.5 | 165 | 59.8 | 2.8 | 3:1 | 3.3 | 9.9 | 20.0 | 59.8 | 132 |
| 30 | 177 | 62.2 | 2.8 | 3:1 | 3.4 | 10.2 | 20.9 | 62.2 | 137 |
| 32.5 | 190 | 64.4 | 2.9 | 3:1 | 3.5 | 10.6 | 21.6 | 64.4 | 142 |
| 35 | 201 | 66.6 | 3.0 | 3:1 | 3.6 | 10.8 | 22.5 | 66.6 | 147 |
| 37.5 | 213 | 68.7 | 3.1 | 3:1 | 3.7 | 11.1 | 23.3 | 68.7 | 151 |
| 40 | 225 | 70.7 | 3.2 | 3:1 | 3.8 | 11.4 | 24.0 | 70.7 | 156 |
| 42.5 | 236 | 72.7 | 3.2 | 3:1 | 3.9 | 11.6 | 24.8 | 72.7 | 160 |
| 45 | 248 | 74.6 | 3.3 | 3:1 | 4.0 | 11.9 | 25.5 | 74.6 | 164 |
| 47.5 | 259 | 76.4 | 3.4 | 3:1 | 4.0 | 12.1 | 26.1 | 76.4 | 168 |
| 50 | 270 | 78.2 | 3.4 | 3:1 | 4.1 | 12.3 | 26.8 | 78.2 | 172 |

*From USGS Scientific Investigations Report 2004-5247

## Instructions:

1) Select the table for the drainage basin that your project is in.
2) Select the drainage area (DA) in the selected table that most closely matches the DA at your project site.
3) Under "Construction Dimensions" read the channel dimensions tabulated.
4) Build the channel to these "approximately bankfull" channel dimensions.




**Legend**

D = depth
3D = 3 times depth
X = half bottom width
TW = Top width
Min. FP = Minimum floodplain
CL = centerline

## *Classroom Examples on How to Use Bankfull Hydraulic Geometry Tables*

Some examples are provided below using the tables. The answers are provided below each example with a detailed explanation.

**Example 1:**

Flooding has occurred in Bloomville, NY and repairs work is needed on a small stretch of stream. There is a bridge ¼ mile downstream of the affected area with a drainage area of 12.7 square miles. Using the appropriate table from previous pages, find the following:

a) Bankfull width
b) Bankfull depth
c) Bankfull area
d) Floodplain width

**Answer to Example 1:**

- Determine the basin in which the site is located. In this case, it is the West Branch Delaware River Basin. Use the West Branch Delaware River Basin table.
- Locate in the table the drainage area (DA) closest to the site. In this case, the closest DA is 12.5 square miles.
- The answers are highlighted in the table below:
    - Bankfull width = 44.1 ft.
    - Bankfull depth = 1.8 ft.
    - Bankfull area = 78 $ft^2$
    - Floodplain width (FP) = 97 ft.

### *WEST BRANCH DELAWARE RIVER BASIN*

*Bankfull Hydraulic Geometry vs. Drainage Area for Selected Drainage Areas*

| | | | | Construction Dimensions | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DA (sq. mile) | Bankfull Area (sq. ft) | Bankfull Width (ft) | Bankfull Depth (ft) | channel side slope | D (ft) | 3D (ft) | X (ft) | TW (ft) | Min. FP (ft) |
| 1 | 10 | 15.7 | 0.6 | 3:1 | 0.7 | 2.2 | 5.6 | 15.7 | 35 |
| 2.5 | 21 | 22.8 | 0.9 | 3:1 | 1.1 | 3.2 | 8.2 | 22.8 | 50 |
| 5 | 37 | 30.3 | 1.2 | 3:1 | 1.4 | 4.3 | 10.9 | 30.3 | 67 |
| 7.5 | 51 | 35.8 | 1.4 | 3:1 | 1.7 | 5.0 | 13.0 | 35.8 | 79 |
| 10 | 65 | 40.2 | 1.6 | 3:1 | 1.9 | 5.6 | 14.5 | 40.2 | 88 |
| 12.5 | 78 | 44.1 | 1.8 | 3:1 | 2.1 | 6.2 | 15.9 | 44.1 | 97 |

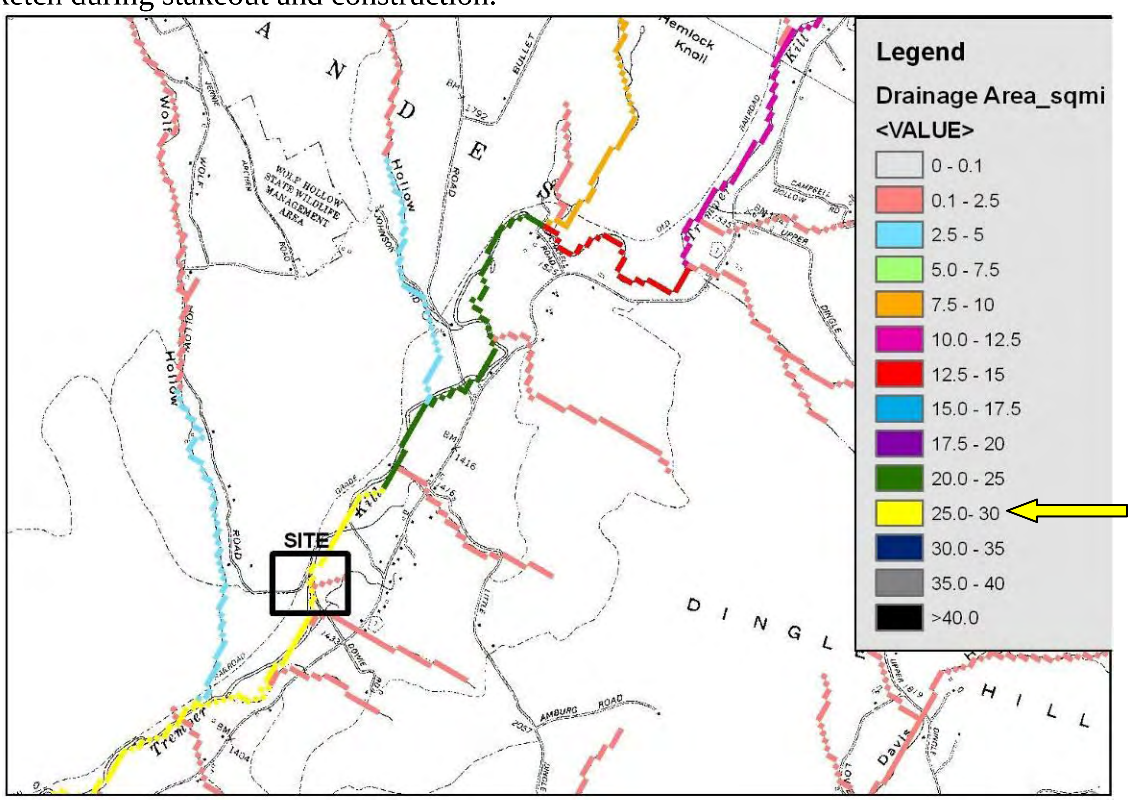
**Example 2:**

Flooding has occurred in Andes, NY on a portion of the Tremper Kill stream near Wolf Hollow Road. From the map provided determine the approximate Drainage Area (DA), then use the appropriate table to determine the approximate construction dimensions

**Answer to Example 2:**

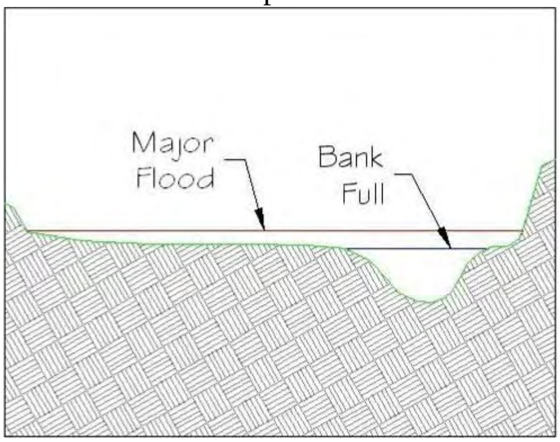
- On the map, the reach in question is color coded yellow. The key tells us that this means that the DA is between 25 and 30 square miles.
- The project is located in the East Branch Delaware River Basin. Use the table for this basin.
- As a practical matter we could use the dimensions for 25, 27.5, or 30 square miles, however the road intersection is near the upper end of the color coded reach so we will use 25 square miles.
- Under D.A. we find 25, then reading across under the heading Construction Dimensions we get the following answers:
    - D = 3.0 ft
    - 3D = 9.0 ft
    - X = 18.7 ft
    - TW (top width) = 55.5 ft
    - Min. FP (minimum floodplain) = 122 ft

It is best practice to make a sketch of the cross section using these dimensions, and then refer to the sketch during stakeout and construction.



## *Re-connecting Floodplains*

When streams are disconnected from floodplains by berming or dredging, the natural balance is disrupted – often with undesirable impacts. Berms are described as an earthen embankment or wall, usually built to provide protection or a result of side casting during stream channel dredging. **Figure 3.9** shows the same flood event occurring in both diagrams. The diagram on the left depicts slow, shallow water on the floodplain. The diagram on the right shows the same water volume, but the floodplain access has been blocked with a berm. There is a lot of water and energy that is stored behind the berm. If the structure fails it could cause devastation in its path. It is, therefore, an important component of any long-term restoration project to give prioritization to floodplain re-connection.



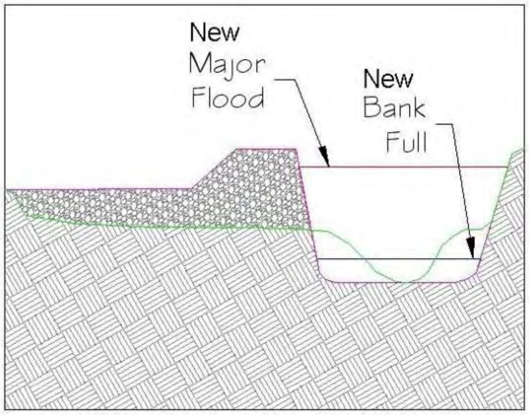




**Figure 3.9 shows the same flood situation on a fully functional floodplain vs. a filled in floodplain and berm.**

**Figure 3.10** is picture of a functioning floodplain during a storm event. Notice the slow moving water with low energy moving on the floodplain. **Figure 3.11** is picture of a berm protecting a corn field that was breached during a storm event. Notice the high energy that was released when the berm was compromised and destroyed the field.


**Figure 3.10 Functioning Floodplain**


**Figure 3.11 Berm that was breached in 2005 storm event**

## *Post-Flood Intervention using Regional Curves*

DCSWCD SCMP utilized the Regional Curves during the 2006 flood event in the Town of Walton.

**Figure 3.12** is a picture taken after the flood and before any stream construction has begun. The stream was filled with debris and sediment. Construction consisted of excavating the stream channel using dimensions determined from the Regional Curves.


**Figure 3.12 Shows stream channel after flood event.**


**Figure 3.13 Shows stream channel after Post Flood Intervention.**

**Figure 3.13** is a picture at the same location taken after stream channel construction. Notice a floodplain was constructed.

**Figure 3.14** was taken two years later at the same location. The stream has kept the general form of the cross section with a few natural adjustments. The stream is stable with minimum efforts.


**Figure 3.14 Two years later after Post Flood Intervention.**

## *Effect of Slope on Post-flood Emergency Reconstruction*

If the stream slope is found to be 4% or greater in the Catskill region, the stream *will* almost inevitably have a step-pool sequence. If the stream slope is 2% - 4% the stream *could* be a step-pool sequence. Step-pool sequence requires special construction measures and designs, such as cross-vanes or other structures designed to mimic the operation of step-pools. In post-flood emergencies, there is not enough time for such design and implementation.

In an emergency, immediate priority requires the channel be constructed as has been previously described using the Regional Curves. Stream work on a steep grade will require careful monitoring. Contact DCSWCD or NYCDEP to monitor the repair work, and if necessary, devise and implement a long-term stabilization program.

If it is not an immediate priority or you are not sure how to proceed, please contact DCSWCD or NYCDEP.

## *Consideration of Upstream and Downstream Impacts*

Impacts upstream and downstream of a stream restoration project always need to be considered. For example, if a streambank is to be armored with rip rap or other hard material, consideration must be given to increased velocities and erosion potential on an opposing downstream bank. Likewise, if a restoration project is designed to improve sediment transport through a reach, deposition potential downstream must be assessed. It is a goal with natural stream channel design to not only repair an impacted reach but to *not* create undue stress elsewhere in the stream system.

## *Using Vegetation and Natural Channel Design Structures*

Woody debris can be found in abundance after a flooding event. The large amount of debris poses huge problems such as difficulty removing the debris from the stream, disposal once removed, and the cost of disposal. The simplest solution is to utilize the woody debris onsite for streambank stabilization. DCSWCD SCMP has utilized woody debris in post-flood intervention saving time and money to implement additional projects. Placing a large tree into the streambank oriented so that the root mass is facing the water pointing upstream and the trunk is buried into the bank, is referred to as a root wad. The bottom of the root ball should be below the channel grade to avoid the toe of the root wad to be washed out and be braced with boulders or crisscrossed with other logs. Several layers maybe necessary to get the depth of the structure below the stream channel bed. The exposed root mass dissipates water, protects the streambank and provides good aquatic habitat. Root wad details can be found in **Appendix E**.


**Root wads were placed in two layers with large boulders or logs to hold them in place**

**Figure 3.15** shows a stream that has been impacted by the 2006 flood event. The stream's original channel was to the left of the willow tree and an agricultural field is located on the right where the stream is now flowing. Note the location of the willow in both pictures.

**Figure 3.15 Stream impacted by the 2006 Flood.**

**Figure 3.16** shows the stream placed back into the original channel using the Regional Curve and typical cross-sections developed by DCSWCD SCMP. The large woody debris found on-site was used as root wads to protect the streambank and newly formed floodplain.

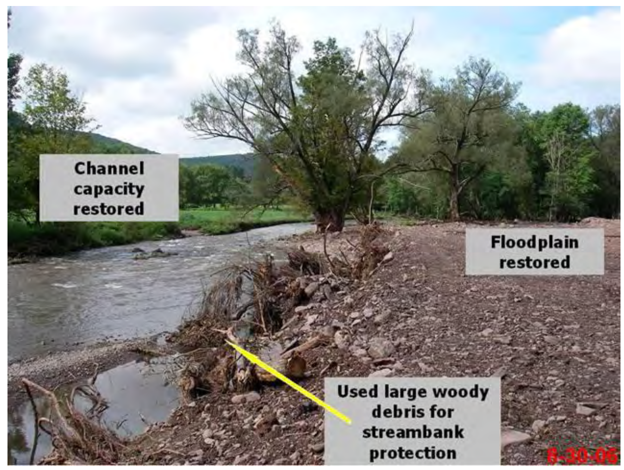



**Figure 3.16 Stream construction using Regional Curve, typical cross-section and root wad.**

Natural channel structures can be used to reduce stress on the streambank by re-directing stream flow toward the center of the stream. These typically include single arm vanes or cross-vanes that are made out of large rocks but logs maybe used in some small streams. Rock vane structures are built with layers of large rocks, one layer that is well-footed below the stream bed, and well-tied into the stream bank. The vane arm slopes from the top of the stream bank to the stream bed. A rock cross-vane is simply two single arm vanes with a throat in the center (**Figure 3.17**). Vegetative plantings are done around both at the ends of the vane arms (where they are tied into the stream bank). There is, however, a standard design for using them in restoration projects requiring technical data and they are expensive to be placed, so this option may not be feasible without funding.

**Figure 3.17 Rock Cross-Vane**

## *Limiting Gravel Removal*

As storm flows subside, bed material overlaps and becomes wedged together like shingles; this process is called imbrication. Bed material mobilizes during highwater events, and when the water velocity slows down, the material drops out. This interlocking material becomes less mobile. Rearranging the stream bed and banks loosens the interlocking material, and allows the material to become more transportable in the next highwater event. **Figure 3.18** is an example of imbrication after the June 2006 food.

**Figure 3.18 shows imbrication after the 2006 flood.**

Gravel removal at a project site should be given careful consideration. Some gravel bars, such as transverse bars (those bars across a stream that direct flow toward a stream bank), center bars (those in the center of a stream with flow on both sides), or deposition near drainage structures should be considered for removal. Point bars (those on the inside of a bend) actually serve a hydraulic function (**Figure 3.19**). Point bars are formed by lack of stream energy on the inside of a bend and are partially eroded away during flood events, then are re-deposited as flood flows subside. Removing point bars will reduce stream energy at low flows, thereby creating potential for increased deposition in the form of transverse and/or center bars.

**Figure 3.19 Looking upstream at a point bar in the Tremper Kill Sub-basin**

A straightened stream will also adjust itself. Notice in **Figure 3.20**, how the stream was manipulated in to the classic parabolic shape. This adjustment was made after the June 2006 flood event, and this photo was taken in October 2006. The stream has adjusted itself by downcutting approximately 6 feet and eroding the streambanks. The stream will continue to adjust by transporting loosened sediment downstream until it reaches equilibrium and re-builds a floodplain at a new elevation.


**Figure 3.20 shows downcutting after dredging.**

## *Environmental Permitting*

Compliance with State and Federal Environmental Permitting Laws will need to be established before work can commence. This compliance will need to be documented prior to receiving any Federal Emergency Management Agency (FEMA) or State Office of Emergency Management (SOEM) disaster relief funds. Work without the necessary permits can lead to significant fines and the need to redo the project and possible no reimbursement from funding agencies.

The New York State Department of Environmental Conservation (NYSDEC) regulates activities in and around the water resources of New York State pursuant to the Environmental Conservation Law (ECL) Article 15, Title 5, Protection of Waters Program. This is known as an Article 15 Permit, and is issued to applicants at no charge.

A Protection of Waters Permit is required for temporary or permanent disturbances to the bed or banks of a stream with a classification and standard of C(T) or higher. Examples of activities requiring this permit are:

- Placement of structures in or across a stream (i.e., bridges, culverts or pipelines);
- Fill placement for bank stabilization or to isolate a work area (i.e., riprap or other forms of revetment);
- Excavations for gravel removal or as part of a construction activity;
- Lowering streambanks to establish a stream crossing;
- Use of heavy equipment in a stream to remove debris or to assist in-stream construction.

### NYSDEC Permit Requirements

Emergency Authorizations (EA)

- Available only to Municipalities
- Issued for emergency actions to protect life, health, property and natural resources
- Written pre-notification & plan required (Or within 24 hours if not possible)
- NYSDEC must certify or deny the EA within 2 business days
- Expire in 30 days

General Permits for Widespread Natural Disasters

- Available to everyone
- Expedited review process
- Valid for all restoration work not just Emergencies
- Available for a set period after a Natural Disaster (i.e. 6 months)
- Expiration date is variable
- In Region 4 these can be issued during a site visit or on response to an application received at the DEC office
- For more information see **Appendix F** – Stream Disturbance Permit Regulations in Natural Disasters

Emergency Authorizations (EA) and Permit Conditions

All Emergency Authorizations and Permits will contain enforceable conditions designed to ensure that the project will not impact adjacent landowners, protect natural resources and maintain state water quality standards. These conditions will include:

- Isolating and dewatering the work area
- June 15 – September 30 work windows for trout waters
- Proper bedding of culverts
- No discharge of turbid waters
- Proper stabilization and re-vegetation of work site

For permit applications and any questions regarding the permit process contact the Deputy Regional Permit Administrator at:

NYS Department of Environmental Conservation
Division of Environmental Permits, Region 4
65561 State Highway 10, Suite 1
Stamford, NY 12167-9503
(607) 652-7741

Protection of Waters permit information is also available on the NYSDEC website: http://www.dec.ny.gov/permits/6042.html (Verified March 21, 2012).

## U. S. Army Corps of Engineers (USACE) Permit Requirements

Section 10 of the Rivers and Harbors Act requires a permit from the U.S. Army Corps of Engineers for any work (including structures) in or affecting navigable waters of the United States. In Delaware County, navigable waters include the East and West Branch of the Delaware River and the Susquehanna River.

Section 404 of the Clean Waters Act requires a permit for any activities that involve or result in the discharge of fill material into waters of the United States. Waters of the United States include: 1) navigable waters and adjacent wetlands, 2) tributaries to navigable waters and wetlands, regardless of their NYSDEC classification.

Typical flood response actions that require a permit are:

- Channel shaping
- Sediment removal
- Bank stabilization
- Culvert and bridge repair or replacement
- Road repair or replacement that takes place in water
- Cofferdams or temporary fills required to complete the work

Minor projects with minimal individual and cumulative impacts may be authorized under general permits including Nationwide Permits. Many Nationwide Permits require pre-construction notification to the Army Corps prior to the commencement of work, especially if the activities:

- Are in or near wetlands
- Are in or near riffle pool complexes
- May affect historic property
- May affect endangered species

All terms and conditions of the Nationwide Permit must be complied with even if pre-construction notification or prior written approval of the Army Corps is not required. Special conditions, such as monitoring requirements, may be added to a permit by the Corps to assure that impacts are minimal.

The U.S. Army Corps of Engineers also has emergency procedures (33 CFR Part 325.2), which may be used to authorize work when their existing permit processing procedures are not timely enough for responding to emergency work.

*NYSDEC* ***no longer forwards permit applications to the Army Corps***. The applicant must send a copy of the application to the Army Corps. If the emergency is a federal declared disaster, the Army Corps will accept complete jurisdictional inquiry forms which are available from State Office of Emergency Management (SOEM).

Nationwide permits may be used to authorize the types of activities typically done in response to flooding events:

- Nationwide Permits 3 – Maintenance
- Nationwide Permit 13 – Bank Stabilization
- Nationwide Permit 27 – Aquatic Habitat Restoration, Establishment, and Enhancement Activities
- Nationwide Permit 33 – Temporary Construction, Access and Dewatering
- Nationwide Permit 37 – Emergency Watershed Protection and Rehabilitation
- Nationwide Permit 45 – Repair of Uplands Damaged by Discrete Events

Nationwide Permits, like all permits from the USACE, require compliance with:

- Wild and Scenic River Act (Delaware River)
- Section 7 of the Endangered Species Act
- Section 106 of the National Historic Preservation Act

If a project would affect any of these conditions then notification will be triggered.

For more information contact the regional USACE office at:

Department of the Army,
U.S. Army Corps of Engineers, New York
Upstate Regulatory Field Office
1 Buffington Street, Bldg. 10, 3rd Floor
Watervliet, NY 12189-4000
(518) 266-6350

# ~ IV. References ~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# APPENDIX A

## *Problem Itemization Sheet*

# Immediate Post Flood Emergency Stream Intervention
## Problem Itemization Sheet

**Date:** ______________________ **Time:** ______________________

**Crew:** ____________________________________________

| | |
|---|---|
| **Stream** | |
| **Reach** | |

| | | YES | NO |
|---|---|---|---|
| **Debris Jam at Bridge/Culvert** | | | |
| | Bridge / Culvert | | |
| | Location | | |
| **Scour at Bridge/Culvert** | | | |
| | Footings exposed | | |
| | Undermining | | |
| **Mass Failure** | | | |
| | Estimated height (avg) | | |
| | Estimated length (avg) | | |
| | Number of failures | | |
| **Debris/Log/Gravel Jams** | | | |
| **Avulsion** | | | |
| | Estimated length | | |
| | Estimated width | | |
| **Scouring/ Down Cutting** | | | |
| | Estimated depth | | |
| **Head Cut** | | | |
| | Estimated depth | | |
| **Gravel Deposits** | | | |
| | Location - center | | |
| | Location - left side | | |
| | Location - right side | | |
| | Estimated height | | |
| | Estimated length | | |
| **Eroded Banks** | | | |
| | Left bank | | |
| | Right bank | | |
| | Estimated height | | |
| | Estimated length | | |

| **Sketch or Comments** |
|---|
| |

# APPENDIX B

## *Immediate Post-Flood Emergency Stream Intervention Suggested Repairs*

## *Immediate Post-Flood Emergency Stream Intervention*
## *Suggested Repairs*

### Debris Jams at Bridges/Culverts

- Remove the debris
- Do **NOT** over excavate
- Do **NOT** try to deepen or widen the channel
- Do **NOT** use the debris to build berms

### Scour at Bridges/Culverts


**NOTE:** All scour can be dangerous. All scour should be reported to the Delaware County Department Public Works, New York State Department of Transportation, or local highway agency, (the appropriate owner of the structure) as the scour may be severe enough that the structure may need to be closed. If the footing is undermined it should be reported **immediately**.

### Mass Failure


- If room is available move the channel away from the land slide, and construct a level bench at the bankfull elevation at the toe of the landslide. Make the bench as wide as possible given the room available.
- If the landslide is blocking the channel remove that portion that is in the channel.
- If trees are leaning at an acute angle and are prying on the earth mass, they may be removed. Leave the stumps in place.
    - Often trees will lean at an acute angle on the bank that did NOT move, but is next to the mass failure. To preserve stability these leaning trees can be removed and their roots can remain in place.
- Keep the number of trees removed to a minimum.
- It can be difficult to determine what trees should taken or even if any should be taken. Should there be any doubts contact DCSWCD, DPW, DEP or some other organization for technical assistance.
- WARNING – mass failures can be dangerous. Use extreme caution. Seek technical assistance!

### Debris/Log/Gravel Jams


- Remove the debris
- Do not over excavate
- Do not try to deepen or widen the channel
- Do NOT use the debris to build berms.

### Avulsion

- Seek technical assistance from DCSWCD, NYCDEP, or some other competent technical agency.

### Scouring/Down Cutting


- Construct a new channel to bankfull dimensions and with as much floodplain bench as available room allows.
- Usually there is an alternating pattern of scouring/down cutting and gravel deposits. Therefore, a source of material may be located up stream or down stream of the scoured/down cutting reach.


### Head Cut

- Usually a cross vane or other similar structure is required to prevent head cutting.
- Seek technical assistance from DCSWCD, NYCDEP, or some other competent technical agency.


## Gravel Deposits

- Remove the gravel deposits.  Use the gravel in a scoured reach if possible.
- Do not over excavate.
- Do not try to widen or deepen the channel.
- Construct a new channel to bankfull dimensions and with as much floodplain bench as available room allows.

## Eroded Banks

- Construct a new channel to bankfull dimensions and with as much floodplain bench as available room allows.
- Slope the eroding banks to a stable slope such as 2:1 or 3:1.
- If the banks are not actively eroding or exhibiting other signs of instability, emergency intervention may not be required. If you are unsure of the stability of the banks seek technical assistance from DCSWCD, NYCDEP, or some other competent technical agency.

# APPENDIX C

## *Bankfull Hydraulic Geometry vs. Drainage Area for Selected Drainage Areas*

## *EAST BRANCH DELAWARE RIVER BASIN*

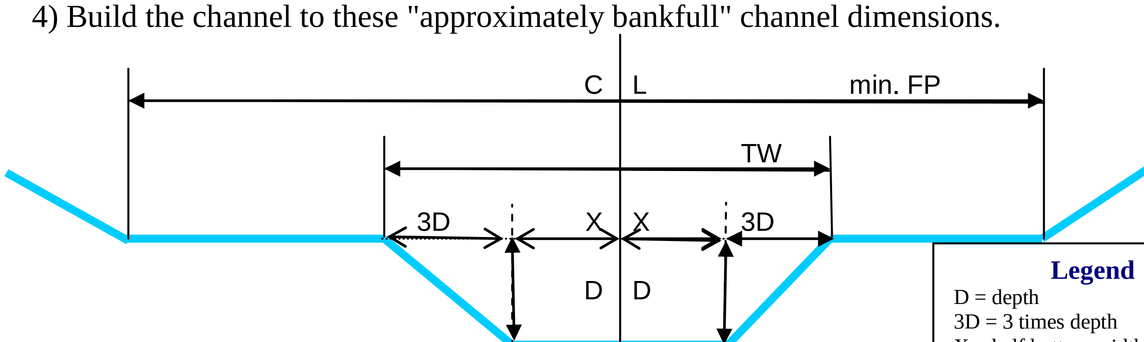
### *Bankfull Hydraulic Geometry vs. Drainage Area for Selected Drainage Areas*

| | | | | Construction Dimensions | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DA (sq. mile) | Bankfull Area (sq. ft) | Bankfull Width (ft) | Bankfull Depth (ft) | channel bank side slope | D (ft) | 3D (ft) | X (ft) | TW (ft) | Min. FP (ft) |
| 1 | 7 | 8.1 | 0.9 | **2:1** | 1.3 | 2.6 | 1.5 | 8.1 | 18 |
| 2.5 | 16 | 13.9 | 1.2 | **2:1** | 1.5 | 3.0 | 4.0 | 13.9 | 31 |
| 5 | 31 | 21.1 | 1.5 | 3:1 | 2.1 | 6.3 | 4.3 | 21.1 | 46 |
| 7.5 | 46 | 27.0 | 1.7 | 3:1 | 2.3 | 6.8 | 6.7 | 27.0 | 59 |
| 10 | 60 | 32.0 | 1.9 | 3:1 | 2.4 | 7.3 | 8.7 | 32.0 | 70 |
| 12.5 | 73 | 36.6 | 2.0 | 3:1 | 2.5 | 7.5 | 10.8 | 36.6 | 81 |
| 15 | 87 | 40.9 | 2.1 | 3:1 | 2.6 | 7.9 | 12.5 | 40.9 | 90 |
| 17.5 | 100 | 44.8 | 2.2 | 3:1 | 2.7 | 8.2 | 14.2 | 44.8 | 99 |
| 20 | 114 | 48.6 | 2.3 | 3:1 | 2.8 | 8.5 | 15.8 | 48.6 | 107 |
| 22.5 | 127 | 52.1 | 2.4 | 3:1 | 2.9 | 8.8 | 17.3 | 52.1 | 115 |
| 25 | 140 | 55.5 | 2.5 | 3:1 | 3.0 | 9.0 | 18.7 | 55.5 | 122 |
| 27.5 | 153 | 58.8 | 2.6 | 3:1 | 3.1 | 9.3 | 20.1 | 58.8 | 129 |
| 30 | 166 | 62.0 | 2.7 | 3:1 | 3.2 | 9.5 | 21.5 | 62.0 | 136 |
| 32.5 | 179 | 65.0 | 2.7 | 3:1 | 3.2 | 9.7 | 22.8 | 65.0 | 143 |
| 35 | 191 | 68.0 | 2.8 | 3:1 | 3.3 | 9.8 | 24.2 | 68.0 | 150 |
| 37.5 | 204 | 70.8 | 2.9 | 3:1 | 3.4 | 10.1 | 25.3 | 70.8 | 156 |
| 40 | 217 | 73.6 | 2.9 | 3:1 | 3.4 | 10.3 | 26.5 | 73.6 | 162 |
| 42.5 | 229 | 76.4 | 3.0 | 3:1 | 3.5 | 10.4 | 27.8 | 76.4 | 168 |
| 45 | 242 | 79.0 | 3.1 | 3:1 | 3.5 | 10.6 | 28.9 | 79.0 | 174 |
| 47.5 | 254 | 81.6 | 3.1 | 3:1 | 3.6 | 10.8 | 30.0 | 81.6 | 180 |
| 50 | 267 | 84.2 | 3.2 | 3:1 | 3.6 | 10.9 | 31.2 | 84.2 | 185 |

* From Regional Relationships of Bankfull Hydraulic Geometry to Drainage Area for 18 USGS Stream Gages in the Catskill Mts., NY - Stratified by Mean Annual Runoff (MAR) MAR<2.3

## Instructions:

1) Select the table for the drainage basin that your project is in.
2) Select the drainage area (DA) in the selected table that most closely matches the DA at your project site.
3) Under "Construction Dimensions" read the channel dimensions tabulated.
4) Build the channel to these "approximately bankfull" channel dimensions.




**Legend**
D = depth
3D = 3 times depth
X = half bottom width
TW = Top width
Min. FP = Minimum floodplain
CL = centerline

## *WEST BRANCH DELAWARE RIVER BASIN*

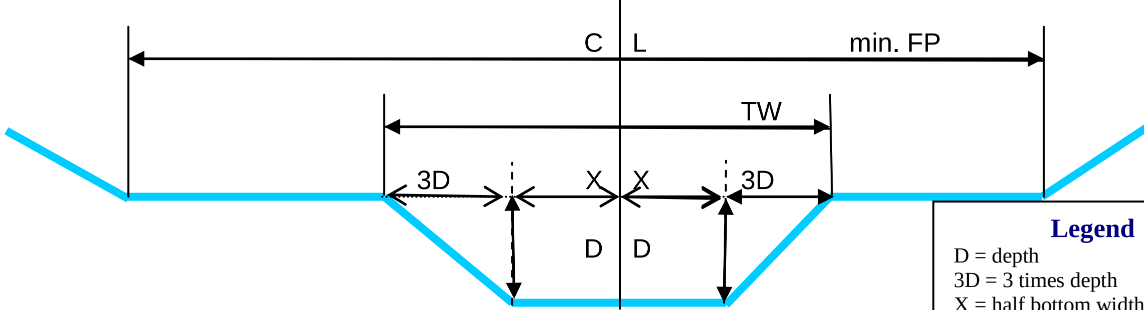
### *Bankfull Hydraulic Geometry vs. Drainage Area for Selected Drainage Areas*

| | | | | Construction Dimensions | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DA (sq. mile) | Bankfull Area (sq. ft) | Bankfull Width (ft) | Bankfull Depth (ft) | channel side slope | D (ft) | 3D (ft) | X (ft) | TW (ft) | Min. FP (ft) |
| 1 | 10 | 15.7 | 0.6 | 3:1 | 0.7 | 2.2 | 5.6 | 15.7 | 35 |
| 2.5 | 21 | 22.8 | 0.9 | 3:1 | 1.1 | 3.2 | 8.2 | 22.8 | 50 |
| 5 | 37 | 30.3 | 1.2 | 3:1 | 1.4 | 4.3 | 10.9 | 30.3 | 67 |
| 7.5 | 51 | 35.8 | 1.4 | 3:1 | 1.7 | 5.0 | 13.0 | 35.8 | 79 |
| 10 | 65 | 40.2 | 1.6 | 3:1 | 1.9 | 5.6 | 14.5 | 40.2 | 88 |
| 12.5 | 78 | 44.1 | 1.8 | 3:1 | 2.1 | 6.2 | 15.9 | 44.1 | 97 |
| 15 | 90 | 47.5 | 1.9 | 3:1 | 2.2 | 6.6 | 17.2 | 47.5 | 105 |
| 17.5 | 102 | 50.6 | 2.0 | 3:1 | 2.3 | 7.0 | 18.3 | 50.6 | 111 |
| 20 | 113 | 53.5 | 2.1 | 3:1 | 2.5 | 7.4 | 19.4 | 53.5 | 118 |
| 22.5 | 125 | 56.1 | 2.2 | 3:1 | 2.6 | 7.7 | 20.3 | 56.1 | 123 |
| 25 | 136 | 58.6 | 2.3 | 3:1 | 2.7 | 8.1 | 21.2 | 58.6 | 129 |
| 27.5 | 147 | 60.9 | 2.4 | 3:1 | 2.8 | 8.4 | 22.1 | 60.9 | 134 |
| 30 | 158 | 63.1 | 2.5 | 3:1 | 2.9 | 8.7 | 22.8 | 63.1 | 139 |
| 32.5 | 168 | 65.2 | 2.6 | 3:1 | 3.0 | 9.0 | 23.6 | 65.2 | 143 |
| 35 | 178 | 67.3 | 2.7 | 3:1 | 3.1 | 9.2 | 24.5 | 67.3 | 148 |
| 37.5 | 189 | 69.2 | 2.7 | 3:1 | 3.2 | 9.5 | 25.1 | 69.2 | 152 |
| 40 | 199 | 71.0 | 2.8 | 3:1 | 3.3 | 9.8 | 25.8 | 71.0 | 156 |
| 42.5 | 209 | 72.8 | 2.9 | 3:1 | 3.3 | 10.0 | 26.4 | 72.8 | 160 |
| 45 | 219 | 74.6 | 2.9 | 3:1 | 3.4 | 10.2 | 27.1 | 74.6 | 164 |
| 47.5 | 229 | 76.2 | 3.0 | 3:1 | 3.5 | 10.4 | 27.7 | 76.2 | 168 |
| 50 | 238 | 77.9 | 3.1 | 3:1 | 3.5 | 10.6 | 28.4 | 77.9 | 171 |

*From Bankfull Geometry vs. DA for 31 West Branch Cross Sections and 4 USGS Stream Gages with Walton at 7200cfs

## Instructions:

1) Select the table for the drainage basin that your project is in.
2) Select the drainage area (DA) in the selected table that most closely matches the DA at your project site.
3) Under "Construction Dimensions" read the channel dimensions tabulated.
4) Build the channel to these "approximately bankfull" channel dimensions.




**Legend**
D = depth
3D = 3 times depth
X = half bottom width
TW = Top width
Min. FP = Minimum floodplain
CL = centerline

## *SUSQUEHANNA RIVER BASIN*

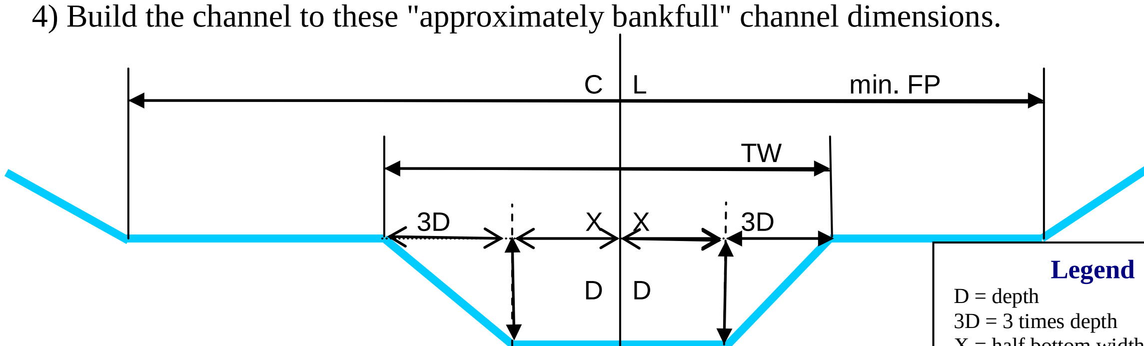
### *Bankfull Hydraulic Geometry vs. Drainage Area for Selected Drainage Areas*

| DA (sq. mile) | Bankfull Area (sq. ft) | Bankfull Width (ft) | Bankfull Depth (ft) | Construction Dimensions | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | channel bank side slope | D (ft) | 3D (ft) | X (ft) | TW (ft) | Min FP (ft) |
| 1 | 11 | 13.5 | 0.8 | 3:1 | 1.1 | 3.2 | 3.5 | 13.5 | 30 |
| 2.5 | 23 | 20.4 | 1.1 | 3:1 | 1.4 | 4.3 | 5.9 | 20.4 | 45 |
| 5 | 41 | 27.8 | 1.5 | 3:1 | 1.8 | 5.5 | 8.4 | 27.8 | 61 |
| 7.5 | 57 | 33.4 | 1.7 | 3:1 | 2.1 | 6.3 | 10.4 | 33.4 | 73 |
| 10 | 72 | 38.0 | 1.9 | 3:1 | 2.3 | 7.0 | 12.0 | 38.0 | 84 |
| 12.5 | 86 | 42.0 | 2.1 | 3:1 | 2.5 | 7.5 | 13.5 | 42.0 | 92 |
| 15 | 100 | 45.5 | 2.2 | 3:1 | 2.7 | 8.0 | 14.7 | 45.5 | 100 |
| 17.5 | 114 | 48.8 | 2.3 | 3:1 | 2.8 | 8.5 | 15.9 | 48.8 | 107 |
| 20 | 127 | 51.8 | 2.4 | 3:1 | 3.0 | 8.9 | 17.0 | 51.8 | 114 |
| 22.5 | 140 | 54.6 | 2.6 | 3:1 | 3.1 | 9.3 | 18.0 | 54.6 | 120 |
| 25 | 153 | 57.3 | 2.7 | 3:1 | 3.2 | 9.6 | 19.0 | 57.3 | 126 |
| 27.5 | 165 | 59.8 | 2.8 | 3:1 | 3.3 | 9.9 | 20.0 | 59.8 | 132 |
| 30 | 177 | 62.2 | 2.8 | 3:1 | 3.4 | 10.2 | 20.9 | 62.2 | 137 |
| 32.5 | 190 | 64.4 | 2.9 | 3:1 | 3.5 | 10.6 | 21.6 | 64.4 | 142 |
| 35 | 201 | 66.6 | 3.0 | 3:1 | 3.6 | 10.8 | 22.5 | 66.6 | 147 |
| 37.5 | 213 | 68.7 | 3.1 | 3:1 | 3.7 | 11.1 | 23.3 | 68.7 | 151 |
| 40 | 225 | 70.7 | 3.2 | 3:1 | 3.8 | 11.4 | 24.0 | 70.7 | 156 |
| 42.5 | 236 | 72.7 | 3.2 | 3:1 | 3.9 | 11.6 | 24.8 | 72.7 | 160 |
| 45 | 248 | 74.6 | 3.3 | 3:1 | 4.0 | 11.9 | 25.5 | 74.6 | 164 |
| 47.5 | 259 | 76.4 | 3.4 | 3:1 | 4.0 | 12.1 | 26.1 | 76.4 | 168 |
| 50 | 270 | 78.2 | 3.4 | 3:1 | 4.1 | 12.3 | 26.8 | 78.2 | 172 |

*From USGS Scientific Investigations Report 2004-5247

## Instructions:

1) Select the table for the drainage basin that your project is in.
2) Select the drainage area (DA) in the selected table that most closely matches the DA at your project site.
3) Under "Construction Dimensions" read the channel dimensions tabulated.
4) Build the channel to these "approximately bankfull" channel dimensions.




**Legend**
D = depth
3D = 3 times depth
X = half bottom width
TW = Top width
Min. FP = Minimum floodplain
CL = centerline

# APPENDIX D

## *How to Use USGS New York Streamstats web tool*

# How to use the USGS New York Streamstats Web Tools to Calculate Watershed Area (WA)

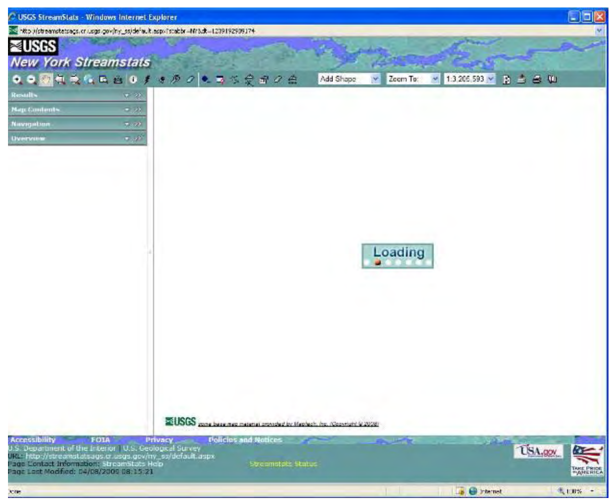
Acquiring the watershed area in square miles (area upstream of a location on a stream) for use with the Regional Curves of Hydraulic Geometry[2] is key to using the curves for checking the bankfull dimensions of a channel. Until recently, the time needed to calculate watershed area was a major impediment to using the curves. USGS has recently developed an excellent tool for this calculation and it is openly available on the internet.

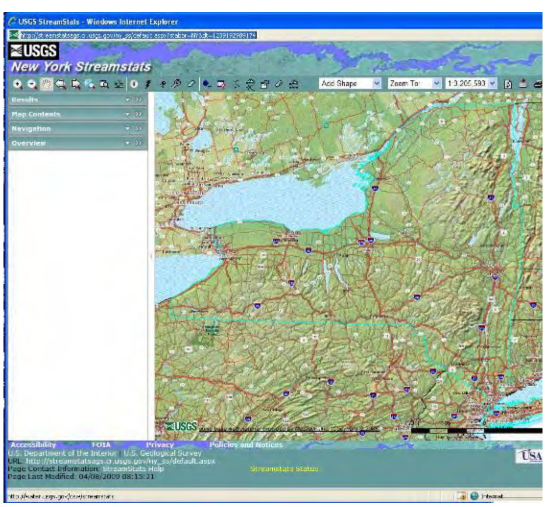
To use this tool you will need high speed internet access. Even with high speed internet access this program can be slow to load. If the process hangs up in loading mode, get out and re-connect to the site. Patience is needed.

**Step 1: Navigate to the USGS Streamstats page for New York**. This the current link to the site:

http://streamstatsags.cr.usgs.gov/ny_ss/index.htm

When you connect to the site the program will start up and you will get this "loading" screen.




Once fully loaded you will get this screen. If it does not load you may need to temporarily turn off any "pop up blockers" your computer virus protection software uses.

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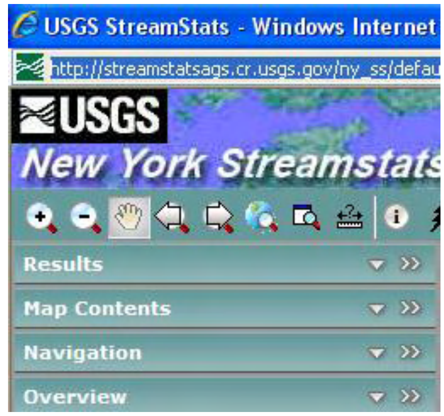
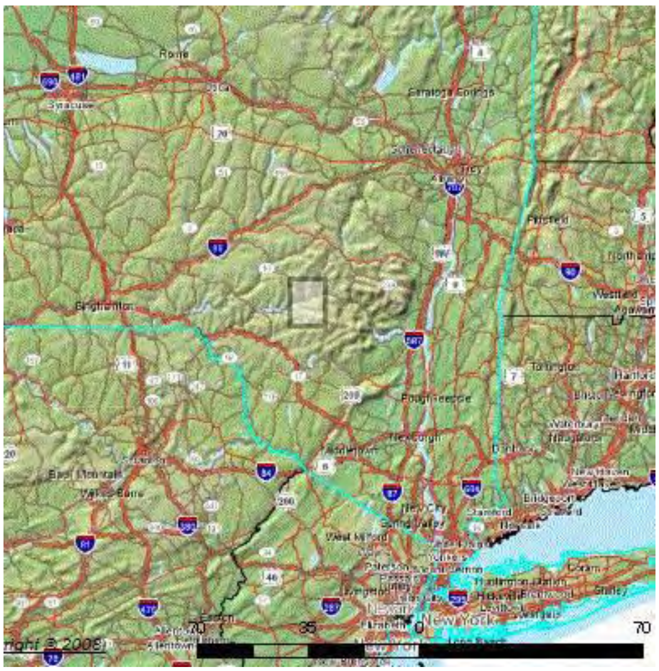
2 For more information on Regional Relationships of bankfull hydraulic geometry for streams in the Catskill or other areas of NYS see the following links: http://home2.nyc.gov/html/dep/html/watershed_protection/pdf/smp.pdf or http://ny.cf.er.usgs.gov/nyprojectsearch/projects/2457-A29-1.html

**Step 2: Zoom to the area of interest**



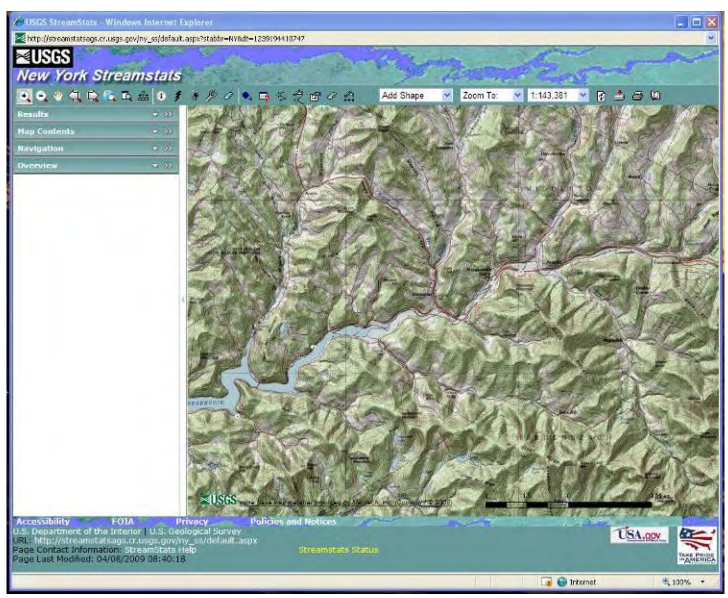

Select the zoom in button in the upper left of the screen. Zoom in is the magnifier glass icon with the plus sign in the center. Single click on the icon will activate this tool.



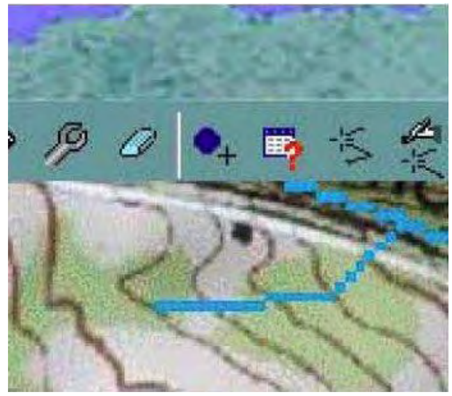
To zoom in you are going to create a drag box. Hold down the left mouse button on a point on the map to the north and west of the area of interest, and while keeping the button held down, move the mouse to the south and east so that a box is created around the area of interest. Release the left mouse button to complete the box (see the gray area in the image to the left). The program will zoom in to the extent of the box.

This will be your first zoom in extent.

You will probably have to repeat this process until you get fully zoomed into the project site. With the site centered in the map frame you can also use the scale pull down to set the scale to about 1:10,000. This scale will enable you to accurately use the point delineation tool. *<u>Don't zoom in too far as the application may hang up in the loading mode.</u>*

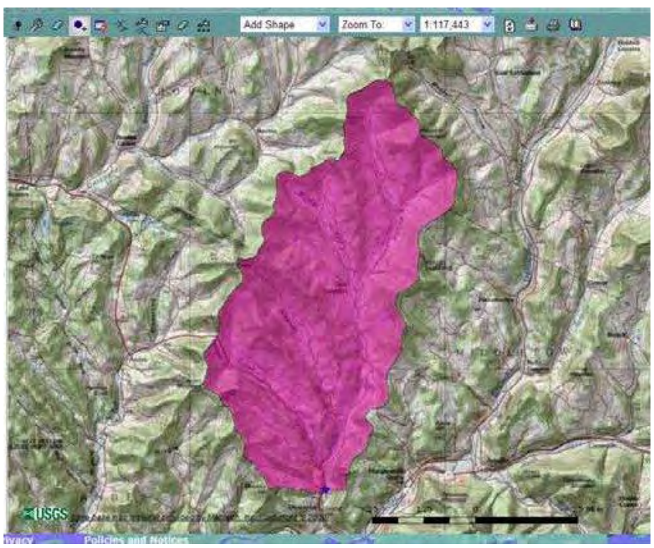


**Step 3: Use the Watershed delineation from a point tool to select the location of interest**



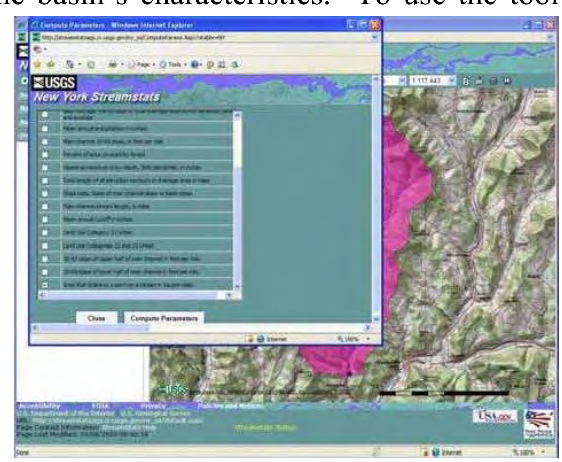
Use the button with the grey dot and plus sign to select the point on the stream where you wish to calculate the watershed area.

Single click on the icon to make it active. You will note that the stream appears as a series of connected light blue cells (pixels). Select the cell on the stream that you wish to be the lowest point on the watershed. This is also called the “pour point”. You will determine the total upstream area contributing flow to this point on the stream. The program will then outline the watershed area contributing flow to this point.




**Step 4: Calculate Watershed Area**

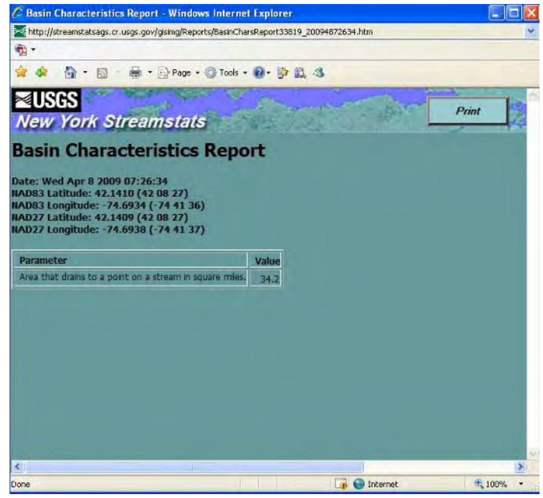
Use the Basin Characteristics icon (rectangular box with red question mark located to the right of the point delineation icon) to generate a report of the basin’s characteristics. To use the tool simply single click the icon and a check box will appear on your screen.




The tool will calculate numerous statistics for the basin. To save time, uncheck all of the boxes except the box labeled “Area that drains to a point on a stream in square miles” Then left mouse button click on “Compute Parameters”

The program will compute the area.

There are numerous help screens available for use with this tool. To access the instructions left click on the top bar (aqua blue area near where the USGS agency block). A window will open with a table of contents located on the left. Click on the User Instructions hyperlink to access the instructions.




Many thanks to Martyn Smith and the GIS staff at USGS Troy office for their efforts to create this excellent application. We especially acknowledge the contributions of Barry Baldigo, Fisheries Biologist of USGS who helped make this application available for our use.

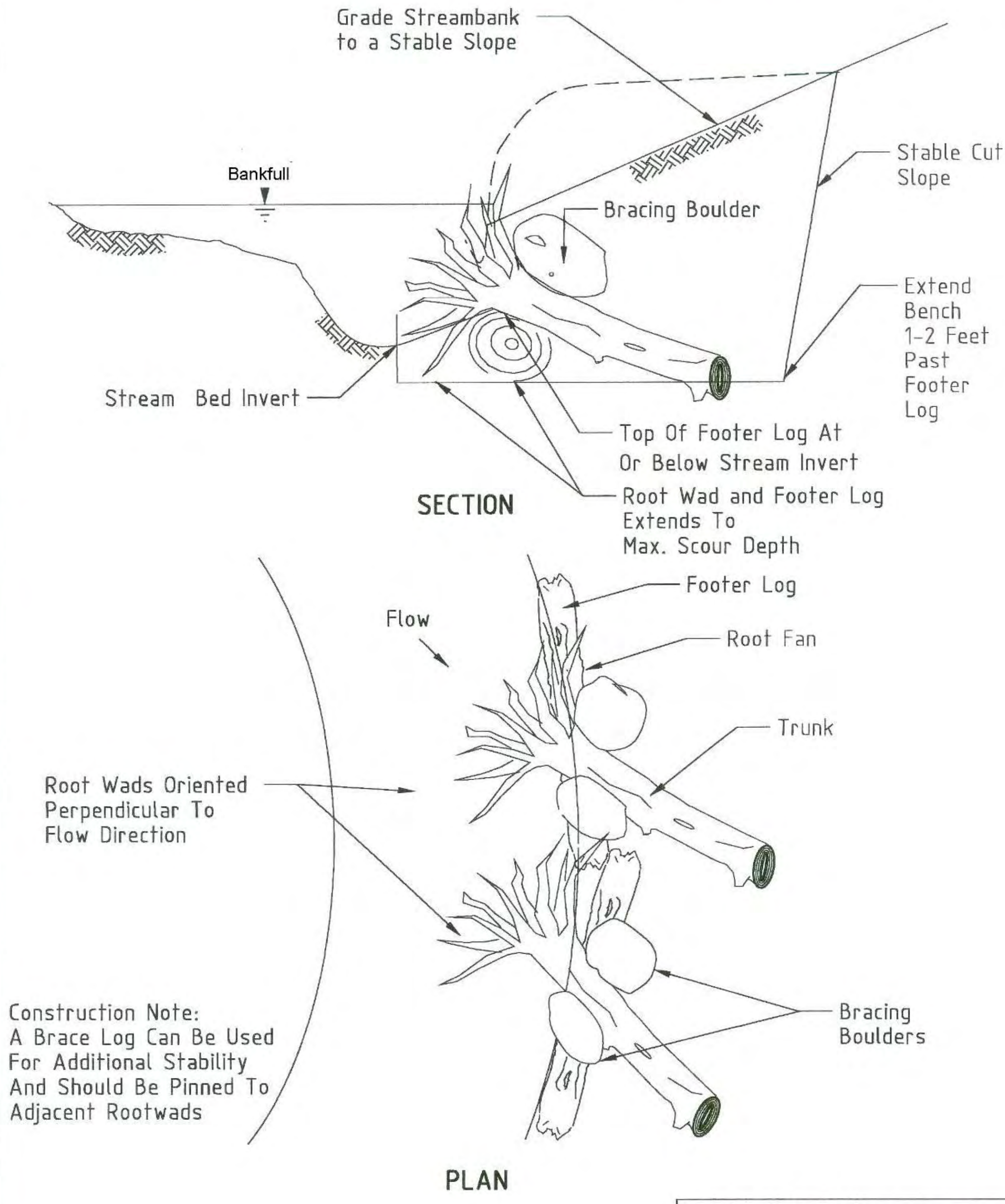
Prepared by: P. Eskeli, NYC DEP 4/09

# APPENDIX E

## *Root Wad Detail*

# The Virginia Stream Restoration & Stabilization Best Management Practices Guide

## DETAIL 1.2: ROOT WAD REVETMENT




Section & Plan Views Adapted From Rosgen (1999)

| BANK PROTECTION GUIDELINES | DECEMBER 2003 | VIRGINIA DEPARTMENT OF CONSERVATION RECREATION |
|---|---|---|

# APPENDIX F

## *Stream Disturbance Permit Regulations in Natural Disasters*

**Stream Disturbance Permit Regulations in Natural Disasters under New York's Environmental Conservation Law.**

**NYCRR Part §608.2 Disturbance of Protected Streams**

(a) *Permit required.* Except as provided in subdivision (b) of this section, no person or local public corporation may change, modify or disturb any protected stream, its bed or banks, nor remove from its bed or banks sand, gravel or other material, without a permit issued pursuant to this Part.

(b) *Exceptions.* The requirement of a permit pursuant to subdivision (a) of this section does not apply to the following:

(1) a local public corporation that has entered into a written memorandum of understanding with the department establishing the plan of operation that will be followed in conducting any activity described in subdivision (a) of this section that will afford proper protection to the public beneficial uses of protected streams and navigable waters of the state; or

(2) any person actively cultivating land devoted to agriculture, whether or not such land is along a protected stream, provided that this exception shall be limited to agricultural activities consisting only of the crossing and recrossing of a protected stream by livestock or wheeled farming equipment normally used for traditional agricultural purposes or of withdrawing irrigation water in a manner which does not otherwise alter the stream.

**§608.8 Standards**

The basis for the issuance or modification of a permit will be a determination that the proposal is in the public interest, in that:

(a) the proposal is reasonable and necessary;

(b) the proposal will not endanger the health, safety or welfare of the people of the State of New York; and

(c) the proposal will not cause unreasonable, uncontrolled or unnecessary damage to the natural resources of the state, including soil, forests, water, fish, shellfish, crustaceans and aquatic and land-related environment.

**§621.12 Emergency authorizations.**
For projects carried out in response to an emergency, the following procedures shall apply:

(a) All procedural requirements of this Part related to application processing are waived, except as provided in this section.

(b) Prior to commencement of an emergency action or project, the department must be notified, as specified in subdivision (d) below, and must determine whether to deny or grant approval pursuant to subdivision (e) of this section.

(c) If circumstances warrant immediate action by a state or local government agency or a public benefit corporation and prior notice to the department is not possible, that agency or corporation may proceed to undertake the emergency action but must then notify the department within 24 hours after commencement of the project. The department must subsequently respond pursuant to subdivision (f) of this section.

(d) Notification pursuant to subdivisions (b) or (c) above may be by certified mail, telegram, mailgram, facsimile (FAX), electronically or a written form of communication to the appropriate regional permit administrator as listed in section 621.19 of this Part. This notification must include submission of the following information:

(1) a description of the proposed action;

(2) location map and plan of the proposed project;

(3) reasons why the situation is an emergency based on the immediate protection of life, health, general welfare, property or natural resources;

(4) actions to be taken to minimize environmental impacts; and

(5) any additional information requested by the department necessary to make a finding of emergency.

(e) Prior to issuing an emergency authorization, the department must:

(1) make a finding of emergency stating that the action is an emergency as defined in Section 621.2(j), why immediate action is needed and the consequences to life, health, general welfare, property or natural resources if the action is not immediately taken; and

(2) determine from the available information that the project will be carried out in a manner that will cause the least change, modification or adverse impact to life, health, property or natural resources. The department may attach conditions to emergency authorizations and enforce them to assure compliance with the

authorization and other regulatory standards that would apply to such actions absent an emergency.

(f) The department will issue a decision granting or denying the emergency authorization within two business days of receipt of the information required in subdivision (d) of this section in the form of a letter that may be facsimiled (FAXED), mailgramed or otherwise electronically sent to the applicant. The original letter must be mailed to the applicant.

(1) The emergency authorization must contain the department's finding of emergency. The finding of emergency must state why the department believes the emergency action is necessary based on the protection of life, health, general welfare, property or natural resources.

(2) The denial of emergency authorization must contain the department's reasons why it has determined the activity does not constitute an emergency.

(g) An emergency authorization may be issued for a term not to exceed 30 calendar days. It may be renewed for one term not to exceed 30 calendar days. On or before 60 calendar days after the department's original approval, the project must be concluded or the authorized person must file a complete application for any necessary permit with the department. The application will be subject to all the procedural requirements of this Part. If the application for a permit is timely and complete the permittee may continue working pursuant to the emergency authorization until the permit is issued.

(h) The department may issue an order summarily suspending:

(1) an action begun before the grant of an emergency authorization, if the department finds that no emergency exists; or

(2) an emergency authorization, if the department finds that an action is no longer immediately necessary to protect life, health, property or natural resources.

Such action must cease immediately upon receipt of the order by the responsible party.

(i) A person who violates any provision of this section or any term or condition of an emergency authorization will be ordered to perform any required restoration or provide department authorized mitigation of environmental damage resulting from that action. In the event that the person fails to undertake the work ordered, the department or its agent may enter upon the lands or waters where the action took place and perform restoration or other activities necessary to mitigate or eliminate environmental damage caused by the action. If the department undertakes the remedial action, or causes it to be undertaken, the full cost for the work will be charged to and be the responsibility of the person who failed to satisfy the provisions of this section.

§621.14 Special provisions.

(c) The department may issue general permits to allow work to eliminate damage caused by natural disasters or extraordinary weather not unique to a particular locality, including repair or replacement in location and in kind of facilities which existed prior to the damage. Processing of such permits need not follow the full procedural requirements of this Part.

# APPENDIX G

## *Maximum Pump Capacities*

**Pump Capacities**

| Pump Size | Max Capacity CFS | Max Capacity GPM |
|---|---|---|
| 2" | 0.5 | 216 |
| 3" | 0.7 | 300 |
| 4" | 1.6 | 700 |
| 6" | 4.5 | 2000 |
| 8" | 7 | 3200 |
| 10" | 7.8 | 3500 |
| 12" | 10 | 4500 |

Source: Godwind Pump, CD Series Dri-Prime

Note that these are theoretical maximum capacities.  In the field, due to head losses, (losses through pipes, bends, changes in elevation, etc.), actual pumping capacity *will be less*.