

Functional Lift Quantification Tool for Stream Restoration Projects in North Carolina

Spreadsheet User Manual





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Version 2**

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Glossary of Terms

Best Management Practice (BMP) – Defined by state administrative code rule 02 NCAC 60C.0102 (4) as “a practice, or combination of practices, that is determined to be an effective and practicable means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.”

Condition Score – A value between 1 and 0 that expresses whether the associated parameter, functional category, or overall restoration reach is functioning, functioning-at-risk, or not functioning compared to a reference condition.

- ECS = Existing Condition Score
- PCS = Proposed Condition Score

Functional Category – The levels of the stream functions pyramid: Hydrology, Hydraulics, Geomorphology, Physicochemical, and Biology. Each category is defined by a functional statement.

Functional Foot Score (FFS) – The product of a condition score and stream length.

- EFFS = Existing Functional Foot Score. Calculated by measuring the existing stream length and multiplying it by the ECS.
- PFFS = Proposed Functional Foot Score. Calculated by measuring the proposed stream length and multiplying it by the PCS.

Function-Based Parameter – A metric that describes and supports the functional statement of each functional category.

Measurement Method – Specific tools, equations, assessment methods, etc. that are used to quantify a function-based parameter.

Performance Standard – Determines functional capacity of a measurement method using a 0.0 to 1.0 scale. Performance standards are stratified by functioning, functioning-at-risk, and not functioning. Measurement method performance standards are then averaged to create parameter performance standards.

Reference Condition – A stream condition that is considered fully functioning for the parameter being assessed. It does not simply represent the best condition that can be achieved at a given site; rather, a condition score of 1.0 represents a pristine system.

Stream Functions Pyramid Framework (SFPF) – The Stream Functions Pyramid is comprised of five functional categories (see above) stratified based on the premise that lower-level functions support higher-level functions and that they are all influenced by local geology and climate. The Framework includes the organization of function-based parameters, measurement methods, and performance standards.

I. Introduction, Purpose, and Use

The purpose of this document is to provide instruction on how to use the Stream Functional Lift Quantification Tool (SQT) in North Carolina streams. The instructions below will help the user input data into the Microsoft Excel Workbook by providing rules and procedures that must be followed. The instructions will also provide guidance on selecting function-based parameters and measurement methods.

This user manual does not provide guidance on data collection techniques or the supporting science for the performance standards. The Data Collection and Analysis Manual is available as a separate document and the science manual has not been written. A guide to these three manuals is provided in the call-out box. This manual also does not provide a methodology for creating credits from the SQT results since NC already has a credit determination method.

This version of the SQT and user manual have been tailored for North Carolina. Many of the parameters, measurement methods, and performance standards are therefore unique to this state. Definitions of parameters, measurement methods, and performance standards are provided in the Background Section below and in the glossary. Additional versions of the SQT and user manual are being developed for other regions.

QT Manual Guide

1. Spreadsheet User Manual – *Rules and procedures for entering data into the Microsoft Excel Workbook.* (This document)
2. Data Collection and Analysis Manual – *Provides instruction on how to collect and analyze data needed to run the SQT.* (Dec. 2016)
3. Performance Standard Reference Manual – *Science behind the development of performance standard curves.* (2017)

**All manuals will be available from
stream-mechanics.com**

I.1. Purpose and Uses of the SQT

The SQT was developed primarily for stream restoration projects completed as part of a compensatory mitigation requirement. However, the tool can be used for any stream restoration project, regardless of the funding driver. Specific reasons for developing the tool include the following:

1. Develop a simple calculator to determine the numerical differences between an existing (degraded) stream condition and the proposed (restored or enhanced) stream condition. This numerical difference is known as functional lift or uplift. It is related to, and could be part of, a stream credit determination method as defined by the 2008 Federal Mitigation Rule.¹

¹ Compensatory Mitigation for Losses of Aquatic Resources, 33 CFR 332 (2012).
<https://www.gpo.gov/fdsys/pkg/CFR-2012-title33-vol3/xml/CFR-2012-title33-vol3-part332.xml>

2. Link restoration activities to changes in stream functions by primarily selecting function-based parameters and measurement methods that can be manipulated by stream restoration practitioners.
3. Link restoration goals to restoration potential. Encourage assessments and monitoring that matches the restoration potential.
4. Incentivize high-quality stream restoration and mitigation by calculating functional lift associated with physicochemical and biological improvements.

These purposes translate into at least six different uses for the SQT, and include the following. Note: This is a universal list that applies beyond potential uses in North Carolina.

1. Site Selection – The tool can help determine if a proposed project has enough lift and quality to be considered for a stream restoration or mitigation project. Rapid field assessment methods can be used to produce existing and proposed scores.
2. Functional Lift or Loss – The tool can quantify functional lift or loss from a proposed or active stream restoration project. This first happens during the design or mitigation plan phase and is re-scored for each post-construction monitoring event.
3. Credit Determination Method – Existing ratio based credit determination methods can be adapted to use the proposed condition score minus the existing condition score as a way to select the appropriate ratio. This can be done without changing the existing ratio method. New credit determination methods can be developed to simply use the difference in the proposed functional foot score minus the existing functional foot score. Scoring is described below in section III.5.c. Scoring Functional Lift.
4. Permittee Responsible Mitigation – The tool can be applied to on-site, permittee-responsible mitigation to help determine if the proposed mitigation activities will offset the proposed impacts.
5. Debit Determination Method – A modified version of the SQT can be used to show the functional loss associated with proposed or permitted impacts. The math used to calculate a stream credit (described above under 3. Credit Determination) is used to calculate a debit. The difference is that the proposed condition will have a lower value than the existing condition, resulting in a negative number.
6. Stormwater Best Management Practices (BMPs) in Conjunction with Stream Restoration – There is a subroutine in the SQT that applies to stream restoration projects using BMPs to treat adjacent runoff. However, the SQT should not be used for projects that only install stormwater BMPs and do not include stream restoration (in channel) work.

I.2. Downloading the Quantification Tool and Supporting Information

The SQT and supporting documents can be downloaded from the Stream Mechanics web page (stream-mechanics.com). Select the Stream Functions Pyramid Framework tab.

Functional Lift Quantification Tool – Includes the NC SQT spreadsheet, NC SQT Example, List of Metrics, Data Collection and Analysis Manual and Spreadsheet User Manual. The List of Metrics is a spreadsheet file that provides a comprehensive list of the function-based parameters with their measurement methods, performance standards, stratification methods, and references. The SQT and List of Metrics will be updated frequently, so users should check the web page before starting a new project to make sure they are using the latest version.

This page includes other resources like the Stream Functions Pyramid diagram, *A Function-Based Framework for Stream Assessment and Restoration Projects*² (includes the science behind the SQT), a rapid assessment method, and new function-based parameters with measurement methods and performance standards (not included in the Framework book).

In addition, the Workshops tab provides a list of courses providing further education on the Stream Functions Pyramid Framework, the SQT, and other courses related to stream assessment and restoration.

II. Background

II.1. Stream Functions Pyramid Framework

The Stream Functions Pyramid Framework (SFPF) provides the scientific basis of the SQT, which is described in detail in *A Function-Based Framework for Stream Assessment and Restoration Projects*, published by the US Environmental Protection Agency and the US Fish and Wildlife Service.² The Stream Functions Pyramid, shown below in Figure 1, includes five functional categories: Level 1 = Hydrology, Level 2 = Hydraulics, Level 3 = Geomorphology, Level 4 = Physicochemical, and Level 5 = Biology. The Pyramid is based on the premise that lower-level functions support higher-level functions and that they are all influenced by local geology and climate. Each functional category is defined by a functional statement. For example, the functional statement for Level 1, Hydrology is “the transport of water from the watershed to the channel,” which supports all higher-level functions.

The Stream Functions Pyramid *alone* shows a hierarchy of stream functions but does not provide a specific mechanism for addressing functional capacity, establishing performance standards, or communicating functional lift. The diagram in Figure 2 expands the Pyramid concept into a more detailed framework to quantify functional capacity, establish performance standards, show functional lift, and establish function-based goals and objectives.

² Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. *A Function-Based Framework for Stream Assessment and Restoration Projects*. US EPA, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006.

Figure 1: Stream Functions Pyramid

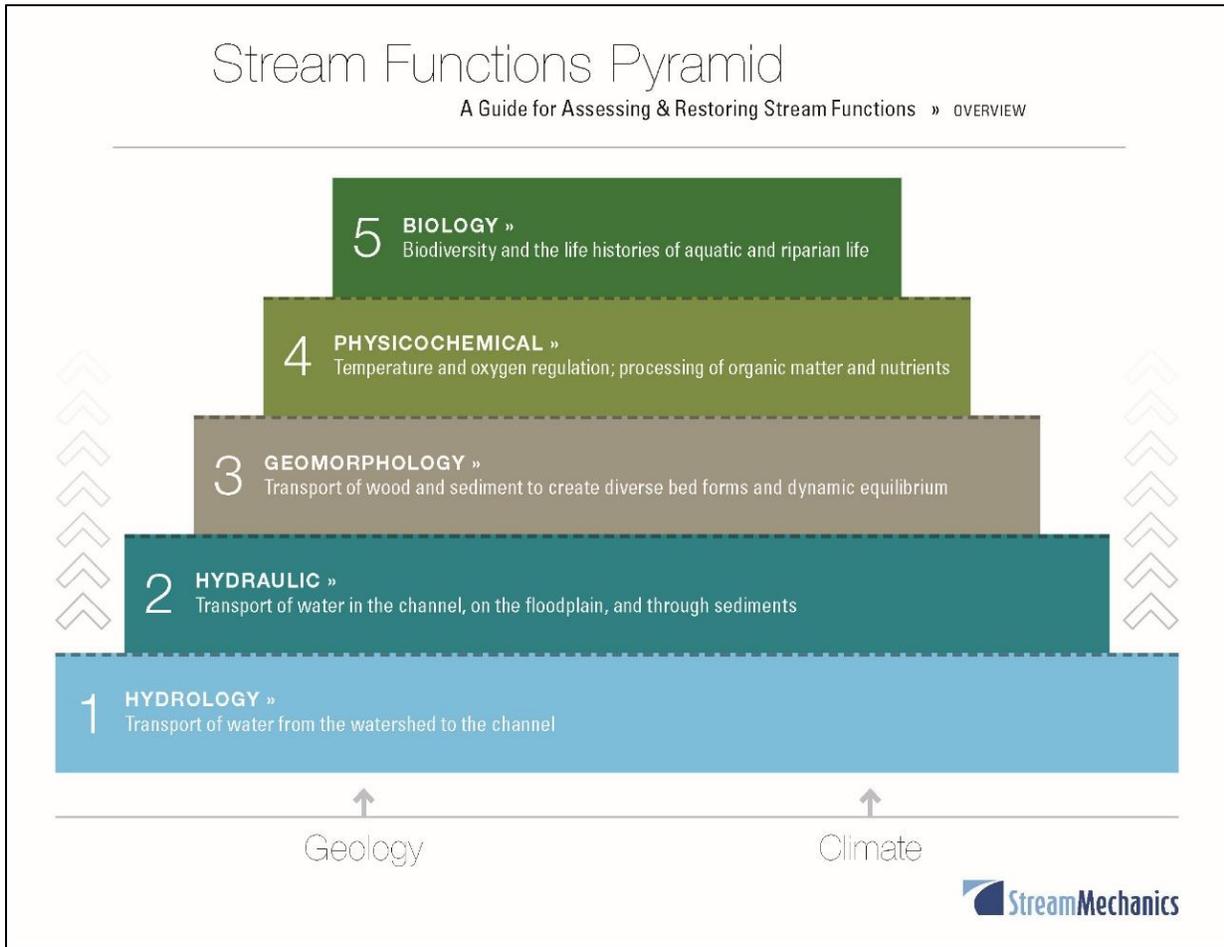
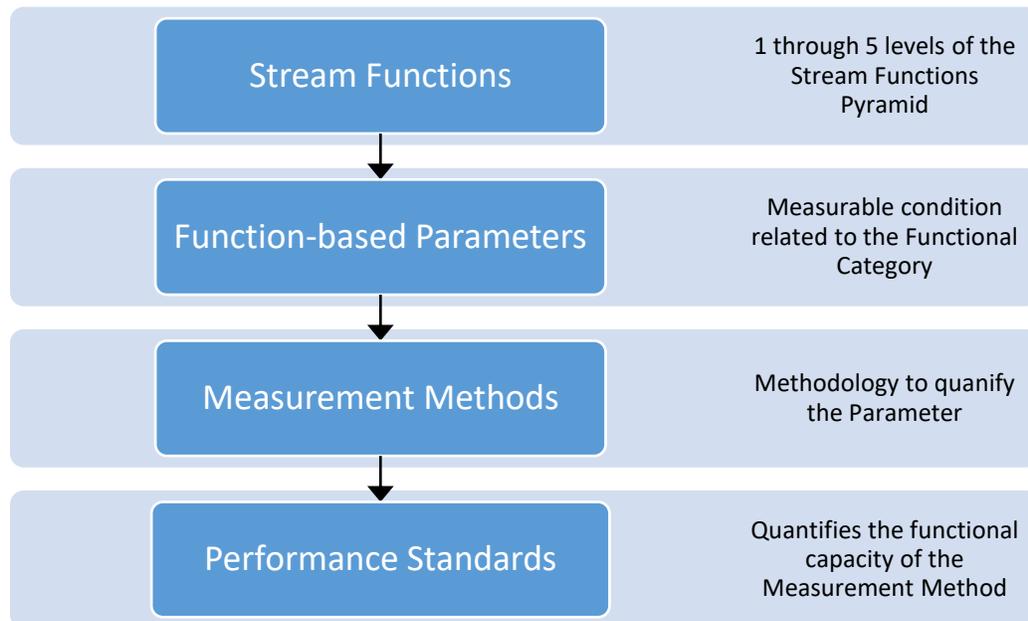


Figure 2: Stream Functions Pyramid Framework



The Stream Functions block shown at the top of Figure 2 represents the five levels of the Stream Functions Pyramid shown in Figure 1. The remainder of the framework is a “drilling down” approach that provides more detailed forms of analysis to quantify stream functions. The function-based parameters describe and support the functional statements of each functional category. The measurement methods are specific tools, equations, assessment methods, etc. that are used to quantify the function-based parameter; there can be more than one measurement method for a single function-based parameter.

Performance standards are used to determine functional capacity at the measurement method level on a 0.0 to 1.0 scale and are assessed as functioning (0.7 to 1.0), functioning-at-risk (0.3 to 0.69), and not functioning (0 to 0.29). Definitions for each are provided below:

- **Functioning** – A functioning score means that the measurement method is quantifying or describing the functional capacity of one aspect of a function-based parameter in a way that **does support** a healthy aquatic ecosystem. In other words, it is functioning at reference condition. The reference condition concept as used here aligns with the definition laid out by Stoddard, et al. (2006)³ for a reference condition for biological integrity. It is important to note that a reference condition does not simply represent the best condition that can be achieved at a given site; rather, a condition score of 1.0 represents a pristine system.

However, a single functioning measurement method, out of several measurement methods, may not mean that the function-based parameter or particular stream process

³ Stoddard, J.L., D.P. Larsen, C.P. Hawkins, R.K. Johnson, and R.H. Norris, 2006. Setting Expectation for the Ecological Condition of Streams: The Concept of Reference Condition. *Ecological Applications*, 16(4): 1267-1276.

is functioning. The SQT averages measurement method scores to calculate a parameter score. Therefore, a functioning measurement method score averaged with a not functioning score could yield a functioning-at-risk score. For example, bed form diversity is a function-based parameter and pool spacing, pool depth compared to riffle depth, and percent riffle are its three measurement methods. Understanding how each measurement method result contributes to the overall bed form condition is more important than a single measurement method result, like the depth of one pool. Functioning bed form diversity would have an appropriate number of pools (pool spacing), good variability in depth, and an appropriate split of riffles and pools.

- **Functioning-At-Risk** – A functioning-at-risk score means that the measurement method is quantifying or describing one aspect of a function-based parameter in a way that **can support** a healthy aquatic ecosystem. In many cases, this indicates the function-based parameter is adjusting in response to changes in the reach or the watershed. The trend may be towards lower or higher function. A functioning-at-risk score implies that the aspect of the function-based parameter, described by the measurement method, is between functioning and not functioning.
- **Not Functioning** – A not functioning score means that the measurement method is quantifying or describing one aspect of a function-based parameter in a way that **does not support** a healthy aquatic ecosystem. It is not functioning like a reference condition. A single not functioning measurement method may not mean that the function-based parameter is not functioning.

II.2. Restoration Potential

Restoration potential is a key application from the Stream Functions Pyramid Framework. Restoration potential is defined as the highest level (on the pyramid) of restoration that can be achieved based on the health of the watershed, the condition of the reach, and anthropogenic constraints. A restoration potential of Level 5 means that the project has the potential to restore biological functions to a reference condition. This can only happen if the catchment health is good enough to support that level of biology and anthropogenic constraints do not prevent the practitioner from implementing the required activities. Examples of anthropogenic constraints include adjacent sewer lines, easement width, in-lieu fee funding limits, and infrastructure. Natural landscape features like bedrock and hillslopes are not constraints; they are simply watershed features that must be considered.

If the catchment health is somewhat impaired and/or constraints limit restoration activities, then the restoration potential will be less than Level 5. Typical stability focused projects in impaired watersheds would reach Level 3 (Geomorphology). Level 3 projects can improve floodplain connectivity, lateral stability, bed form diversity, and riparian vegetation (function-based parameters describing geomorphology functions) to a reference condition, but not physicochemical or biological functions. Biological or physicochemical improvement can still be obtained; however, the improved condition will remain in the functioning-at-risk or not functioning category. This doesn't mean that Level 3 projects shouldn't be pursued; however, the design goals and objectives, as well as monitoring, should focus on lower-level functions. Note that stream restoration projects have a minimum restoration potential of Level 3.

Level 4 projects are less common and would typically include a stormwater BMP. The most common example would be a headwater urban project where the stream reach is restored and BMPs are installed to reduce runoff and nutrients from lateral sources, e.g. parking lots.

Biological improvement can still be obtained; however, the improved biological condition will remain in the functioning-at-risk or not functioning category.

The SQT requires the user to determine the restoration potential for each project reach. The restoration potential is then used to create function-based design goals and objectives.

II.3. Function-Based Design Goals and Objectives

Function-based design goals and objectives can be developed once the restoration potential is determined. Design goals are different than programmatic goals which generally relate to the project's funding source. Programmatic goals are bigger-picture goals that are often independent of the project site. For example, a programmatic goal might be to create mitigation credits. Design goals are statements about *why* the project is needed at the specific project site. They are general intentions and often cannot be validated. Objectives are more specific. They help explain *how* the project will be completed. Objectives are tangible and can be validated, typically by performance standards.

Examples of design goals include: restore native brook trout habitat (Level 3 goal), restore native brook trout biomass (Level 5), restore the stream to a biological reference condition (Level 5), reduce sediment supply from eroding streambanks (Level 3), and reduce nutrient inputs (Level 4). All of these goals communicate why the project is being undertaken. Example objectives include: increasing floodplain connectivity, establishing a riparian buffer, and increasing bed form diversity. These objectives can't stand alone, but with the goals, they can describe what the practitioner will do to address the functional impairment. The objectives can be quantitative as well. For example: floodplain connectivity will be improved by reducing the bank height ratio from 2.0 to 1.0. Now, functional lift is being communicated and the performance standard is established for monitoring.

The design goals and objectives are communicated in a narrative form and entered into the SQT. The design goals are then compared to the restoration potential to ensure that the goals do not exceed the restoration potential. For example, it is not possible to have a design goal of restoring native brook trout biomass (Level 5) if the restoration potential is Level 3, meaning that the catchment stressors and reach constraints will not support brook trout, e.g., because the watershed is developed and water temperature entering the project reach is too high for brook trout. However, the goal could be revised to restore the physical habitat for native brook trout, e.g. provide riffle-pool sequences, cover from a riparian buffer, and appropriate channel substrate. This is a Level 3 goal that matches the Level 3 restoration potential. If native brook trout populations in the project reach are to be monitored, increasing native brook trout biomass could be possible even with a restoration potential of Level 3 but restoring native brook trout populations to reference conditions would not be expected or possible. If watershed-level improvements are implemented, over time, the restoration potential could shift from a Level 3 to 5. Notice however, that this requires reach-scale *and* watershed-scale restoration.

III. Spreadsheet User Manual

The Stream Functional Lift Quantification Tool (SQT) is a Microsoft Excel Workbook with 7 visible worksheets and one hidden worksheet. There are no macros in the spreadsheet and all formulas are visible but some worksheets are locked to prevent editing. The worksheets include:

- Project Assessment
- Catchment Assessment
- Parameter Selection Guide
- Quantification Tool (locked)
- Performance Standards (locked)
- Monitoring Data (locked)
- Data Summary (locked)
- Pull Down Notes – This worksheet is hidden and contains all the inputs for drop down menus throughout the workbook.

The Quantification Tool, Performance Standards and Monitoring Data worksheets are locked to protect the formulas that provide scores and calculate functional lift. This chapter will describe each of the visible worksheets in detail.

Project Initialization – Once the SQT is downloaded, the Project Assessment Worksheet should be completed first, followed by the Catchment Assessment Form, and a review of the Parameter Selection Guide. For each site, project reaches will need to be delineated. General guidance on selecting project sites and identifying project reaches is provided below; more detailed instructions are provided in the Data Collection and Analysis Manual.

Site Selection – The SQT can be used to assist with selecting a potential stream restoration or mitigation site. During the site selection process, the user may want to estimate the field values required as input based on rapid assessment methods and Best Professional Judgement (BPJ)—the difference between rapid-based assessments and detailed assessments for various measurement methods is described in the Data Collection and Analysis Manual. If the user is deciding between multiple sites, the quantification tool can be used to rank sites based on the amount of functional lift available and overall quality. The functional lift is calculated from the difference in condition scores and/or the functional foot scores. The overall quality is the overall proposed condition score for the restoration reach. Another way to assess overall quality is to evaluate the functional lift of the individual parameters. At a minimum, a proposed site should produce functioning conditions for floodplain connectivity, bed form diversity, and lateral stability. Riparian vegetation should be well within the functioning-at-risk category, e.g. a 0.6 condition score, by the end of monitoring.

Once a site has been selected for a project, a detailed assessment should be completed. This will include taking quantitative measurements of the function-based parameters selected for the project. Guidance on how to select function-based parameters is included in section III.3. Parameter Selection Guide Worksheet.

Determining Stream Reaches – The SQT is a reach-based assessment and one excel workbook should be assigned to each reach in a project. If there are multiple reaches in a single project, then multiple workbooks are needed. A reach is defined as a stream segment with

similar valley morphology and stream type, stability condition, vegetation, bed material, and restoration potential. Stream length is not used to delineate a stream reach, i.e., stream reaches can be short or long depending on their characteristics. For example, a culvert removal reach may be short and a channelized stream through cropland may be long. Reach identification is discussed in detail in section II.1. of the *Data Collection and Analysis Manual*.

To evaluate projects that consist of multiple reaches, the functional feet scores for each reach can be summed to create an overall project score. The condition scores are dimensionless and cannot be summed, but could be averaged for all reaches or for reaches with similar characteristics. Care should be taken in averaging reach scores to ensure that pertinent information is not lost or hidden in averaging. Functional feet and condition scores are discussed in section III.5.c. Scoring Functional Lift.

III.1. Project Assessment Worksheet

The purpose of the Project Assessment Worksheet is to communicate the goals of the project related to the funding drivers and the restoration potential of the specific site. Guidance on completing this Worksheet follows.

Programmatic Goals – The programmatic goals relate to the funding source of the project. These are bigger-picture goals that are often independent of the project site. Select Mitigation, TMDL, Grant, or Other from the drop down menu. There is space provided to expand on the programmatic goals. For example, if the programmatic goal is to create mitigation credits, then the text box could be used to provide more information about the type and number of credits needed.

Restoration Potential – The connection between the restoration potential and the programmatic goals should be explained. The restoration potential is described as Level 3: Geomorphology, Level 4: Physicochemical, or Level 5: Biology. The restoration potential is also entered on the Quantification Tool Worksheet. Restoration potential is defined in section II.2. Restoration Potential and in the glossary. For example, if the programmatic goal is to create mitigation credits and the restoration potential was Level 3, then the text box could explain how bringing geomorphology to a functioning level would create the necessary credits. It would also communicate that the project is unlikely to return biology to a reference condition.

Function-Based Goals and Objectives – Space is provided to describe the function-based goals and objectives of the project. These goals should match the restoration potential. More information on developing goals and objectives is provided in the section II.3. Function-Based Design Goals and Objectives.

Reach and reach break description – The SQT is a reach-based assessment and one Excel workbook should be assigned to each reach in a project site. Space is provided to describe the reach and the characteristics that separate it from the other reaches in the project.

Aerial Photograph of Project Reach – Provide an aerial photograph of the project reach. The photo could include labels indicating where work is proposed, the project easement, and any important features within the project site or watershed.

III.2. Catchment Assessment Form Worksheet

The purpose of the Catchment Assessment Form is to assist in determining the restoration potential of the project reach and to score the catchment hydrology parameter. Each use is described in this section.

The Catchment Assessment Form includes descriptions of watershed processes and stressors that exist outside of the project reach and may limit functional lift. Most of the categories describe potential problems upstream of the project reach since the contributing catchment has the most influence on water quality and biological health of the project reach. However, there are a few categories, like location of impoundments that look upstream and downstream of the project reach. Further detail on completing the catchment assessment is provided in section II.2.b. of the *Data Collection and Analysis Manual*.

Categories of watershed conditions and stressors are listed by functional category. The categories considered are provided in Table 1 on the following page.

Table 1: Catchment Assessment Categories

Categories (Functional Category Affected)		Descriptions
1	Concentrated Flow (Hydrology)	Potential for concentrated flow/impairments to reach restoration site.
2	Impervious cover (Hydrology)	Percent of watershed that is impervious surface upstream of the restoration site.
3	Land Use Change (Hydrology)	Rapidly urbanizing versus rural and primarily forested.
4	Distance to Roads (Hydrology)	Proximity of existing and planned roads to the restoration site.
5	Watershed Hydrology (Hydrology)	Flow regime and basin characteristics.
6	Percent Forested (Watershed) (Hydrology)	Percent of watershed that is forested upstream of the restoration site.
7	Riparian Vegetation (Geomorphology)	Width of riparian corridors on streams contributing to the restoration site.
8	Sediment Supply (Geomorphology)	Potential sediment supply from upstream bank erosion and surface runoff.
9	Located on or downstream of a 303(d) listed stream; TMDL presence/absence (Physicochemical)	Proximity of site to 303(d) listed streams and whether the listed streams have a TMDL/WS management plan.
10	Agricultural Land Use (Physicochemical)	Livestock access to stream and/or intensive cropland in the watershed likely to impact restoration site conditions.
11	NPDES Permits	Proximity of NPDES permits to the restoration site.
12	Specific Conductance ($\mu\text{S}/\text{cm}$ at 25°C) (Physicochemical)	Measurement of specific conductance at upstream extent of the restoration site.
13	Watershed impoundments (Biology)	Proximity of impoundments and impact on project area and fish passage.
14	Organism Recruitment (Biology)	Condition of channel bed and bank immediately upstream and downstream of the restoration site.
15	Percent of Catchment being Enhanced or Restored	Percent of watershed that is included in the restoration site easement.
16	Other	Choose your own.

A catchment condition of good, fair, or poor is assessed for each category in Table 1. There is no requirement to provide an answer for all categories listed and there is space for the user to enter an additional category. Once the categories are assessed there is space at the top of the form to enter the user's evaluation of the Overall Watershed Condition. This is based on best professional judgement and not an automatic scoring methodology. The result is not linked to the Quantification Tool worksheet.

The overall watershed condition is left as a subjective determination so that the user can assess and interpret the information gathered about the catchment. It is possible that one or more of the

categories is a “deal breaker,” meaning that the result of that category overrides all other answers. For example, a high specific conductivity in a stream impacted by mining operations could indicate there is little potential for biological lift even if the other categories showed a good condition. Conversely, it is also possible for a good category score to overcome catchment stressors. For example, “percent of watershed being treated” is included as a category to show that a project could be large enough to overcome watershed stressors.

III.2.a. Using the Catchment Assessment Form to Determine Restoration Potential

Restoration potential is the highest level (on the pyramid) of restoration achievable based on the health of the upstream watershed (catchment), condition of the reach, and human constraints that interfere with selecting preferred restoration activities. Refer to section II.2. Restoration Potential for more information.

A catchment condition of good, fair, or poor is assessed for each category in Table 1. There is no requirement to provide an answer for all categories listed and there is space for the user to enter an additional category that would affect restoration potential. Categories that have a poor or fair catchment condition can limit the potential lift that is possible through restoration activities and a restoration potential should be selected based on the constraints identified in this form. Table 2 shows how the catchment assessment can be used to determine restoration potential.

Table 2: Connecting Catchment Condition and Restoration Potential

Restoration Potential	Results from Catchment Assessment
Level 5 (Biology)	Overall Score = Good. The watershed has very few stressors and would support water quality and biology at a reference condition if the reach-scale problems are corrected. Note: It is possible to achieve a Level 5 with a Poor to Fair catchment score if the percent of the watershed being treated is very high (see category 15). However, it may take a long period of time to achieve.
Level 4 (Physicochemical)	Overall Score = Poor to Fair. The watershed will have hydrology impairments from runoff entering the project reach from adjacent sources, e.g. parking lots or heavy use areas. Stormwater and agricultural BMPs can be used to reduce runoff and nutrient levels to reference condition at a sub-catchment scale (catchment draining to the BMP).
Level 3 (Geomorphology)	Overall Score = Poor to Fair. Catchment health will not support water quality and biology to a reference condition. For watersheds that score near the higher end of fair, reach-scale restoration may improve water quality and biology, just not to a reference condition. The chances of water quality and biological improvement will increase with project length and percent of watershed being treated.
None	It is possible to have a catchment health score so low that reach-scale restoration is unattainable. In addition to the catchment score, however, this is dependent on the reach length, reach condition, and constraints.

III.2.b. Using the Catchment Assessment Form to Score the Catchment Hydrology Parameter

Recall that the purpose of the Catchment Assessment Form is to assist in determining the restoration potential of the project reach and to score the catchment hydrology parameter. The former was discussed in the previous section while the catchment hydrology parameter is discussed here. Catchment hydrology is a function-based parameter used to assess the Hydrology Functional Category (see section III.5.b. Existing and Proposed Condition Data Entry). This parameter is recommended for all stream restoration projects in order to capture the hydrologic quality of the upstream watershed which affects the restoration potential of all higher functional categories.

Assessing the Catchment Hydrology Parameter requires the user to determine the quality of the catchment as high, medium or low. There are nine options to describe catchment hydrology: L1, L2, L3, M1, M2, M3, H1, H2, and H3. The parameter field value should be selected primarily based on the hydrology stressors (categories 1 through 6 from Table 1). Table 3 shows the relationship between catchment hydrology quality, catchment condition, and the performance standard used in the SQT. For more detail on performance standards and index values, see section III.4. Performance Standards Worksheet.

Table 3: Catchment Hydrology Parameter

Field Value	Index Value	Example Description
H3	1	The overall catchment condition is good; there are few if any fair ratings in the catchment assessment, no poor ratings, and all 6 of the hydrology categories are good.
H2	0.9	The average condition for the hydrology categories is good but there may be some potential for concentrated flow impairments. (i.e. 5 good categories and 1 fair)
H1	0.8	The average condition for the hydrology categories is good but there is some potential for concentrated flow impairments and the watershed is only 65% forested. (i.e. 4 good hydrology categories and 2 fair)
M3	0.6	The average condition for hydrology categories is fair or good but there is an active headcut supplying a significant amount of sediment to the reach. (i.e. 3 or 4 good hydrology categories, 2 or 3 fair and possibly a poor rating in another category)
M2	0.5	The average hydrology condition is fair. A highly cultivated watershed with little impervious surface and no roads near the project but highly flashy with concentrated flows entering the reach. (i.e. 3 poor hydrology categories and 3 high categories)
M1	0.4	The hydrology categories average a good score but the rest of the categories in the Catchment Assessment average a poor condition.
L3	0.3	The average condition for the hydrology categories is poor but there is some potential for concentrated flow impairments and

Field Value	Index Value	Example Description
		the watershed is 25% forested. (i.e. 4 poor hydrology categories and 2 fair)
L2	0.2	The average condition for the hydrology categories is poor but the watershed is mostly rural. (i.e. 5 poor categories and 1 fair or good)
L1	0.1	Most or all of the hydrology categories are poor.

The existing and proposed condition scores for catchment hydrology will typically be the same because practitioners will rarely change the runoff characteristics of the upstream watershed. Therefore, this parameter will typically affect the stream condition score, but not the functional lift (because existing condition = proposed condition). Exceptions include projects where the practitioner is significantly changing land uses within the watershed or restoring a significant percentage of the watershed. In this case, the proposed condition could exceed the existing condition and thereby show functional lift.

III.3. Parameter Selection Guide Worksheet

The Parameter Selection Guide worksheet can help the user determine which parameters are required for different types of stream restoration projects. A project would rarely, if ever, enter field values for all measurement methods included in the SQT. **However, if a value is entered for a measurement method in the Existing Condition Assessment, a field value must also be entered for the same measurement method in the Proposed Condition Assessment.**

A summary of the Parameter Selection Guide is provided below.

The following parameters should be required for all assessments throughout North Carolina:

- Catchment Hydrology (assessed using the Catchment Assessment worksheet)
- Reach Runoff
- Floodplain Connectivity
- Lateral Stability
- Riparian Vegetation
- Bed Form Diversity
- Large Woody Debris
- Sinuosity

Of these, it is recommended that **ALL** projects monitor and bring floodplain connectivity, lateral stability, and bed form diversity to a functioning condition at the end of the monitoring period to prevent 'credit chasing' and provide a minimum condition achieved by restoration. It is also recommended that **ALL** projects monitor riparian vegetation; however, since the riparian vegetation parameter is based on a functioning forest, restoration sites with newly-planted trees will not achieve a functioning score within the typical 10-year monitoring period. Regardless, it should be included in minimum quality requirements by achieving a score well within the functioning-at-risk category, e.g., 0.6.

The Quantification Tool worksheet will display a warning message reading “WARNING: Sufficient data are not provided” if data are not entered for at least these four parameters. Practitioners should not be allowed to “cherry pick” parameters to create lift at minimal cost. For example, a practitioner should not be allowed to only plant trees, creating lift in riparian vegetation, when the channel is incised and actively eroding the bed and/or banks.

The following parameters are suggested for urban projects with BMPs:

- Runoff
- Temperature
- Specific Conductivity
- Nitrogen
- Phosphorus

The SQT can be applied to stream restoration projects installed in combination with BMPs but should not be applied to BMP projects that are not connected to a stream restoration reach. The parameters listed above occur in the BMP Routine portion of the SQT. For most projects, these parameters will only be modeled for BMP performance and values entered in the BMP Routine. However, if the practitioner or regulator believes that the BMPs or the restoration practices could have an effect on the receiving stream (which will also be the stream restoration project reach), temperature, nitrogen and phosphorus could be monitored in the stream and values entered into the reach condition assessments. Notice that values entered in the BMP Routine are modeled and the values entered in the condition assessments are monitored.

The following additional parameters should be required for projects with a level 4 – physicochemical restoration potential:

- Organic Carbon
- Temperature

The following additional parameters should be required for projects with a level 5 – biology restoration potential:

- Macros for regions with macroinvertebrate data
- Fish for regions with fish data

The remaining parameters can be selected based on their applicability to the project reach:

- Bed Material Characterization (gravel bed and sandy banks, with potential to coarsen the bed)
- Temperature (coldwater or cool-water designated streams)
- Bacteria (livestock access to stream)

For example, consider a typical project located in a pasture with a level 3 restoration potential. The project goals are improving native aquatic habitat and reducing sediment supply from bank erosion. The work will include fencing to keep the cattle out of the channel and channel reconstruction. The watershed is small and consists mostly of cropland. The overall catchment assessment is fair and supports some biological lift. The parameter list would likely consist of:

- Catchment Hydrology
- Reach Runoff

- Floodplain Connectivity (Must be brought to a functioning condition)
- Lateral Stability (Must be brought to a functioning condition)
- Riparian Vegetation (Must be brought to a functioning condition unless this is not possible within the monitoring period)
- Bed Form Diversity (Must be brought to a functioning condition)
- Large Woody Debris
- Sinuosity
- Bacteria
- Macros
- Fish

While the project only has level 3 restoration potential, there is monitoring at levels 4 and 5 because the project is expected to show some improvement in these functional categories. However, the project is not expected to return macros and fish biomass back to a forested reference condition.

III.4. Performance Standards Worksheet

The purpose of the Performance Standards Worksheet is to provide equations that convert field values for measurement methods into index values. The field value is measured while the index value is a score between 0 and 1. The performance standards determine the functional capacity of a measurement method as functioning (F), functioning-at-risk (FAR), or not functioning (NF) compared to a reference condition. The following delineations apply to all index values:

- Index value range of 0.7 – 1 = Functioning (F)
- Index value range of 0.3 – 0.69 = Functioning-At-Risk (FAR)
- Index value range of 0 – 0.29 = Not Functioning (NF)

Best fit equations were applied to the known breaks between F, FAR and NF based on published research or best professional judgement of the author and contributors. A Performance Standard Reference Manual is in progress and expected to be published in 2017.

The Performance Standards worksheet is locked to protect the performance standard calculations. The user cannot make changes to the performance standards without approval from the regulatory agency. However, the user can see all of the performance standards and can make suggested changes based on better data. This could include local reference reach data or better modeling, depending on the parameter and measurement method.

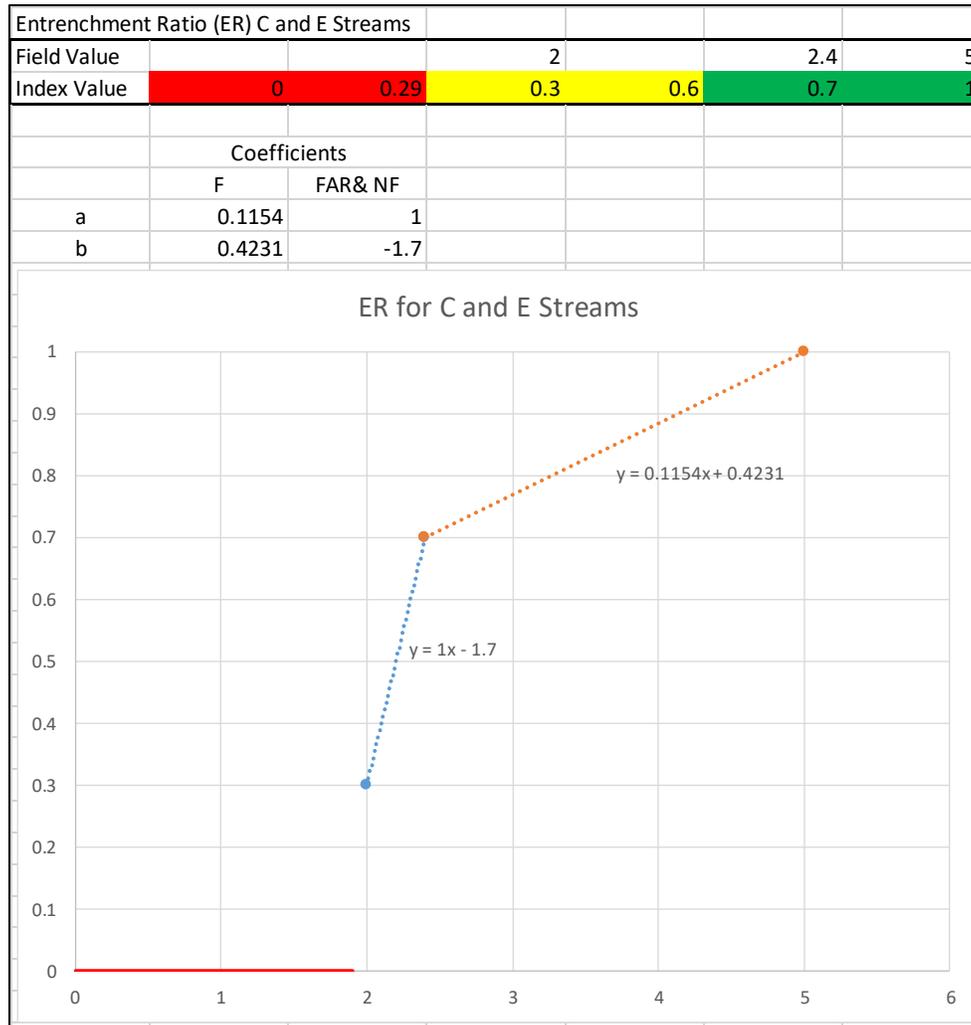
On this worksheet, measurement method performance standards are organized into columns based on the functional category and appear in the order they are listed on the Quantification Tool worksheet. For each measurement method, the field data are translated into an index value ranging from 0.0 to 1.0 using performance standards. One measurement method can have multiple sets of performance standards depending on the stratification requirements. For example, the entrenchment ratio has different performance standards based on the proposed stream type (shown in Table 4 on the following page). Entrenchment ratio is one of two measurement methods that determines the functional capacity of floodplain connectivity. The full list of performance standards and their stratification is provided in in the List of Metrics spreadsheet.

Table 4: Entrenchment Ratio Performance Standards

Measurement Method (Units)	Performance Standard Stratification		NF Score		FAR Score		F Score	
	Type	Description	Min	Max	Min	Max	Min	Max
Entrenchment Ratio (ft/ft)	Proposed Stream Type	C or E	< 2.0		2.0	2.3	2.4	>= 5
	Proposed Stream Type	A, B or Bc	< 1.2		1.2	1.3	1.4	>= 2.2

For a C-type channel, an entrenchment ratio of 2.4 or greater is considered functioning while an entrenchment ratio of less than 2.0 is considered not functioning. An entrenchment ratio of 5 or greater will give the maximum index value possible in the SQT. The performance standard sheet uses these breaks to define equations that relate field values (x) to index values (y). The performance standard curve for entrenchment ratio of C or E channels is shown in Figure 3 on the following page.

Figure 3: Entrenchment Ratio Performance Standards for C and E Stream Types



The Quantification Tool worksheet links to the coefficients on the Performance Standards worksheet to calculate index values (y) from the field values (x). The red line shown at the bottom of Figure 3 indicates where a cliff occurs in the performance standard curve. For C and E proposed stream types, it is not possible to receive an index value of between 0 and 0.3; therefore any entrenchment ratio less than 2.0 will yield an index value of 0. The equation for calculating the entrenchment ratio index value is provided on the following page.

Figure 4: Index Value Equation Example for Entrenchment Ratio. Colors help match IF STATEMENTS to corresponding explanation.

Cell F49 of the Quantification Tool worksheet:

```

"=IF(E49="", "", IF(OR(B$7="A", B$7="B", B$7="Bc"), IF(E49<1.2, 0, IF(E49>=2.2, 1,
ROUND(IF(E49<1.4, E49*Performance Standards!$K$84+Performance
Standards!$K$85, E49*Performance Standards!$L$84+Performance
Standards!$L$85), 2))), IF(OR(B$7="C", B$7="E"), IF(E49<2.0, 0, IF(E49>=5, 1,
ROUND(IF(E49<2.4, E49*Performance Standards!$L$49+Performance
Standards!$L$50, E49*Performance Standards!$K$49+Performance
Standards!$K$50), 2))))))"
    
```

Translation:

If field value not entered, provide no index value.

If Proposed Stream Type is A, B, or Bc, then

If Field Value ≤ 1.2, then index value = 0

Else, if Field Value ≥ 2.2, then index value = 1,

Else, if Field Value < 1.4, then (Field Value) * a_{FAR & NF} + b_{FAR & NF},

Else, (Field Value) * a_F + b_F

If Proposed Stream Type is C or E, then

If Field Value < 2.0, then index value = 0

Else, if Field Value ≥ 5, then index value = 1,

Else, if Field Value < 2.4, then (Field Value) * a_{FAR & NF} + b_{FAR & NF},

Else, (Field Value) * a_F + b_F

III.5. Quantification Tool Worksheet

The Quantification Tool worksheet is the main sheet in the Excel Workbook. It is the calculator where users enter data describing the existing and proposed conditions of the project reach and functional lift is quantified.

The Quantification Tool Worksheet always requires data entry in three areas: Site information and Performance Standard Stratification, Existing Condition Field Values, and Proposed Condition Field Values. For projects with adjacent or upstream BMPs, the BMP Routine is completed. Cells that allow input are shaded grey and all other cells are locked. Each section of the worksheet is discussed below.

III.5.a. Site Information and Performance Standard Stratification

The Site Information and Performance Standard Stratification section is shown in Figure 5 and each item is briefly described in this section. The performance standards and stratification for each measurement method are summarized in the List of Metrics document.

Except for the first four inputs shown in Figure 5 (Project Name through Existing Stream Type), these inputs are linked to the selection of performance standards where a field value is entered for a measurement method. If there are no performance standards for a selected measurement method, the spreadsheet may return an index value of FALSE. An index value of FALSE may also occur if there are data missing from the Site Information and Performance Standard Stratification section. If the SQT is returning FALSE, the user should check this section in the SQT for data entry errors and then check the stratification for the measurement method in the List of Metrics to see if there are performance standards applicable to the project. Incorrect information in the Site Information and Performance Standard Stratification section may result in applying performance standards that are not suitable for the project. Each of the inputs to this section are described below.

If there are no performance standards for a selected measurement method, the spreadsheet may return an index value of FALSE. An index value of FALSE may also occur if there are data missing from the Site Information and Performance Standard Stratification section.

Figure 5: Site Information and Performance Standard Stratification Input Fields

Site Information and Performance Standard Stratification	
Project Name:	
Reach ID:	
Restoration Potential:	
Existing Stream Type:	
Proposed Stream Type:	
Region:	
Drainage Area (sqmi):	
Proposed Bed Material:	
Existing Stream Length (ft):	
Proposed Stream Length (ft):	
Stream Slope (%):	
Flow Type:	
River Basin:	
Stream Temperature:	
Data Collection Season:	
Riparian Soil Texture:	

Project Name – Enter the project name

Reach Name or ID – Enter a unique name or identification number for the project reach. For example: Reach 1. Note, a single project can have multiple reaches.

Restoration Potential – Select the restoration potential from the drop down menu. The choices are Level 3: Geomorphology, Level 4: Physicochemical, or Level 5: Biology. This input is not used in the scoring; it is only for communication purposes.

Existing Stream Type – Select the existing Rosgen Stream Type from the drop down menu. This input is not used in the scoring; it is only for communication purposes.

Proposed Stream Type - Select the proposed Rosgen Stream Type from the drop down menu. The proposed stream type is used as a communication tool and to select the correct performance standard table for entrenchment ratio, large woody debris, riparian buffer width, pool spacing ratio, pool depth ratio, and sinuosity.

Region – Select Mountains, Piedmont, or Coastal Plain from the drop down menu. This selection is used to determine the correct performance standard table for specific conductivity, percent shredders, and macroinvertebrate biotic index.

Drainage Area – Enter the drainage area in square miles. This value is used to determine the correct performance standard table for pool spacing ratio, gross primary production, percent shredders, and macroinvertebrate biotic index.

Proposed Bed Material - Select sand or gravel from the drop down menu based on the dominant bed material for the project reach. The selection should be based on the proposed condition, so if the existing condition has sand and the proposed condition is gravel dominated, the selection should be gravel. This selection is used to determine the correct performance standard table to use for pool depth ratio and bed material characterization.

Existing Stream Length – Enter the existing stream length in feet. The proposed and existing stream lengths are used in the functional foot calculation.

Proposed Stream Length – Enter the proposed stream length in feet. The proposed and existing stream lengths are used in the functional foot calculation.

Stream Slope (%) – Enter the proposed stream slope as a percent. This value is used to determine the correct performance standard table to use for pool spacing ratio and percent riffle.

Flow Type – Select perennial, intermittent, or ephemeral from the drop down menu. If a selection is not made, the tool assumes that the stream reach is perennial.

River Basin – Select one of the basins from the drop down menu. This selection is used to determine the correct performance standard table to use for fish community.

Stream Temperature – Select the coldwater or cool water option if the project reach is in a state designated coldwater or coolwater stream. This selection is used to determine the correct performance standard table to use for temperature. Warm water performance standards are not available.

Data Collection Season – Select the season in which macroinvertebrate (percent shredders) data were collected. This value is used to determine the correct performance standard table to use for percent shredders.

Riparian Soil Texture – Select the dominant soil texture for the land draining directly to the project reach. This value is used to determine the correct performance standards for soil compaction.

III.5.b. Existing and Proposed Condition Assessment Data Entry

Once the Site Information and Performance Standard Stratification section have been completed, the user can input data into the field value column of the Existing and Proposed Condition Assessment tables. There are separate tables for the Existing Condition Assessment and Proposed Condition Assessment. The user will input field values for the measurement methods associated with a function-based parameter (Figure 6). The function-based parameters are listed by functional category, starting with hydrology. The Proposed Condition Assessment field values should consist of reasonable values that the project could achieve within the monitoring period. In other words, the proposed values are a prediction, which will be validated during the monitoring phase.

Figure 6: Field Value Data Entry in the Condition Assessment Table

Functional Category	Function-Based Parameters	Measurement Method	Field Value
Hydrology	Catchment Hydrology	Catchment Assessment	
	Reach Runoff	Curve Number Concentrated Flow Points Soil Compaction	
Hydraulics	Floodplain Connectivity	Bank Height Ratio Entrenchment Ratio	
Geomorphology	Large Woody Debris	LWD Index	
	Lateral Stability	Erosion Rate (ft/yr) Dominant BEHI/NBS Percent Streambank Erosion (%)	
	Riparian Vegetation	Left Canopy Coverage (%) Right Canopy Coverage (%) Left Buffer Width (ft) Right Buffer Width (ft) Left Basal Area (sq.ft/acre) Right Basal Area (sq.ft/acre) Left Stem Density (stems/acre) Right Stem Density (stems/acre)	
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)	
	Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle	
	Sinuosity	Plan Form	
Physicochemical	Temperature	Temperature (°F)	
	Bacteria	Fecal Coliform (Cfu/100 ml)	
	Organic Carbon	Leaf Litter Processing Rate Percent Shredders	
	Nitrogen	Monitoring (mg/L)	
	Phosphorus	Monitoring (mg/L)	
Biology	Macros	Biotic Index EPT Taxa Present	
	Fish	North Carolina Index of Biotic Integrity	

A project would rarely, if ever, enter field values for all measurement methods included in the SQT. The Parameter Selection Guide worksheet and section III.3. of this manual provide guidance on which parameters to assess. It is recommended that practitioners and regulators work together to determine a list of parameters suitable for each project that will determine whether project goals and objectives are being met. Likewise, the practitioners and regulators can work together to determine if any performance standards need to be adjusted based on local data.

Important Notes:

- If a value is entered for a measurement method in the Existing Condition Assessment, a value must also be entered for the same measurement method in the Proposed Condition Assessment.
- For measurement methods that are not assessed (i.e., a field value is not entered), the measurement method is removed from the scoring. It is NOT counted as a zero.

A brief description of each function-based parameter is provided below. For guidance on collecting and calculating the field values see the *Data Collection and Analysis Manual*. Additionally, the List of Metrics document includes a list of all function-based parameters, measurement methods, and performance standards with a reference citing the source of the performance standard and in some cases a link to tools and data collection guidance.

Hydrology Functional Category

1. Catchment Hydrology Parameter. This parameter should be assessed for all projects. The purpose is to score the hydrologic health of the upstream catchment. The user should rely on answers from the Catchment Assessment worksheet, especially the questions from the Hydrology category, to select the appropriate option from the drop down menu. See section III.2.b. Using the Catchment Assessment Form to Score the Catchment Hydrology Parameter. Typically, the user will enter the same value in the existing and proposed field value. This will affect the overall assessment score, but it will not show functional lift or loss. This is the only parameter and measurement method that is taken from a qualitative assessment. In some cases, a restoration provider may improve the catchment hydrology. An example is a small headwater project where the entire watershed is re-forested. In this case, the user could show an improved score in the proposed condition.
2. Reach Runoff Parameter. Reach runoff addresses the land that drains directly to the project reach while the catchment hydrology parameter refers to the watershed upstream of the project reach. It is recommended that reach runoff be assessed for all projects. The reach runoff parameter consists of three measurement methods: curve number, concentrated flow points, and soil compaction. Curve number and concentrated flow points should be assessed for all projects where reach runoff is measured. Soil compaction should be added once a project site has been approved as a restoration or mitigation site, e.g. at the mitigation plan stage. An area-weighted curve number can be calculated using recent orthoimagery, while concentrated flow points and soil compaction can be counted or measured in the field.
3. Runoff Parameter – BMP Routine. Runoff is assessed for projects that will include stormwater BMPs adjacent to the stream restoration project. To assess BMP runoff, the user must use the Jordan/Falls Lake Stormwater Nutrient Load Accounting Tool (JFSLAT) to calculate the proposed condition runoff and effective percent impervious cover. The existing percent impervious cover is entered as the field value for the Existing Condition Assessment. For the proposed condition field value, the user will re-run JFSLAT with the proposed BMP and then back-calculate the effective percent impervious cover.

Hydraulics Functional Category

4. Floodplain Connectivity Parameter. This parameter is assessed for all projects and contains two measurement methods: entrenchment ratio and bank height ratio. Both measurement methods should be used for all projects. The existing condition entrenchment ratio (ER) and bank height ratio (BHR) can be calculated from field measurements. The proposed condition can be calculated from the proposed profile and cross sections or the as-built data if available.

Geomorphology Functional Category

5. Large Woody Debris Parameter. It is recommended that this parameter be used for all projects. The measurement method for this parameter applies a USDA Forest Service large woody debris (LWD) assessment method that generates a LWD Index (LWDI). The LWDI is determined based on the 100-meter length section of the project reach that will yield the highest score. The proposed condition would estimate the number and characteristics of large wood pieces that will be left in the channel, installed in the channel, and recruited to the channel during the monitoring period.
6. Lateral Stability Parameter. This parameter is assessed for all projects. There are three measurement methods for this parameter: erosion rate, dominant BEHI/NBS, and percent streambank erosion. It is not suggested to use both erosion rate and dominant BEHI/NBS. It is suggested to use percent eroding bank to supplement the data from either erosion rate or dominant BEHI/NBS and not use it by itself to describe lateral stability.
7. Riparian Vegetation Parameter. This parameter is assessed for all projects. There are four measurement methods for riparian vegetation and each measurement method assesses the left and right bank separately resulting in 8 possible field values. The measurement methods are canopy coverage, basal area, buffer width, and density. It is recommended to use either basal area or stand density to assess all projects, not both. Buffer width should be assessed for all projects while canopy coverage is optional.
8. Bed Material Characterization Parameter. Bed material is an optional parameter assessed for projects in gravel bed streams with sandy banks where fining of the bed material is occurring due to bank erosion. Pebble counts are necessary for the project reach and a reference condition. The field value is the p-value, which tests whether the project reach pebble count data is statistically different from the reference pebble count data. The p-value is obtained by entering pebble count data into the Size Class Pebble Count Analyzer spreadsheet tool.⁴
9. Bed Form Diversity Parameter. This parameter is assessed for all projects. There are three measurement methods for this parameter: pool spacing ratio, pool depth ratio, and percent riffle. All three measurement methods should be used for all projects.
10. Sinuosity Parameter. This parameter should be assessed for all projects performed in alluvial valleys with Rosgen C and E stream types. This parameter is optional for B stream types to ensure that practitioners do not propose sinuosity values that are too high.

⁴ <http://www.stream.fs.fed.us/publications/software.html>

Physicochemical Functional Category

11. Temperature Parameter. Temperature is assessed for projects on coldwater or coolwater streams. The performance standards currently in the tool are based on lethal temperatures for representative sport fish species in North Carolina.
12. Specific Conductivity Parameter – BMP Routine. This parameter can be assessed for projects that include stormwater BMPs adjacent to the stream restoration project. Performance standards are only available for the Piedmont and Mountain regions.
13. Bacteria Parameter. This parameter is assessed for stream restoration projects with livestock access. The measurement method in the tool is fecal coliform and the performance standards are based on state standards for fresh surface waters.
14. Organic Carbon Parameter. This parameter should be assessed for all projects with a level 4 or 5 restoration potential and is optional for level 3 restoration potential projects. There are two measurement methods for this parameter: leaf litter processing rate and percent shredders. Percent shredders can be calculated using the same macroinvertebrate sample collected to assess the macroinvertebrate parameter in the biology functional category.
15. Nitrogen Parameter. This parameter is optional. Practitioners may choose to use this parameter if improvement is expected from reach-scale restoration or stormwater BMPs are proposed in conjunction with the stream restoration project. The field values are the pre- and post-construction concentrations of Nitrogen that are either measured, for the reach condition assessments, or modeled using the JFSLAT in the BMP Routine. The performance standards are based on reference condition concentrations by land use.
16. Phosphorus Parameter. This parameter is optional. Practitioners may choose to use this parameter if improvement is expected from reach-scale restoration or stormwater BMPs are proposed in conjunction with the stream restoration project. The field values are the pre- and post-construction concentrations of Phosphorus that are either measured, for the reach condition assessments, or modeled using the JFSLAT in the BMP Routine. The performance standards are based on reference condition concentrations by land use.

Biology Functional Category

17. Macroinvertebrates Parameter. This parameter should be assessed for all projects with a level 5 restoration potential and is optional for level 3 and level 4 restoration potential projects. As restored streams are typically small and likely to have limited habitat, performance standards for the Qual-4 and EPT methods are included in the SQT. There are no performance standards available for small coastal streams.
18. Fish Parameter. This parameter should be assessed for all projects with a level 5 restoration potential and is optional for level 3 and level 4 restoration potential projects. The performance standards for this parameter are based on the North Carolina Index for Biotic Integrity (NCIBI) and are only available for the Broad, Cape Fear, Catawba, French Broad, Hiwassee, Little Tennessee, Neuse, New, Roanoke, Savannah, Tar-Pamlico, Watauga, and Yadkin-PeeDee river basins.

III.5.c. Scoring Functional Lift

Scoring occurs automatically as field values are entered into the Existing Condition Assessment or Proposed Condition Assessment tables. A field value will correspond to an index value ranging from 0 to 1 for that measurement method. Measurement method index values are averaged to calculate parameter scores; parameter scores are averaged to calculate functional category scores. Functional category scores are multiplied by 0.2 and summed to calculate overall condition scores. Each of these components is explained below.

Note that the SQT will display a warning message above the Functional Category Report Card reading “WARNING: Sufficient data are not provided.” if data are not entered for at least the following parameters:

1. Floodplain Connectivity
2. Lateral Stability
3. Riparian Vegetation
4. Bed Form Diversity

Index Values. The performance standards available for each measurement method are visible in the Performance Standards Worksheet and summarized in the List of Metrics document. When a field value is entered for a measurement method on the Quantification Tool worksheet an index value between 0 and 1 is assigned to the field value (Figure 7).

Figure 7: Index Values automatically populate when Field Values are entered.

Measurement Method	Field Value	Index Value
Catchment Assessment	M2	0.5
Curve Number	45	0.88
Concentrated Flow Points	2	0.5
Soil Compaction		
Bank Height Ratio	1.6	0.2
Entrenchment Ratio	1.95	0

When a field value is entered on the Quantification Tool worksheet, the neighboring index value cell checks the data in the Site Information and Performance Standard Stratification section and either returns an index value based on the appropriate performance standard (Figure 7) or returns FALSE (Figure 8). Some of the performance standards have a limited range of application. For example, the NC biotic index for macroinvertebrates only has performance standards for streams in the Mountains and Piedmont. If the stream is in the Coastal Plain, then the field value will return FALSE. An index value of FALSE may also occur if the Site Information and Performance Standard Stratification section is missing data, as is the case in Figure 8 where proposed slope and stream type were not entered into the SQT.

Figure 8: Index Value Errors

Function-Based Parameters	Measurement Method	Field Value	Index Value
Bed Form Diversity	Pool Spacing Ratio	5	FALSE
	Pool Depth Ratio	2	FALSE
	Percent Riffle	60	Need Slope

If the SQT is returning FALSE, the user should check the Site Information and Performance Standard Stratification section in the SQT for data entry errors and then check the stratification for the measurement method in the List of Metrics to see if there are performance standards applicable to the project. Incorrect information in the Site Information and Performance Standard Stratification section may result in applying performance standards that are not suitable for the project.

Roll Up Scoring. Measurement method index values are averaged to calculate parameter scores; parameter scores are averaged to calculate category scores. The category scores are then multiplied by 0.2 and summed to calculate overall condition scores (Figure 9). For measurement methods that are not assessed (i.e., a field value is not entered), the measurement method is removed from the scoring and no index value is provided. It is NOT counted as a zero in calculating the parameter score.

Figure 9: Roll Up Scoring Example

PROPOSED CONDITION ASSESSMENT		Roll Up Scoring				
Functional Category	Function-Based Parameters	Parameter	Category	Category	Overall	Overall
Hydrology	Catchment Hydrology	0.90	0.83	Functioning	0.73	Functioning At Risk
	Reach Runoff	0.79				
Hydraulics	Floodplain Connectivity	1.00	1.00	Functioning		
Geomorphology	Large Woody Debris	0.48	0.71	Functioning		
	Lateral Stability	0.67				
	Riparian Vegetation	0.68				
	Bed Material Characterization					
	Bed Form Diversity	1.00				
	Sinuosity					
Physicochemical	Temperature	0.48	0.48	Functioning At Risk		
	Bacteria					
	Organic Carbon					
	Nitrogen					
	Phosphorus					
Biology	Macros	0.64	0.64	Functioning At Risk		
	Fish					

Recall that the following delineations apply to all index values:

- Index value range of 0.7 – 1 = Functioning (F)
- Index value range of 0.3 – 0.69 = Functioning-At-Risk (FAR)
- Index value range of 0 – 0.29 = Not Functioning (NF)

The category scores are multiplied by 0.2 and summed to calculate overall condition scores. This roll-up scoring procedure will incentivize monitoring at levels 4 and 5 since the maximum overall condition score achievable without monitoring these levels is 0.60.

While the overall condition is described as not functioning or functioning-at-risk depending on the scoring outlined above, a functioning overall condition can only be achieved if all functional categories are functioning, as shown in Figure 9 where the overall condition score is 0.73 but the physicochemical and biology functional categories are functioning-at-risk and so the overall condition is described as functioning-at-risk.

Since the tool is a simple calculator, caution must be taken in interpreting the results. For example, while the tool may report that a stream is functioning at a physicochemical level, this may be because only temperature was monitored but there may be indicators in the catchment assessment to suggest that other parameters may be a concern in the stream. The Parameter Selection Guide can help ensure that all appropriate parameters are selected.

Functional Lift. The Quantification Tool worksheet summarizes the scoring at the top of the sheet, next to and under the Site Information and Performance Standard Stratification section. There are five summary tables: a Functional Lift Summary, BMP Functional Lift Summary, Functional Feet Summary, Functional Category Report Card, and Function Based Parameters Summary. The Functional Lift Summary (Figure 10) provides the overall scores from the Existing Condition Assessment and Proposed Condition Assessment sections.

Figure 10: Functional Lift Summary Example

FUNCTIONAL LIFT SUMMARY	
Existing Condition Score (ECS)	0.20
Proposed Condition Score (PCS)	0.49
Functional Lift Score	0.29
Percent Condition Lift	145%
Existing Stream Length (ft)	3500
Proposed Stream Length (ft)	3500
Additional Stream Length (ft)	0
Existing Stream Functional Foot Score (FFS)	700
Proposed Stream Functional Foot Score (FFS)	1715
Proposed FFS - Existing FFS	1015
Functional Lift (%)	145%

The Functional Lift Score is the difference between the proposed condition score (PCS) and the existing condition score (ECS).

$$\text{Functional Lift Score} = \text{PCS} - \text{ECS}$$

The percent condition lift is the functional lift score divided by the ECS.

$$\text{Percent Condition Lift} = \frac{PCS - ECS}{ECS} * 100$$

The rest of the table calculates and communicates Functional Foot Scores (FFS). A FFS is produced by multiplying a condition score by the stream length. Since the condition score must be 1 or less, the functional feet score is always less than or equal to the actual stream length.

$$\text{Existing Stream EFFS} = ECS * \text{Existing Stream Length}$$

$$\text{Proposed Stream PFFS} = PCS * \text{Proposed Stream Length}$$

The Proposed Stream FFS – Existing Stream FFS is the amount of functional lift generated by the restoration activities, and could be considered a credit as part of a stream mitigation credit determination method. Figure 10 shows that this difference, or functional lift, is 1015 functional feet. The functional lift is also shown as the percent lift in functional feet for a project reach.

$$\text{Functional Lift} = \frac{\text{Proposed Stream FFS} - \text{Existing Stream FFS}}{\text{Existing Stream FFS}} * 100$$

The functional feet score for BMPs is tabulated separately in the BMP Functional Lift Summary (Figure 11). The results in this table are the sum of the Existing and Proposed FFS from the three BMP Routine boxes located under the Proposed Condition Assessment. Similar to above, the difference between the proposed and existing FFS is provided in addition to the percent functional lift. The BMP Routine will be discussed in detail in the next section.

Figure 11: BMP Functional Lift Example

BMP FUNCTIONAL LIFT SUMMARY	
Existing BMP Functional Feet Score (FFS)	25
Proposed BMP Functional Feet Score (FFS)	106
Proposed BMP FFS - Existing BMP FFS	81
Functional Lift (%)	324%

There is a final Functional Feet Summary table that sums the stream reach and BMP scores (Figure 12). The Existing Stream FFS (equal to 700 in Figure 10) and the existing BMP FFS (equal to 25 in Figure 11) are added (equal to 725 in Figure 12). Similarly, the proposed stream FFS and proposed BMP FFS are added, the difference is provided, and the functional lift is calculated.

Figure 12: Functional Feet Summary Example

FUNCTIONAL FEET (FF) SUMMARY	
Existing Stream FFS + Existing BMP FFS	725
Proposed Stream FFS + Proposed BMP FFS	1821
Total Proposed FFS - Total Existing FFS	1096
Functional Lift (%)	151%

The Functional Category Report Card (Figure 13) pulls the existing condition score (ECS) and proposed condition score (PCS) for each of the five functional categories from the Condition Assessment sections of the worksheet for a side-by-side comparison.

Figure 13: Functional Category Report Card Example

FUNCTIONAL CATEGORY REPORT CARD			
Functional Category	ECS	PCS	Functional Lift
Hydrology	0.90	0.90	0.00
Hydraulics	0.72	1.00	0.29
Geomorphology	0.44	0.74	0.31
Physicochemical	0.27	0.38	0.11
Biology	0.51	0.59	0.08

The Function Based Parameters Summary also provides a side-by-side comparison, but for individual parameter scores (Figure 14). Values are pulled from the Condition Assessment sections of the worksheet. This table can be used to better understand how the category scores were determined. For example, while the physicochemical category may be functioning which would suggest the stream could support biology functions, it is possible that only fecal coliform was assessed and water temperature is too high to support functioning biology. This table also makes it possible to quickly spot if a parameter was not assessed for both the existing and proposed condition assessments. Recall that if a value is entered for a measurement method in the Existing Condition Assessment, a value must also be entered for the same measurement method in the Proposed Condition Assessment. Finally, the table can be reviewed to determine if any required parameters were totally omitted from the assessment.

Figure 14: Function Based Parameters Summary Example

FUNCTION BASED PARAMETERS SUMMARY			
Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Hydrology	Catchment Hydrology	0.50	0.90
	Reach Runoff	0.69	0.79
Hydraulics	Floodplain Connectivity	0.10	1.00
Geomorphology	Large Woody Debris	0.29	0.48
	Lateral Stability	0.20	0.67
	Riparian Vegetation	0.00	0.68
	Bed Material		
	Bed Form Diversity	0.34	1.00
	Sinuosity		
Physicochemical	Temperature	0.37	0.48
	Bacteria		
	Organic Matter		
	Nitrogen		
	Phosphorus		
Biology	Macros	0.11	0.64
	Fish		

III.5.d. BMP Routine

There are three BMP Routine boxes in the Quantification Tool worksheet below the Proposed Condition Assessment. Stormwater BMPs that are installed adjacent or upstream of the stream restoration project can be accounted for in the SQT. The SQT should not be applied to stand-alone BMP projects that do not include stream restoration activities. Within each BMP Routine (Figure 15) there are four sections: Site Information, Existing Condition Assessment, Proposed Condition Assessment, and Results.

Figure 15: BMP Routine Example

BMP Routine			
Site Information		BMP 1	
BMP ID	1		
Basin Area treated by BMP (Ac)	0.5		
Basin Length (ft)	145		
Effective Stream Length (ft)	150.21		
Existing Condition Assessment			
Function-Based Parameters	Measurement Method	Field Value	Index Value
Runoff	Impervious Cover (%)	80	0
Temperature	Temperature (°F)	68	0.4
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)	70	0.24
Nitrogen	Falls Lake Nutrient Tool (mg/L)	2	0.3
Phosphorus	Falls Lake Nutrient Tool (mg/L)	0.2	0.2
Proposed Condition Assessment			
Function-Based Parameters	Measurement Method	Field Value	Index Value
Runoff	Impervious Cover (%)	4	0.86
Temperature	Temperature (°F)	66	0.59
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)	55	0.47
Nitrogen	Falls Lake Nutrient Tool (mg/L)	1	0.59
Phosphorus	Falls Lake Nutrient Tool (mg/L)	0.1	0.66
Results			
BMP Existing Score	0.23		
BMP Proposed Score	0.63		
Existing BMP Functional Foot Score	34.25		
Proposed BMP Functional Foot Score	95.23		
Proposed FFS - Existing FFS	60.99		

In the SQT, BMPs are treated as a tributary to the project reach. The BMP ID field is simply a unique identifier for the BMP data being entered. While restoration stream reaches use the length of stream being treated, the BMP Routine calculates an effective stream length from the basin area and basin length. The Basin Area treated by the BMP (Acres) should equal the area of land that drains to the BMP. The basin length is the length of the longest flow path of the basin (in feet). The longest flow path is a common hydrologic measurement and can be estimated from topographic maps or determined using digital topographic data.

$$Effective\ Stream\ Length\ (ft) = 43,560 \frac{ft^2}{Ac} * \frac{Basin\ Area\ (Ac)}{Basin\ Length\ (ft)}$$

Only a subset of function-based parameters and measurement methods available in the stream reach condition assessments are available in the BMP Routine.

1. **Runoff Parameter – BMP Routine.** Runoff is assessed for projects that will include stormwater BMPs adjacent to the stream restoration project. To assess BMP runoff, the user must use Jordan/Falls Lake Stormwater Nutrient Load Accounting Tool (JFSLAT) to calculate the proposed condition runoff and effective percent impervious cover. The existing percent impervious cover is entered as the field value for the Existing Condition

Assessment. For the proposed condition field value, the user will re-run JFSLAT with the proposed BMP and then back-calculate the effective percent impervious cover.

2. Temperature Parameter. Temperature is assessed for projects on coldwater or coolwater streams. The performance standards currently in the tool are based on lethal temperatures for representative sport fish species in North Carolina that live in each habitat.
3. Specific Conductivity Parameter. Performance standards are only available for the Piedmont and Mountains regions.
4. Nitrogen Parameter. The field values are the concentration of Nitrogen modeled using the JFSLAT for pre- and post-construction conditions. The performance standards are based on reference condition concentrations by land use.
5. Phosphorus Parameter. The field value is the concentration of Phosphorus modeled using the JFSLAT for pre- and post-construction conditions. The performance standards are based on reference condition concentrations by land use.

The nitrogen and phosphorus parameters are assessed as concentrations instead of loads (load equals the pollutant concentration times the discharge). This is important because the reduction in runoff volume is captured by the runoff parameter. Calculating reductions in nutrient load would effectively double count the effects of a BMP on reducing runoff volume.

For most projects, runoff, nitrogen, and phosphorus will only be modeled when BMPs are included. However, if the practitioner or regulator believes that the BMPs could have an effect on the receiving stream (which will also be the stream restoration project reach), nitrogen and phosphorus could be monitored in the stream. Notice that values entered in the BMP Routine are modeled and values entered in the stream reach condition assessments are monitored. This combination can capture the functional lift created by the BMP on the reach, as well as the functional lift to the stream reach.

Each BMP Routine has a results section for each individual BMP. Based on the data in the BMP Routine box, the BMP Existing Score is an average of the index values in the BMP Existing Condition Assessment. The BMP Proposed Score is an average of the index values in the BMP Proposed Condition Assessment. For measurement methods that are not assessed (i.e., a field value is not entered), the measurement method is removed from the scoring. It is NOT counted as a zero. The functional foot scores (FFS) are calculated by multiplying the BMP scores by the effective stream length.

$$\text{Existing BMP FFS} = \text{BMP Existing Score} * \text{Effective Stream Length}$$

$$\text{Proposed BMP FFS} = \text{BMP Proposed Score} * \text{Effective Stream Length}$$

The sum of the existing and proposed BMP FFS from the three BMP Routine boxes are summed and included in the BMP Functional Lift Summary at the top of the Quantification Tool worksheet. These scores are added to the stream functional foot score in the Functional Feet Summary table at the top of the Quantification Tool worksheet.

III.6. Monitoring Data Worksheet

The Monitoring Data Worksheet contains 11 condition assessment tables (as shown in Figure 6). The first table is identified as the As-Built Condition followed by 10 condition assessment

tables for monitoring. The user can enter the monitoring year at the top of each condition assessment table. Each table is identical to the Existing and Proposed condition assessments in the Quantification Tool worksheet. The performance standards link to the Site Information and Performance Standard Stratification section on the Quantification Tool worksheet and scoring is identical to the process described in section III.5.c.

Recall that if a value is entered for a measurement method in the Existing Condition Assessment, a field value must also be entered for the same measurement method in the Proposed Condition Assessment. Similarly, the same measurement methods used in the existing and proposed condition assessments must have a field value for every monitoring event completed in the Monitoring Data worksheet. This is critical to being able to track progress over the monitoring period.

III.7. Data Summary Worksheet

This worksheet provides a summary of project data from the existing condition, proposed condition, as-built condition, and monitoring assessments, as pulled from the Quantification Tool and Monitoring Data worksheets. The Data Summary worksheet features two tables and four plots:

- Function Based Parameters Summary shown in Figure 16.

Note that the table in Figure 16 is truncated, as the Data Summary worksheet contains 10 monitoring columns. For any monitoring events that are not completed, the table will read #N/A for the monitoring year. This is necessary to plot the results.

Figure 16: Function Based Parameters Summary

FUNCTION BASED PARAMETERS SUMMARY							
Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter	As-Built	Monitoring Year		
					1	3	5
Hydrology	Catchment Hydrology	0.50	0.50	0.50	0.50	0.50	0.50
	Reach Runoff						
Hydraulics	Floodplain Connectivity	0.20	0.85	0.85	0.85	0.85	0.85
Geomorphology	Large Woody Debris						
	Lateral Stability	0.08	0.85	0.85	0.52	0.32	0.32
	Riparian Vegetation	0.00	0.61	0.46	0.60	0.55	0.61
	Bed Material						
	Bed Form Diversity	0.20	1.00	1.00	1.00	0.98	0.90
	Sinuosity						
Physicochemical	Temperature	0.37	0.48	0.37	0.37	0.43	0.48
	Bacteria						
	Organic Matter						
	Nitrogen						

	Phosphorus						
Biology	Macros	0.11	0.25	0.00	0.02	0.11	0.25
	Fish						

- Functional Category Report Card as shown in Figure 17.

Note that the table in Figure 17 is truncated, as the Data Summary worksheet contains 10 monitoring columns. For any monitoring events that are not completed, the table will read #N/A for the monitoring year and overall score. This is necessary to plot the results.

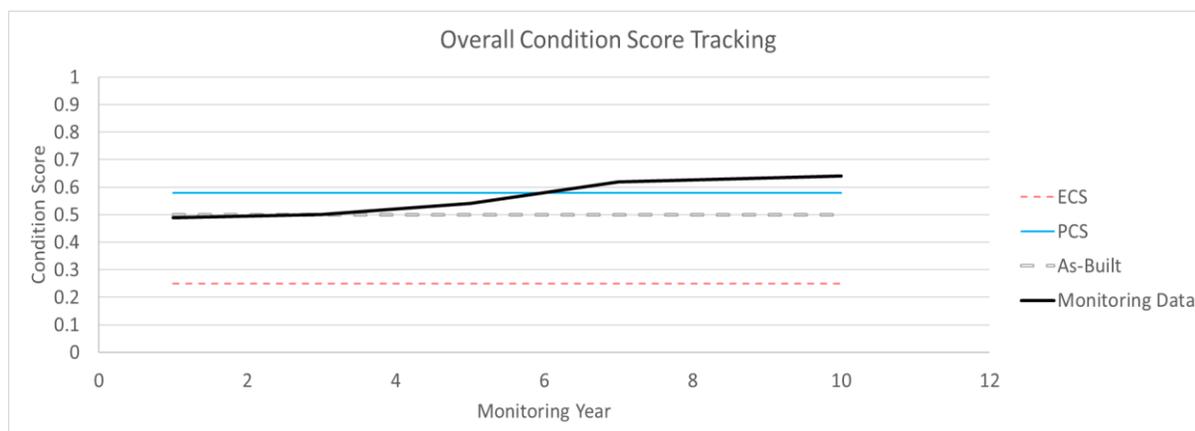
Figure 17: Functional Category Report Card

FUNCTIONAL CATEGORY REPORT CARD									
Functional Category	ECS	PCS	As-Built	Monitoring Year					#N/A
				1	3	5	7	10	
Hydrology	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
Hydraulics	0.20	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
Geomorphology	0.09	0.82	0.77	0.71	0.62	0.61	0.82	0.82	
Physicochemical	0.37	0.48	0.37	0.37	0.43	0.48	0.64	0.69	
Biology	0.11	0.25	0.00	0.02	0.11	0.25	0.30	0.36	
Overall Score	0.16	0.43	0.42	0.41	0.39	0.39	0.43	0.43	#N/A
Functional Feet	16	65	63	62	59	59	65	65	

- The first two plots show tracking for the overall condition score and functional feet score for the project over the monitoring period.

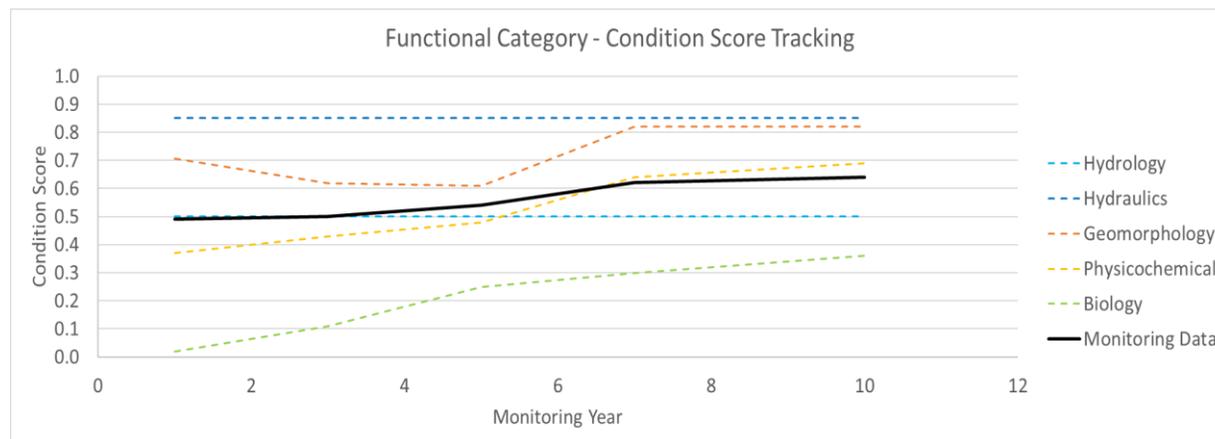
These plots show the existing condition, proposed condition, and as-built condition as horizontal lines on the plot. The Overall Condition Score Tracking is shown in Figure 18 as an example; the Functional Feet Score Tracking plot is similar.

Figure 18: Overall Condition Score Tracking Plot



- The Functional Category Condition Score Tracking plot shows the overall conditions score along with the condition score for each functional category throughout the monitoring period (Figure 19).

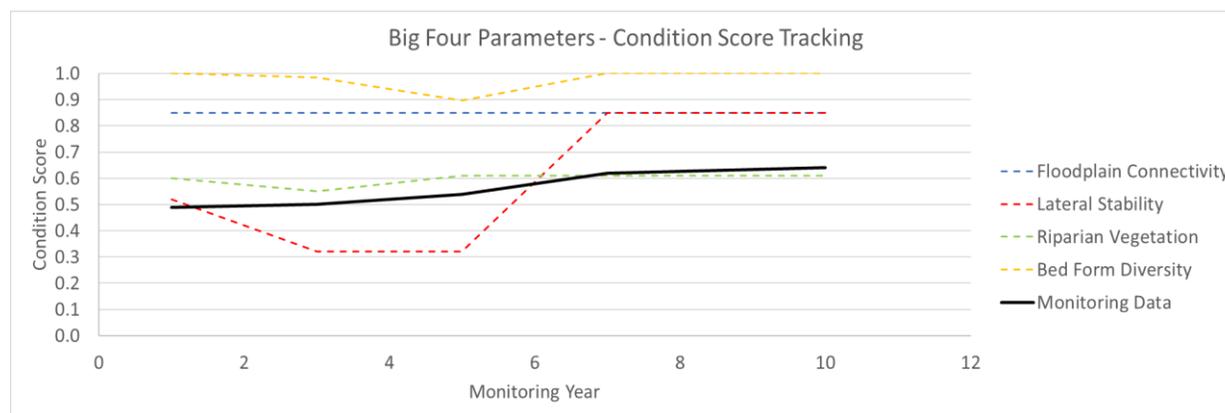
Figure 19: Functional Category Condition Score Tracking



- The Big Four Parameters Condition Score Tracking plot shows the overall conditions score along with the parameter scores for floodplain connectivity, lateral stability, riparian vegetation, and bed form diversity throughout the monitoring period (Figure 20).

In order to prevent projects from chasing credits and to provide a minimum condition achieved by restoration, it is recommended that **ALL** projects monitor and bring floodplain connectivity, lateral stability, and bed form diversity to a functioning condition at the end of the project. Riparian vegetation should be at a 0.6 or greater to show that vegetation growth is on a trajectory towards a mature forest.

Figure 20: Big Four Parameters Condition Score Tracking



The worksheet is locked but if the user wishes to create additional plots of the results, it is possible to add a sheet and pull data from the locked sheets.

IV. Example Spreadsheet

An example SQT spreadsheet populated with a fictional project has been provided to demonstrate how the SQT works. It includes reach-scale restoration with a BMP on an adjacent ephemeral tributary and monitoring data. This example, the SQT and supporting documents can be downloaded from the Stream Mechanics web page (stream-mechanics.com).