# Effectively Accounting for the Effects of Urbanization in Stream Quantification Tools


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## INTRODUCTION

Beaver Creek runs through an urbanizing area of Powell, Tennessee and experiences negative impacts from the increased runoff during even the smallest rain event. The Tennessee Department of Transportation (TDOT) is considering an 1,836-linear foot segment of Beaver Creek at Powell Station Park and behind Powell High School for restoration work. The stream banks are rapidly eroding, dead trees collapse into the stream, and disconnected channels are under utilized. A downstream view from the Brickyard Road bridge is shown in Figure 1. The proposed restoration design will improve the geomorphic function of the stream to minimize erosion, increase sinuosity, and improve habitat availability and quality using in-stream structures such as coir fiber erosion control blankets, constructed alluvial riffles, root wads, j-hooks, and log vanes.

The existing stream conditions of the stretch of Beaver Creek under consideration has been assessed using the Tennessee Stream Quantification Tool (TN SQT). From the proposed design, 251 stream mitigation credits will be generated. However, the current TN SQT does not effectively account for the functional lift resulting from urban stream restoration projects.

A working group lead by Dr. John Schwartz, professor of environmental engineering at the University of Tennessee, Knoxville, is developing a replacement TN SQT. The group will attempt to avoid some of the underlying philosophy of the current TN SQT, namely the reliance on ecoregion reference streams when assessing urban streams. Ecoregion reference streams represent stream conditions which have not been deteriorated by human activities. Though human impacts to urban streams are unavoidable, restoration work is still needed. To incentivize restoration work on urban streams, the proposed TN SQT will assess urban streams on a different standard than ecoregion reference streams.

When it is completed, the proposed TN SQT will be applied to the segment of Beaver Creek to determine if the number of credits generated has changed.

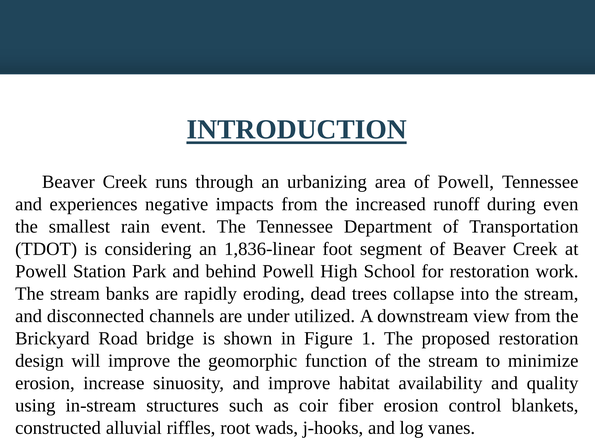

Figure 1. Downstream view of Beaver Creek from Brickyard Road.

## OBJECTIVES

- To finalize the proposed stream restoration design for the segment of Beaver Creek near Powell Station Park and Powell High School.
- To determine the criteria assessed in the proposed TN SQT that successfully account for functional lift.
- To determine difference of the number of credits generated between the current TN SQT and the proposed TN SQT.
- To determine the capability of the proposed TN SQT to assess functional lift on deteriorated urban streams from stream restoration work.

## DATA

The TN SQT has been completed for the existing conditions of the stream reach by Jackson Bogach in 2019 using ArcGIS Pro, field data collection, and online research. The stream lies within EPA Ecoregion 67fhi and both the existing and proposed Rogen Stream Classification Types are C. The main channel was divided into 3 reaches when it was entered into the TN SQT. The first, second, and third reach drainage areas are 52.56 square miles, 52.58 square miles, and 53.71 square miles, respectively. The proposed bed material for all three reaches if silt/clay and the proposed flow type is perennial/intermittent. The channel slopes for the first, second, and third reaches are -0.044, -0.013, and -0.065 percent, respectively. Figure 2 shows a typical cross-section of the main channel with the 2, 10, and 100-year peak discharges.

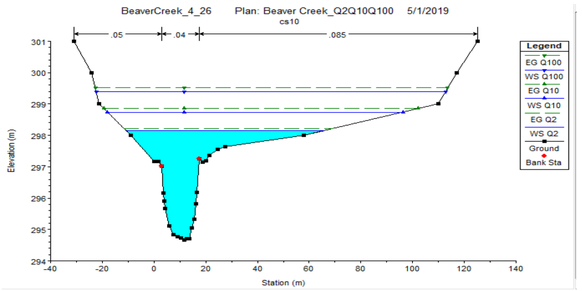


Figure 2. A Beaver Creek cross section showing the 2, 10, and 100-year peak discharges.

The tributary was also divided into 3 reaches. The Rosgen Classification Type of the tributary is E. The first, second and third tributary reach drainage areas are 1.07 square miles, 1.08 square miles, and 1.09 square miles, respectively. The proposed bed material for the entire tributary is gravel. The proposed flow type is ephemeral for reach 1, and perennial/intermittent for reaches 2 and 3. The channel slopes for the first, second, and third tributary reaches are 0.12, 0.25, and 0.69 percent, respectively. This reach information determines the correct reference standard table to apply for a variety of indices.

The goals outlined in Table 1 determine the restoration structures to be installed, procedures to be applied, the functional level, the function-based parameter effects, and the monitoring measurement tools for each reach.

Table 1.Restoration goals with means of achieving them.

| Goals | Objective | Functional Level | Function-Based Parameter Effects | Monitoring Measurement Tool |
|---|---|---|---|---|
| Protect streambanks of main channel from further fluvial erosion | Install streambank protection control measures in areas with active erosion | Geomorphologic | Lateral Migration | Percent stream bank erosion and visual inspection |
| | Remove trees with exposed roots that have the potential to fail | Geomorphologic | Lateral Migration | Percent stream bank erosion and visual inspection |
| Reduce flooding during small rain events | Divert water from main channel into side channels | Hydraulic | Floodplain Connectivity | Bank height ratio & Entrenchment ratio |
| Promote bed form and ecological diversity within main channel | Install in-channel structures that will stengthen and protect riffles, and increase habitat diversity | Geomorphologic | Bed Form Diversity | Percent riffle, pool spacing, and pool depth. Visual inspection of features |
| | | Biological | Macroinvertebrates and Fish | Field tests to determine species and quantity of biota |
| Prevent further erosion within tributary (UT2) | Install in-channel structures that will prevent further headcutting and bank erosion | Geomorphologic | Lateral Migration | Percent stream bank erosion and visual inspection |
| Improve water quality and reduce discharge into main channel from tributary (UT2) | Install stormwater control measures on floodplain and within UT2 | Hydrology | Stormwater Infiltration | Reduction of water capacity entering stream from UT2 during storm events |
| | | Physiochemical | Bacteria, nitrogen, phosphorus | Water quality samples of tributary water |
| Restore and improve riparian vegetation | Plant native trees and shrubs within riparian area. Remove invasive species of plants. | Geomorphologic | Riparian Vegetation | Tree density, native herbaceous and shrub cover, and visual inspection of presence of nuisance species |

The restoration approach and expected credits for each reach is summarized in Table 2. Only reach 3 of the main channel is expected to increase in linear feet due to the reestablishment of flow connections to an existing parallel dry channel.

Table 2. Restoration Approach and Expected Mitigation Credits for each reach.

| Reach | Existing LF | Approach | Proposed LF | Credits |
|---|---|---|---|---|
| Main Channel, Reach 1 | 349.2 | Enhancement | 349.2 | 21 |
| Main Channel, Reach 2 | 621.5 | Restoration | 621.5 | 12 |
| Main Channel Reach 3 | 865.5 | Restoration | 1356.5 | 197 |
| Tributary, Reach 1 | 440.8 | Enhancement | 440.8 | 4 |
| Tributary, Reach 2 | 361.9 | Restoration | 361.9 | 11 |
| Tributary, Reach 3 | 286.6 | Restoration | 286.6 | 6 |
| Total | 2925.5 | | 3416.5 | 251 |

## METHODS

The working group led by Dr. Schwartz will meet on April 8, 2021 in Murfreesboro, TN to finalize the revisions to the current TN SQT. The working group membership includes representatives from the Tennessee Water Resources Research Center, the University of Tennessee, the West Tennessee River Basin Authority, Barge Design Solutions, BDY Environmental, Cumberland River Compact, Civil & Environmental Consultants, Stantec, KCI, Envirogreen, Tennessee Department of Environment and Conservation, and the United States Army Corps of Engineers. The first goal of the TN SQT Review working group is to limit the metrics per category to 2 to 4 to eliminate the existing issue in which the current number of metrics, or lack thereof, unintentionally weights the total Existing Condition Score (ECS), disincentivizing a wide range of restoration practices. The second goal is to identify the current metrics in the TN SQT in which ECS scales are not suitably measuring function and/or lack adequate reference data to appropriately generated a meaningful ECS and identify methods to adjust scales until ecoregion-based data can be obtained. The third goal is to provide alternatives to metrics that require bankfull dimensions so that in highly alternated channels and urban streams the function is accurately scaled and applied and does not dictate or promote restoration design methodology. The final goal is to simplify the TN SQT field and spreadsheet protocols where possible. Table 3 summarizes the discussion topics for the April 8th meeting. The finalized proposed TN SQT is expected to be ready for testing early in the summer of 2021.

Table 3. Modification categories for TN SQT Review Working Group.

| Functional Category | Function-based Parameter | Fundamental Attribute Assessed |
|---|---|---|
| Hydrology | Catchment Hydrology | Rainfall-runoff relationships |
| | Reach Runoff | Infiltration hydrology |
| | Floodplain Inundation | Channel capacity for flood waters |
| | Evapo-transpiration | ET hydrology |
| | Base flow Permanence | Groundwater recharge |
| Hydraulics | Floodplain Connectivity | Extent of floodplain inundation |
| | Channel Incision | Potential for hydraulic downcutting |
| | Channel Erosion Potential | Enhanced erosion from structural diversion of flow |
| Geo-morphology | Large Woody Debris Index | Habitat attribute; Geomorphic dynamics |
| | Lateral Migration | Streambank erosion |
| | Riparian Vegetation | Riparian corridor quality |
| | Bed Material Characterization | Habitat quality and channel stability |
| | Plan Form -Sinuosity | Reach-scale morphology |
| | Channel Evolution Model | Channel stability |
| | Channel Incision | Channel stability and sediment transport |
| Physio-chemical | Bacteria | Fecal contamination |
| | Organic Enrichment | Nutrient pollution |
| | Nitrogen | Nutrient pollution |
| | Phosphorus | Nutrient pollution |
| Water Quality/ Biology | Macro-invertebrates | Water quality and habitat indicator |
| | Fish | Water quality and habitat indicator |
| | Mussels – Native Species | Biotic integrity, biodiversity |
| Riparian Corridor | Riparian Vegetation | Riparian corridor quality |
| Physical Habitat | Physical Habitat | Physical habitat quality |
| | Frequency of Riffles | Pool-riffle sequence for ecosystem health |
| | Pool Variability | Pool habitat quality |
| | Epifaunal Substrate | Stream bed substrate quality |
| | Hyporheic Quality | Bed substrate habitat quality |
| | Aquatic Connectivity | Ecosystem recovery potential |
| | Endangered Species | Habitat quality, biodiversity |

## ASSESSMENTS

During the summer of 2021, Dr. Schwartz and his research assistant, Grace Long, will travel to several of the ninety-two ecoregion reference streams across the state to apply the proposed TN SQT to those sites. The data from the current TN SQT results on those ecoregion reference stream will also be compiled. Additional stream data will be gathered from members of the working group who generously offered the results of stream restoration projects they have recently completed using the current TN SQT. With these two data sets, the results of the current TN SQT on the Beaver Creek Restoration Project will be used to assess the capabilities of the proposed TN SQT.

The data from each current TN SQT results and field assessments will be applied to the proposed SQT. The differences for each site between the current SQT and proposed SQT will be statistically analyzed to determine if the functional lift assessed by the proposed SQT is significant. On a scale of 0 to 1, where 1 is a stream in pristine condition, using the current TN SQT, an ecoregion reference stream has an average existing condition score of 0.76 which is considered just above the functioning range. On the same scale, urban impaired and urban restored streams in Tennessee score on average 0.56 and 0.58, respectively. It is expected that after applying the proposed TN SQT ecoregion reference streams will have an existing conditions score of about 0.85. To incentivize urban stream restoration projects, it is expected that the increase between the scores of the proposed TN SQT on an urban impaired stream before and after restoration will be greater than 0.1.

Using the current TN SQT, the main channel of Beaver Creek has an existing condition score of 0.30, and the tributary currently has an existing condition score of 0.15. The main channel of Beaver Creek currently has a post-restoration proposed condition score of 0.33, and the tributary currently has a proposed condition score of 0.17. This provides a functional lift from the proposed restoration work for the main channel and tributary of 0.03 and 0.02, respectively.

With the proposed changes to the TN SQT, the functional lift of Beaver Creek will score higher thus reflecting more accurately the effects of the restoration work on this urban stream. The improved results will incentivize more urban stream restoration projects because they will generate additional stream mitigation credits.

## REFERENCES


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