Why Stabilizing the Stream "As-Is" is Not Enough

Several examples of alternatives to the County's design approach have been suggested. A common theme of these proposals is a less comprehensive effort focusing on stabilizing the stream in its current state.

More concise information is included in the answers to the Frequently Asked Questions for the project. If more detailed information is desired, please read on.

The County's stream restoration design approach focuses a **natural channel design** process that includes an assessment of existing stream conditions and trends, and a restoration design that integrates three important variables:

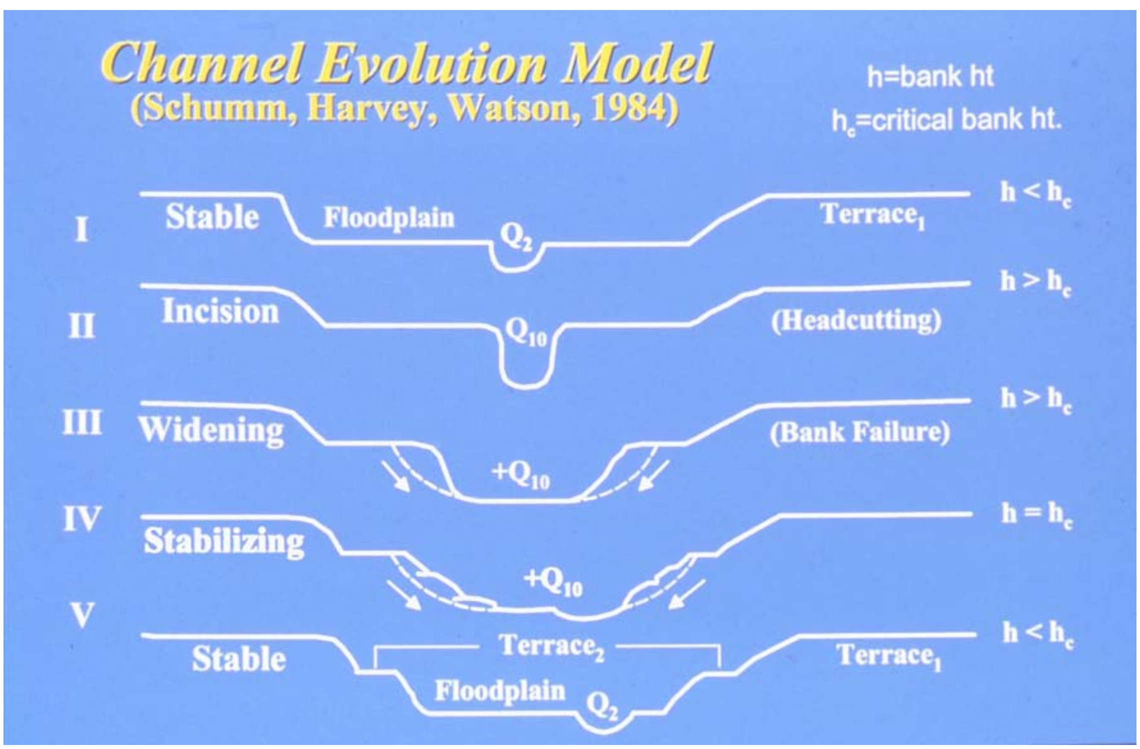
- the flow capacity of the channel,
- the curvature of the stream, and
- the slope of the stream.

A critical element in the design process is reconnecting the stream with a floodplain to reduce the stresses on the urban stream channel. This natural channel design approach is based upon extensive study of natural streams, and application of restoration techniques and is endorsed by State and Federal agencies.

The term floodplain may elicit thoughts of wide, flat areas adjacent to large rivers. But, in the context of smaller streams and particularly the Tributary B valley which is relatively steep (2-3%) and confined, what we're really talking about is a **floodprone area** adjacent to the active channel. The connectivity between the active stream channel and this floodprone area is critical for energy dissipation and stability, and it is quantified in the assessment of existing conditions and in the design of the restoration channel.

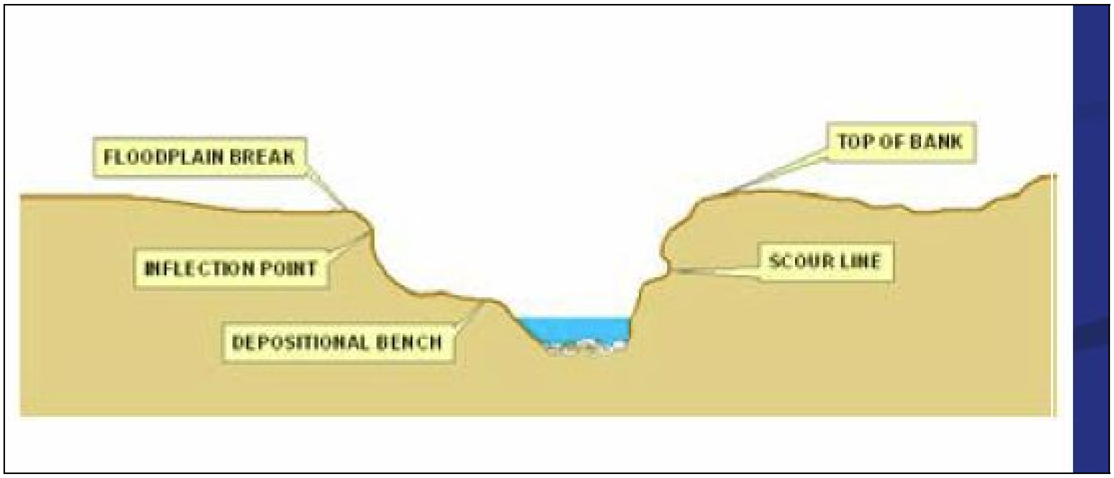
This quantification is discussed below, but first you'll see in the photo below that even in a steep mountain stream that there is still an area adjacent to the main boulder channel (yellow line) where the valley wall slopes away from the stream, allowing water to spread out and slow down in this floodprone area (red line).

In the Channel Evolution Model, Stages II (incision) and III (widening) characterize much of the Tributary B valley. In these stages of channel evolution, a stream has become disconnected from its floodplain or floodprone area. This degree of connection/disconnection is determined by a field measurement and computation of **entrenchment ratio**.

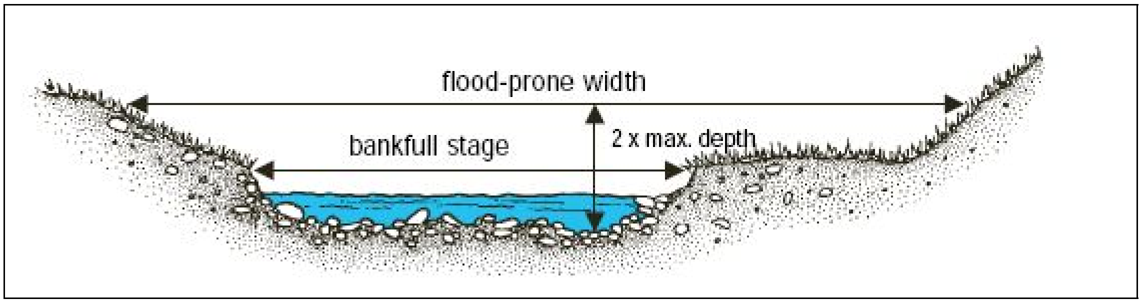


Before entrenchment ratio is computed, a comprehensive field assessment and survey of the stream corridor occurs to identify indicators of the bankfull stage of the stream, the depth at which the bankfull discharge occurs. The **bankfull discharge** is the flow which has the most influence over time on the shape of the channel, including transporting and depositing sediment and forming or changing the meander pattern of the stream. In urban watersheds, this flow occurs on average from several times per year to about once every year. The bankfull discharge is a central restoration design parameter that informs the channel cross section dimensions, spacing of step pools, stream curvature, and other variables.

Indicators of bankfull stage in entrenched streams like Tributary B include the depositional benches and scour lines identified in the illustration below. These indicators are common in portions of the Tributary B valley.



Once the bankfull stage is determined, entrenchment ratio can be calculated. In the field, the width of the floodprone area is determined at an elevation that is twice the bankfull depth, as illustrated below.



The entrenchment ratio is then determined by dividing the width of the flood prone area by the width of the channel at the bankfull stage.

For Tributary B, this ratio is consistently <1.4 in much of the upper section, where steep, eroded, vertical banks are present. This ratio is only slightly greater than 1.4 near the pedestrian bridge and in the lower portion below the footbridge. This low entrenchment ratio means that the stream is fairly well vertically confined (think of the upper line in the images above being close in width to the lower line) and there is not much width for water to spread out and slow down during flows higher than the bankfull stage. As a result, flow from the stream rarely reaches the flat pathway area in the Tributary B valley where high stream energy could be dissipated - this is due to the high degree of entrenchment.

Another key measurement is the **width:depth ratio**, a measurement of the ratio of the channel width at bankfull stage to the mean depth. For much of Tributary B, this ratio is <12 - meaning that the bankfull channel is relatively deep compared to its width.

Based upon the extensive stream classification system developed by Dave Rosgen and used extensively in Virginia, the United States, and internationally, the entrenchment and width:depth ratios computed for most of Tributary B, coupled with the valley slope, tell us that most of the stream is a G stream type. **G stream types are unstable, with grade (slope) control problems and high bank erosion rates.**

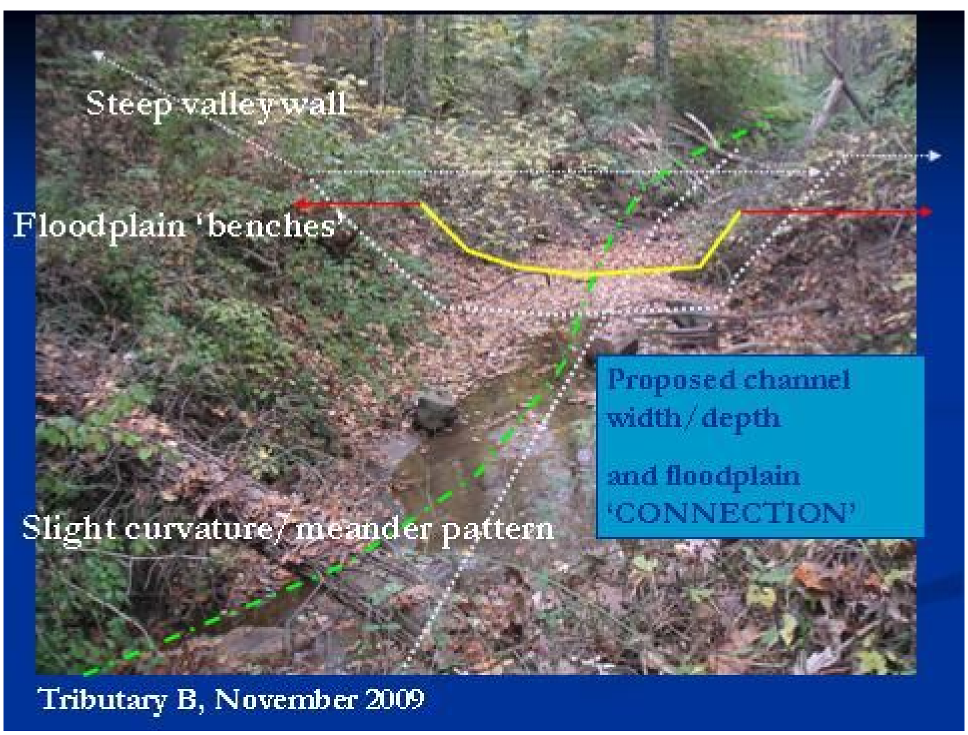
Together, the low entrenchment and width:depth ratios for existing conditions in Tributary B mean that a key hydraulic parameter, shear stress, is high along most of the corridor. Shear stress is the force acted on the streambed by water and is calculated by:

$$\tau = \gamma DS$$

where:
γ is the specific weight of water,
D is the mean depth, and
S is the water surface slope.

The restoration design will create a B stream type, with an entrenchment ratio between 1.4 and 2.2 (by raising the stream bed) and a width:depth ratio >12 (by creating a narrower/shallower bankfull channel within the existing channel). These design elements are illustrated conceptually below, with the white dashed lines showing the existing channel cross section and the yellow/red lines the restoration cross section and floodprone area.

These changes alone will reduce shear stresses by reducing the mean depth of the channel above which flow can spread out in the floodprone area.



Slope is also a term in the shear stress calculation as well, and this is where the engineered step pools come in.

The step pools are grade control features that reduce the streambed slope between each step pool to between 1% and 2%, generally. Without these step pools, the streambed slope would be greater than 3%, resulting in a higher water surface slope and higher shear stresses. Reducing the slope with step pools reduces velocities, shear stress, and erosive power. .

Also, because a key design feature is elevating the new streambed above the existing streambed, the step pools are constructed in soil material and not by disturbing the bedrock features of the valley. The boulders already in the valley will be re-used to build these structures (but will also need additional boulders). The spacing/frequency of these structures will be determined by the slope of the stream and the bankfull discharge. They will not be used more than necessary to control slope and stream energy - but are critical elements due to the slope of the valley and also because there is little room for stream meandering above the footbridge because of the trail and valley wall.

Finally, as new vegetation becomes established, banks are stabilized more completely and overbank flows slowed down in thick vegetation, further reducing stress on the restored channel.

The details above are provided as a more comprehensive way of explaining the importance and effects of creating connection to a floodprone area and controlling slopes and stream energy (shear stress) with step pools as occurred with Tributary A. There is more to the assessment and design process than can be covered here, but we hope the above details help to answer many questions.

In summary: if entrenchment is not addressed, shear stress is not reduced. Attempting to stabilize an entrenched stream like Tributary B without addressing entrenchment will lead either to failure or to a very hardened stormwater channel with little habitat or aesthetic value. And, yet such in-place stabilization still requires a significant amount of money and disturbs the stream and nearby trees for construction. This is not an approach that the County and experts in the field of urban watershed management consider effective or sustainable.