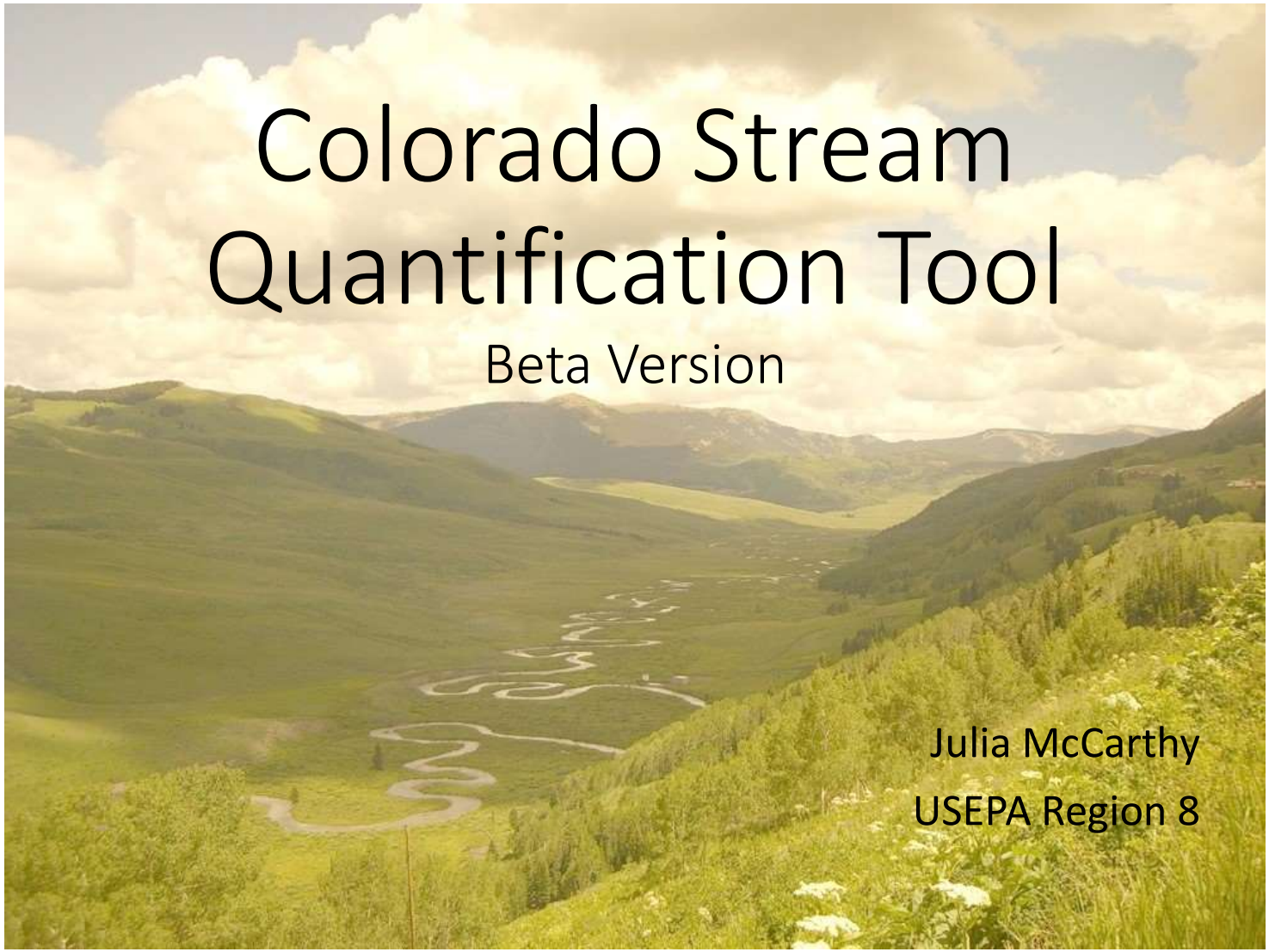


Colorado Stream Quantification Tool

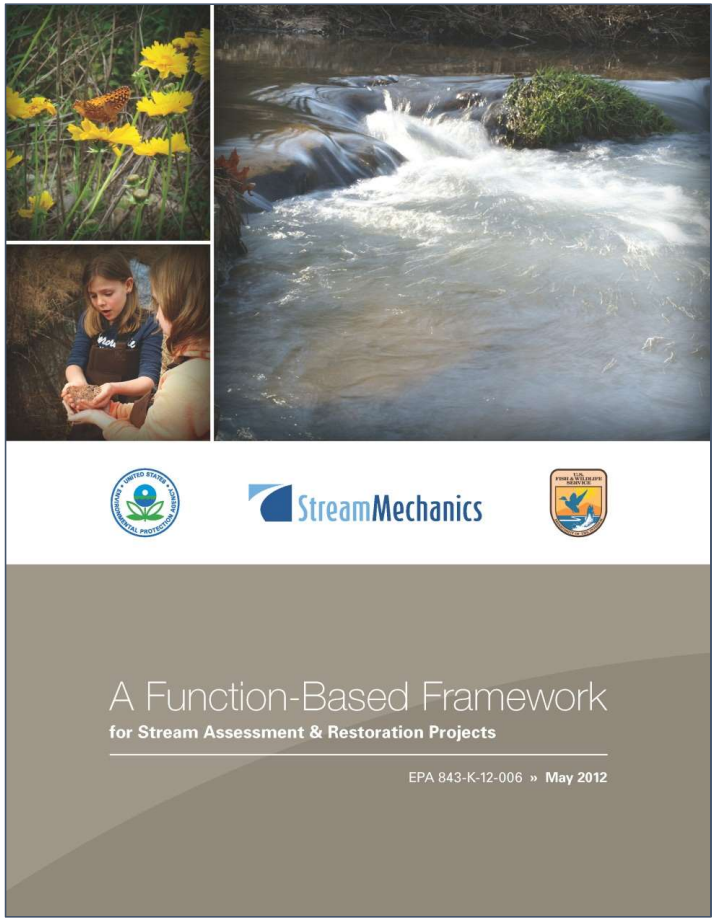
Beta Version

Julia McCarthy

USEPA Region 8

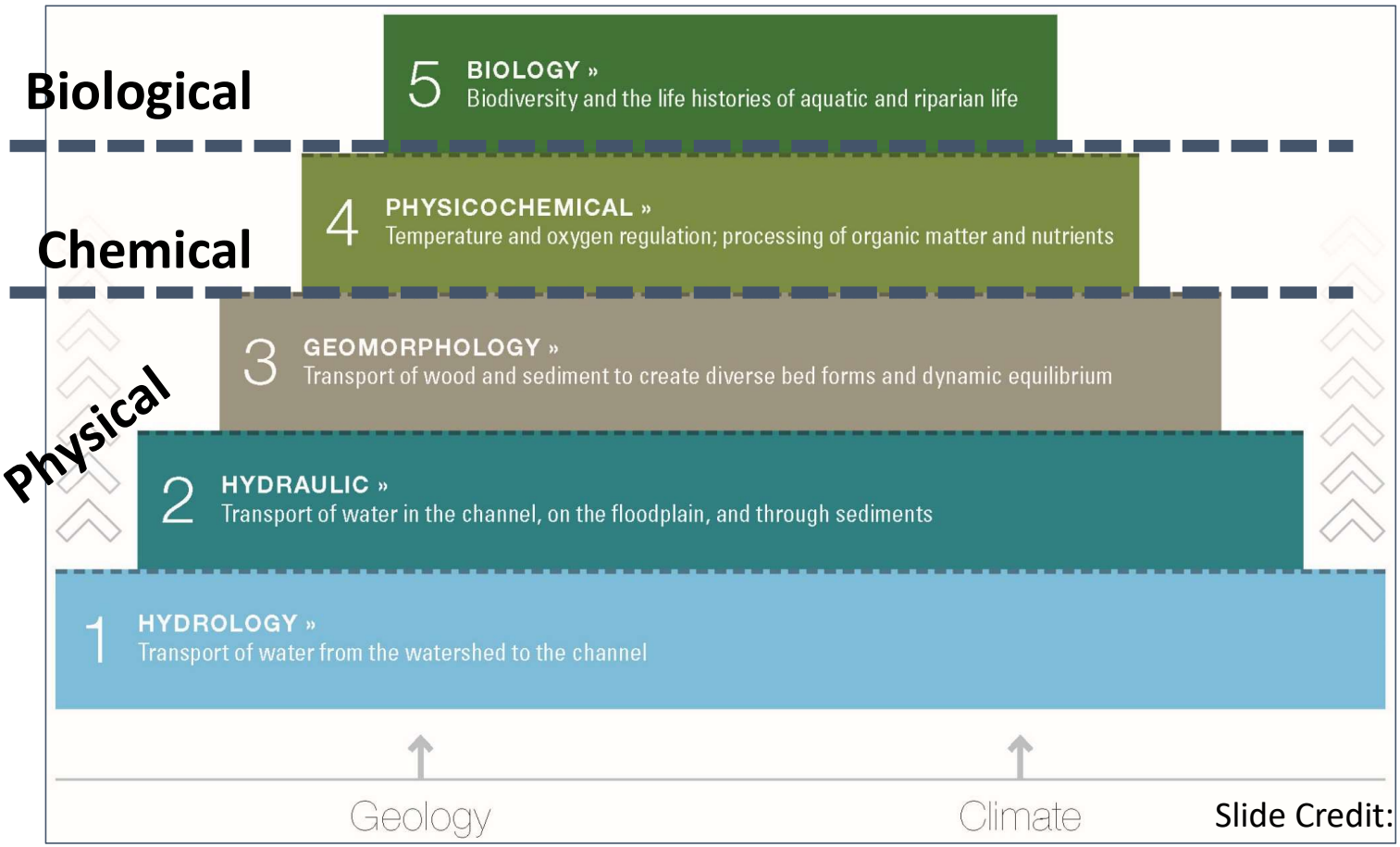
The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency

Function-Based Framework for Stream Assessment and Restoration Projects



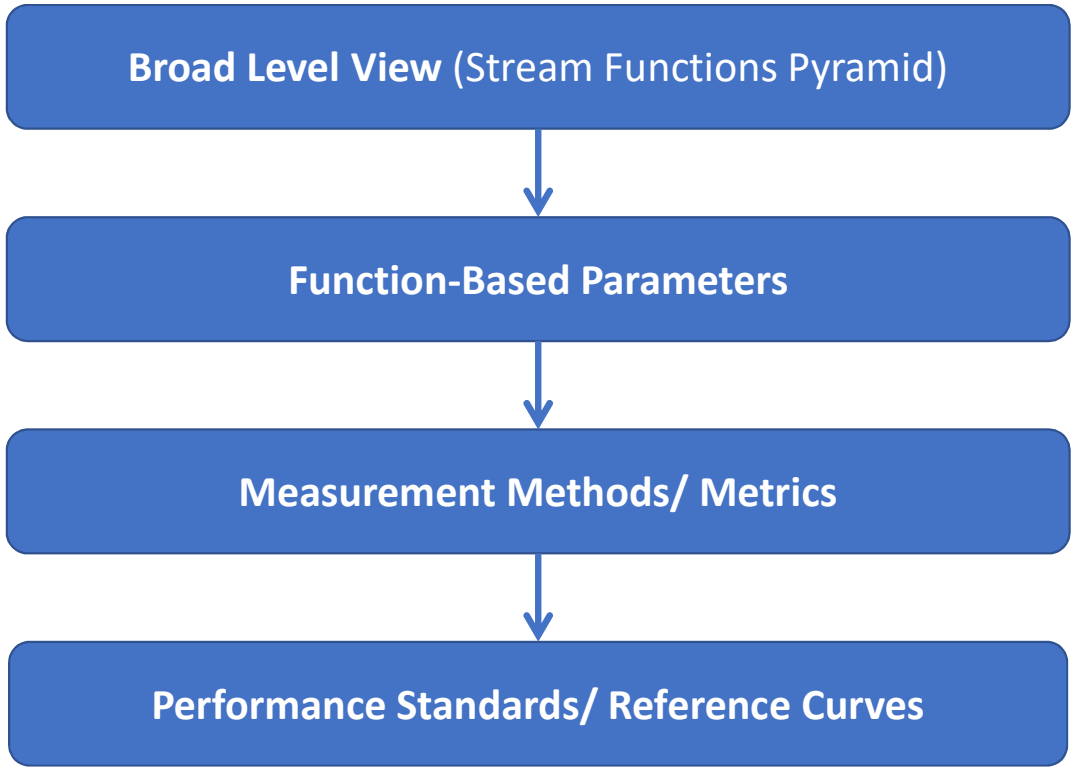
www.stream-mechanics.com

Function - The physical, chemical, and biological processes that occur in ecosystems.



Slide Credit: Stream Mechanics

Stream Functions Pyramid Framework (SFPF)



Functional Categories
Functional Statements

Describes/Supports Functional Statement

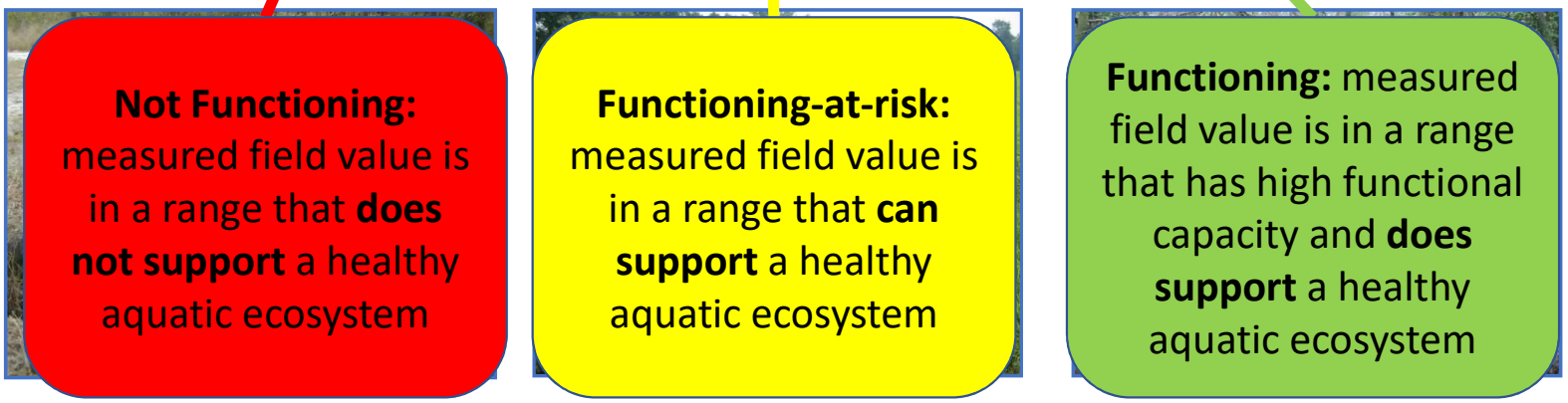
Quantifies Function-Based Parameter

Functioning
Functioning-At-Risk
Not Functioning

Slide Credit: Stream Mechanics

Reference Curves: translating field values into index values

Not Functioning	Functioning-At-Risk	Functioning
0.0 - 0.29	0.3 – 0.69	0.7 – 1.0



Not Functioning: measured field value is in a range that **does not support** a healthy aquatic ecosystem

Functioning-at-risk: measured field value is in a range that **can support** a healthy aquatic ecosystem

Functioning: measured field value is in a range that has high functional capacity and **does support** a healthy aquatic ecosystem

Slide credit: Will Harman

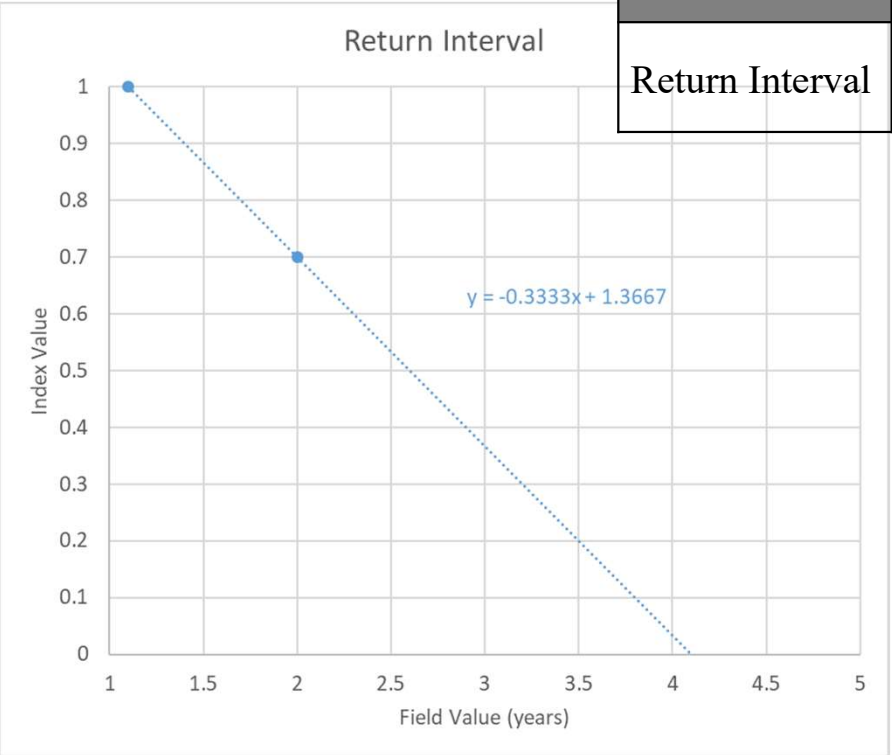
Reference Standard Condition

- Functioning range of condition for a given metric
- Culturally Unaltered
- Minimal Disturbance
- Not the best attainable!
- Scores of 0.7 to 1.0 in the SQT
- Based on:
  - Values provided in peer-reviewed journals, government documents, books or proceeding papers;
  - Regional datasets; and
  - Best Professional Judgment.

Slide Credit: Stream Mechanics

Reference Curves:
Floodplain Connectivity Example

Metric	Functioning	Functioning-At-Risk	Not Functioning
Return Interval	≤ 2.0	2.0 to 3.2	> 3.2



Slide Credit: Stream Mechanics

Stream Quantification Tools (SQTs)

Wyoming:

- WSQT Beta Version – released for public comment August 2017
- WSQT v1.01 – released July 2018 with minor updates October 2018

Colorado:

- CSQT Beta Version – released for public comment May 2019

Other SQTs:

- North Carolina (Harman and Jones 2017)
- Tennessee (TDEC 2018)
- Georgia (USACE 2018b)
- Minnesota (2019)

Colorado SQT

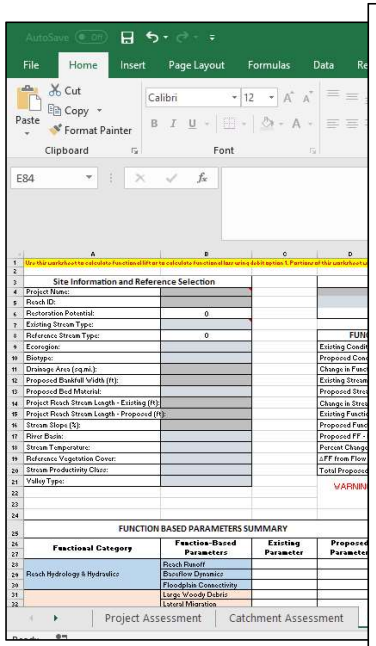
- **Purpose:** to calculate functional loss and lift associated with stream impacts and restoration projects by quantifying changes between existing and future stream condition at a site.

- **Uses:**
  - To inform CWA 404 permitting and mitigation decisions
  - To develop monitoring plans and set performance standards.
  - To assist in site selection, determining restoration potential, and developing project specific function-based goals and objectives

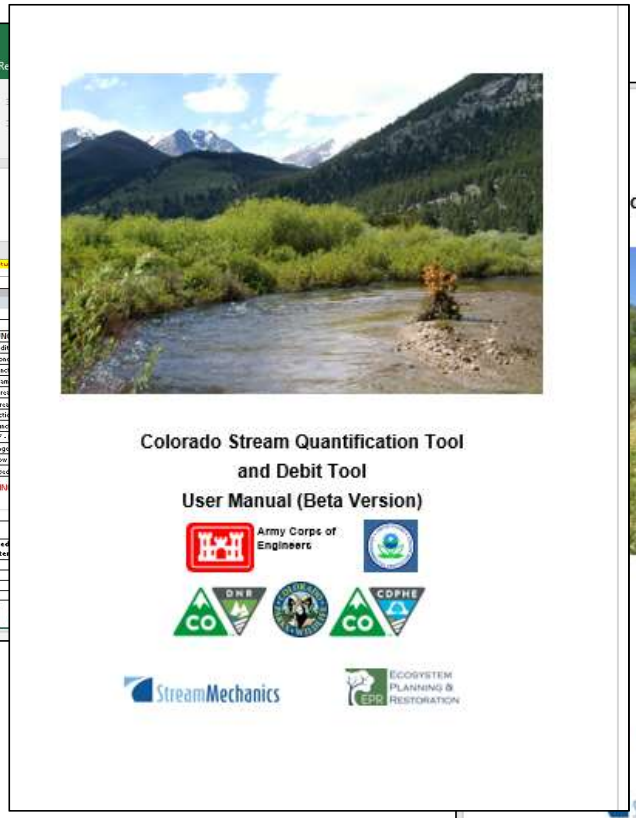
Colorado SQT

- The Stream Quantification Tool measures reach-scale environmental outcomes of projects - It is NOT a design tool.
- In design, it is important to consider other analyses and watershed processes which are outside the scope of this tool.

Colorado SQT and Related Documents

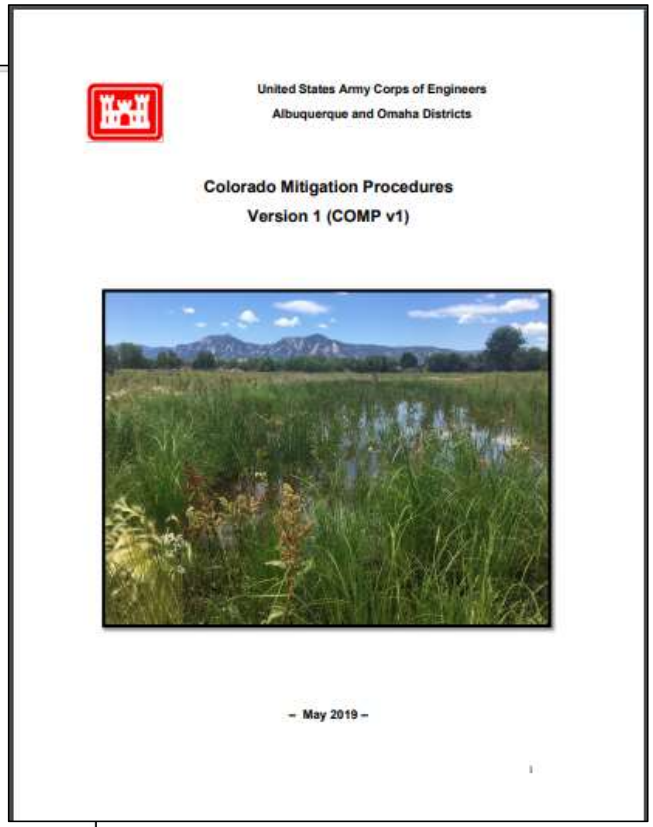


CSQT Beta Version and Debit Calculator excel workbooks



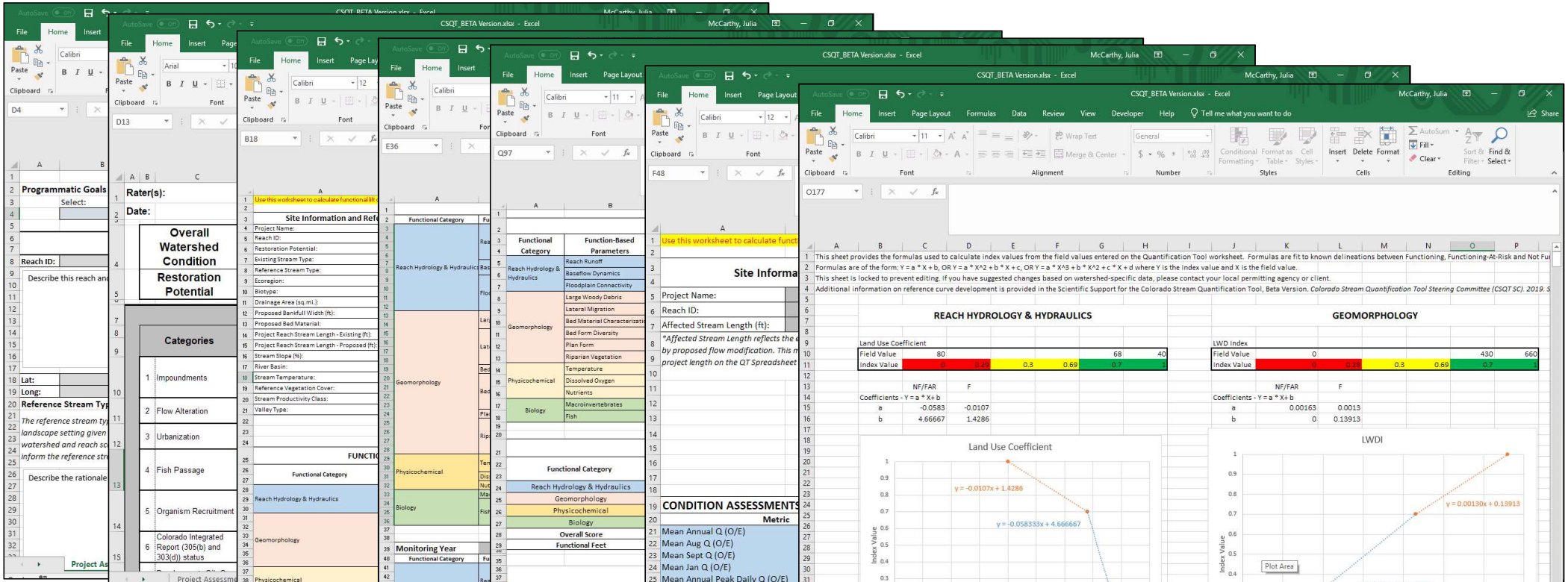
CSQT Beta Version User Manual

CSQT Beta Version Science Support Document



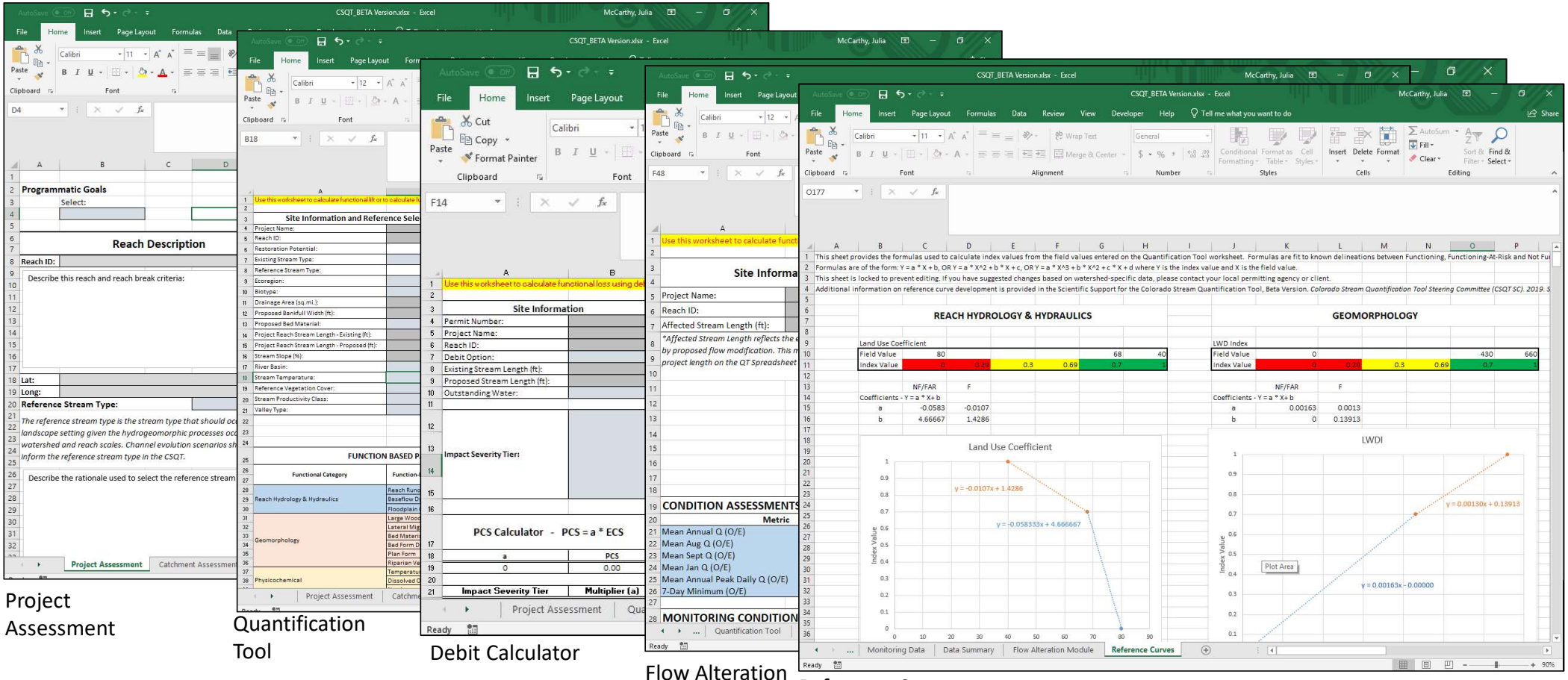
Colorado Mitigation Procedures (COMP) v1

CSQT Beta Version*

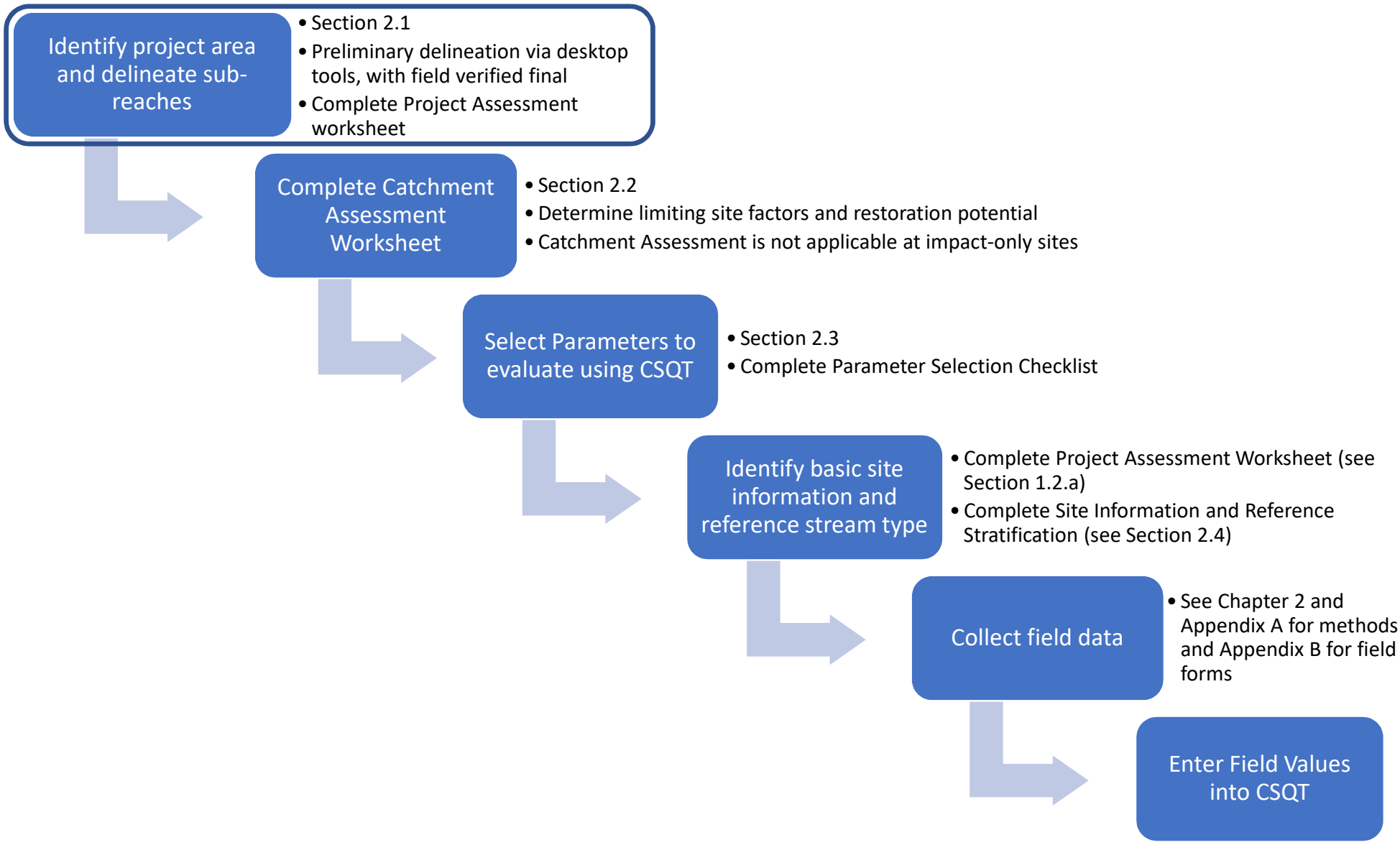


*Use this workbook in reaches where an improved stream condition is anticipated and monitoring will be completed

CSQT Debit Calculator Beta Version*



*Use this workbook to evaluate reaches where adverse impacts (i.e., loss) will occur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• Preliminary delineation via desktop tools, with field verified final
• Complete Project Assessment worksheet
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• Catchment Assessment is not applicable at impact-only sites
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• Complete Parameter Selection Checklist
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• Complete Project Assessment Worksheet (see Section 1.2.a)
• Complete Site Information and Reference Stratification (see Section 2.4)
Collect field data
• See Chapter 2 and Appendix A for methods and Appendix B for field forms
Enter Field Values into CSQT

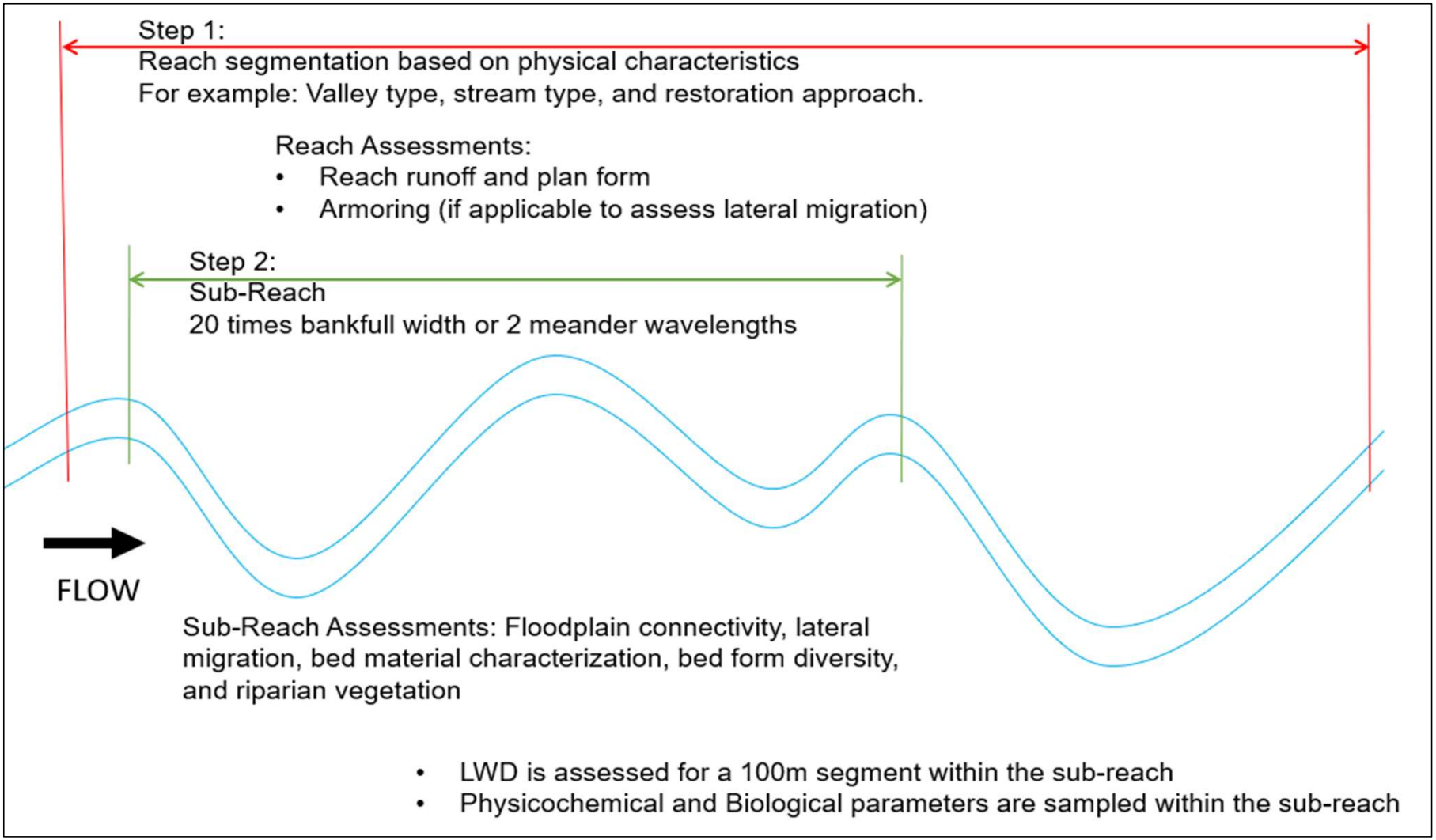
Delineating project reaches

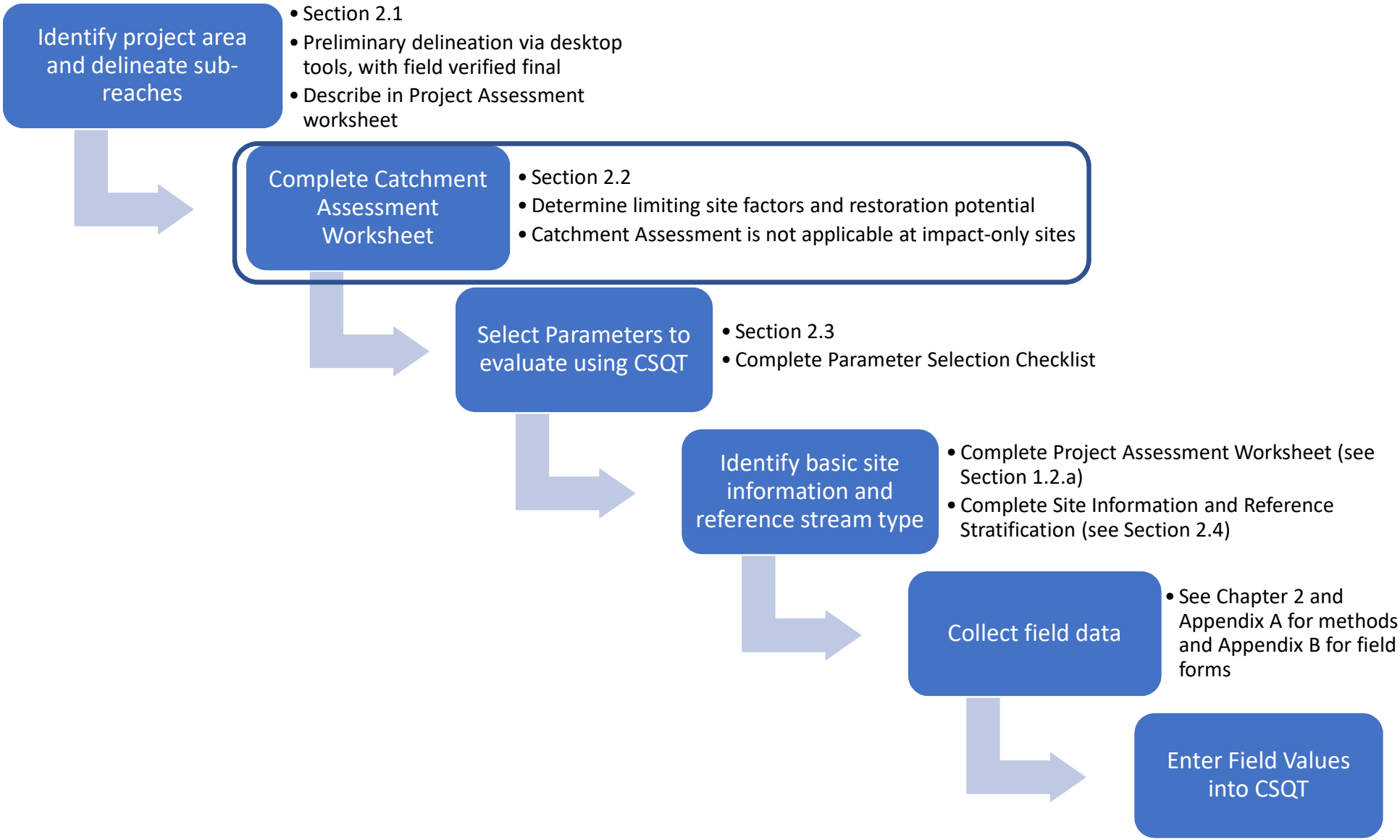
A project area should be broken into more than one project reach where there are:

- Multiple streams, e.g. tributaries vs. main stem.
- A tributary confluence.
- Changes to valley morphology, stream type or bed material composition.
- Diversion dams or other flow modification structures on the stream (separate reaches upstream and downstream of the structure; the structure would also be its own reach).
- Distinct changes in the level of anthropogenic modifications, such as narrowed riparian width from road embankments, concrete lined channels, dams, stabilization, or culverts/pipes.
- Differences in the magnitude of impact or mitigation approach (e.g., enhancement vs. restoration) within the project area.

An explanation of reach breaks should be included in the Reach Description section of the Project Assessment worksheet.


Cub Creek
Cub Creek
POWERED BY esri


Step 1:
Reach segmentation based on physical characteristics
For example: Valley type, stream type, and restoration approach.
Reach Assessments:
• Reach runoff and plan form
• Armoring (if applicable to assess lateral migration)
Step 2:
Sub-Reach
20 times bankfull width or 2 meander wavelengths
FLOW
Sub-Reach Assessments: Floodplain connectivity, lateral migration, bed material characterization, bed form diversity, and riparian vegetation
• LWD is assessed for a 100m segment within the sub-reach
• Physicochemical and Biological parameters are sampled within the sub-reach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Restoration Potential

The level of restoration that can be achieved based on catchment conditions, results of the reach assessment and project constraints.

Slide Credit: Stream Mechanics

Restoration Potential

Full

(Aqua

Partia

(Stabi

Partial can improve biology, but not back to a reference standard condition.

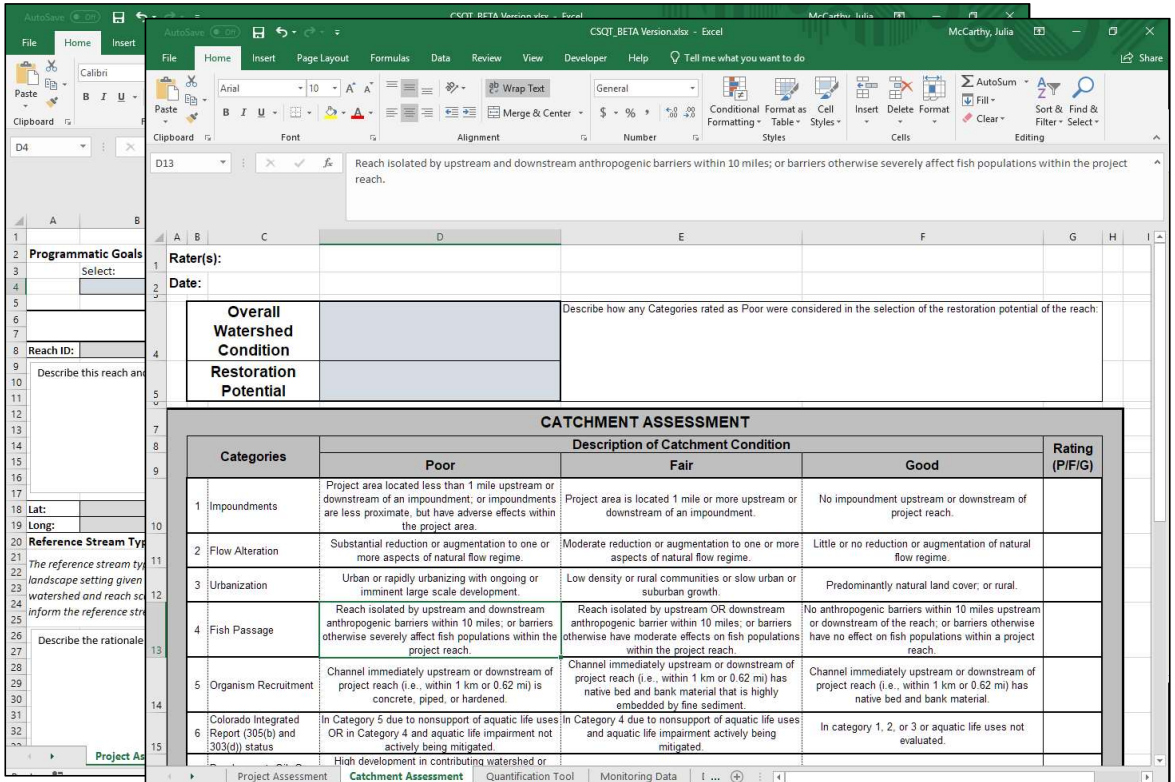
Slide Credit: Stream Mechanics

Function-Based Goals and Objectives

- Goals explain the functional problem and state **why** the project is being pursued.
  - Programmatic
  - Design
- Objectives
  - Explain **how** the goals will be achieved.
  - List function-based parameters that will be manipulated in order to see lift.

Slide Credit: Stream Mechanics

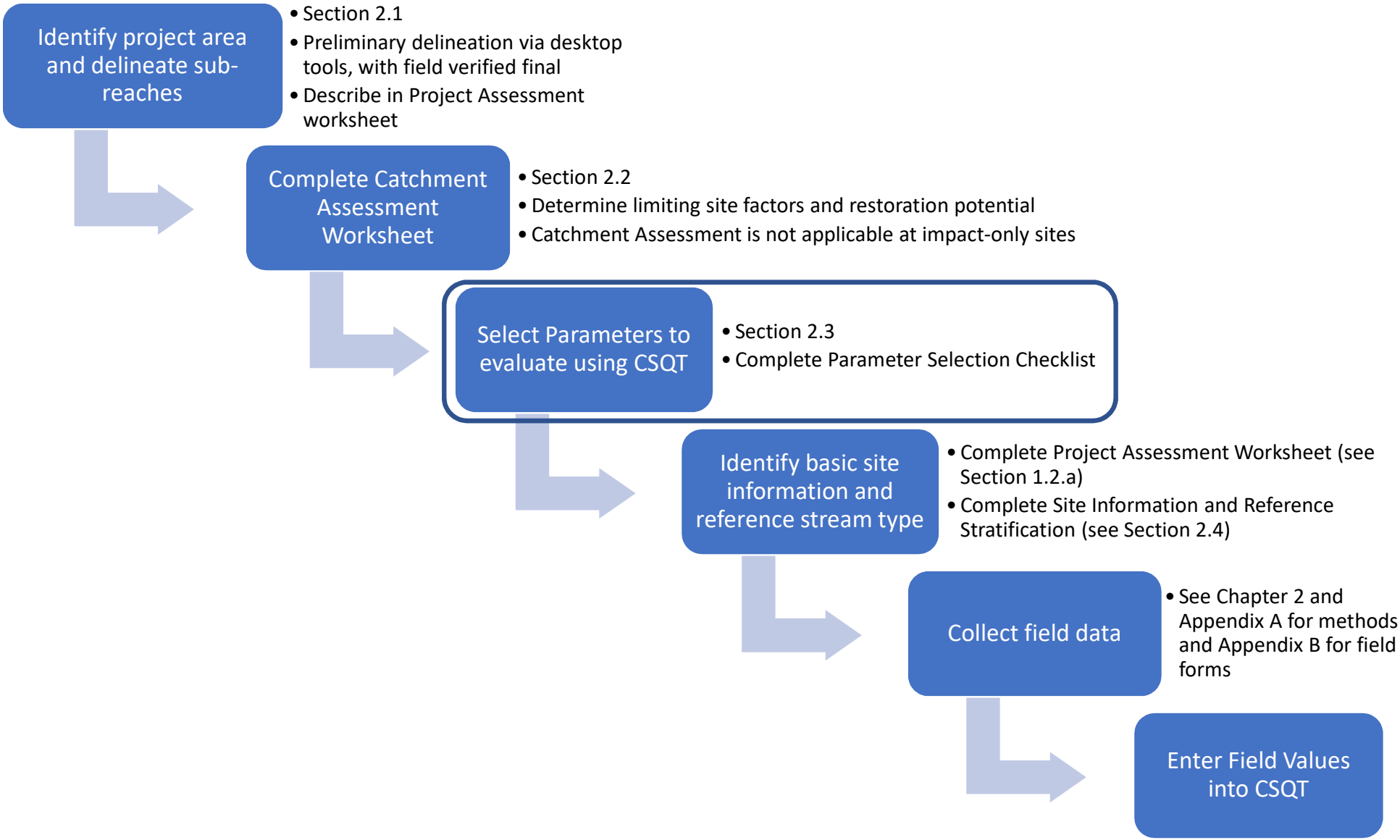
CSQT Beta Version*



Project Assessment

Catchment Assessment

*Use this workbook in reaches where an improved stream condition is anticipated and monitoring will be completed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CSQT Beta Version Parameters and Metrics

Functional Category	Function-Based Parameter	Metric
Reach Hydrology & Hydraulics	Reach Runoff ★	Land Use Coefficient Impervious Cover (%) Concentrated Flow Points (#/1000 LF) Water Quality Capture Volume
	Baseflow Dynamics	Average Velocity (fps) Average Depth (ft)
	Floodplain Connectivity ★	Return Interval (yr) Bank Height Ratio Entrenchment Ratio Percent Side Channels (%)

★ Starred parameters are recommended at every site; additional parameters and metrics should be selected based upon a project's restoration potential and function-based goals and objectives.

CSQT Beta Version Parameters and Metrics

Geomorphology	Large Woody Debris	LWD Index No. of LWD Pieces/ 100 meters
	Lateral Migration ★	Greenline Stability Rating Dominant BEHI/NBS Percent Streambank Erosion (%) Percent Armoring (%)
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)
	Bed Form Diversity ★	Pool Spacing Ratio Pool Depth Ratio Percent Riffle (%) Aggradation Ratio
	Plan Form	Sinuosity
	Riparian Vegetation ★	Riparian Width (%) Woody Vegetation Cover (%) Herbaceous Vegetation Cover (%) Percent Native Cover (%)

★ Starred parameters are recommended at every site; additional parameters and metrics should be selected based upon a project's restoration potential and function-based goals and objectives.

CSQT Beta Version Parameters and Metrics

Physicochemical	Temperature	Daily Maximum Temperature (°C) MWAT (°C)
	Dissolved Oxygen	Dissolved Oxygen Concentration (mg/L)
	Nutrients	Chlorophyll a (mg/m2)
Biology	Macroinvertebrates	CO MMI
	Fish	Native Fish Species Richness (% of Expected) SGCN Absent Score Wild Trout Biomass (% Change)

★ Starred parameters are recommended at every site; additional parameters and metrics should be selected based upon a project's restoration potential and function-based goals and objectives.

Parameter Selection

Project:
Reach ID:

Colorado Stream Quantification Tool
Parameter Selection Checklist

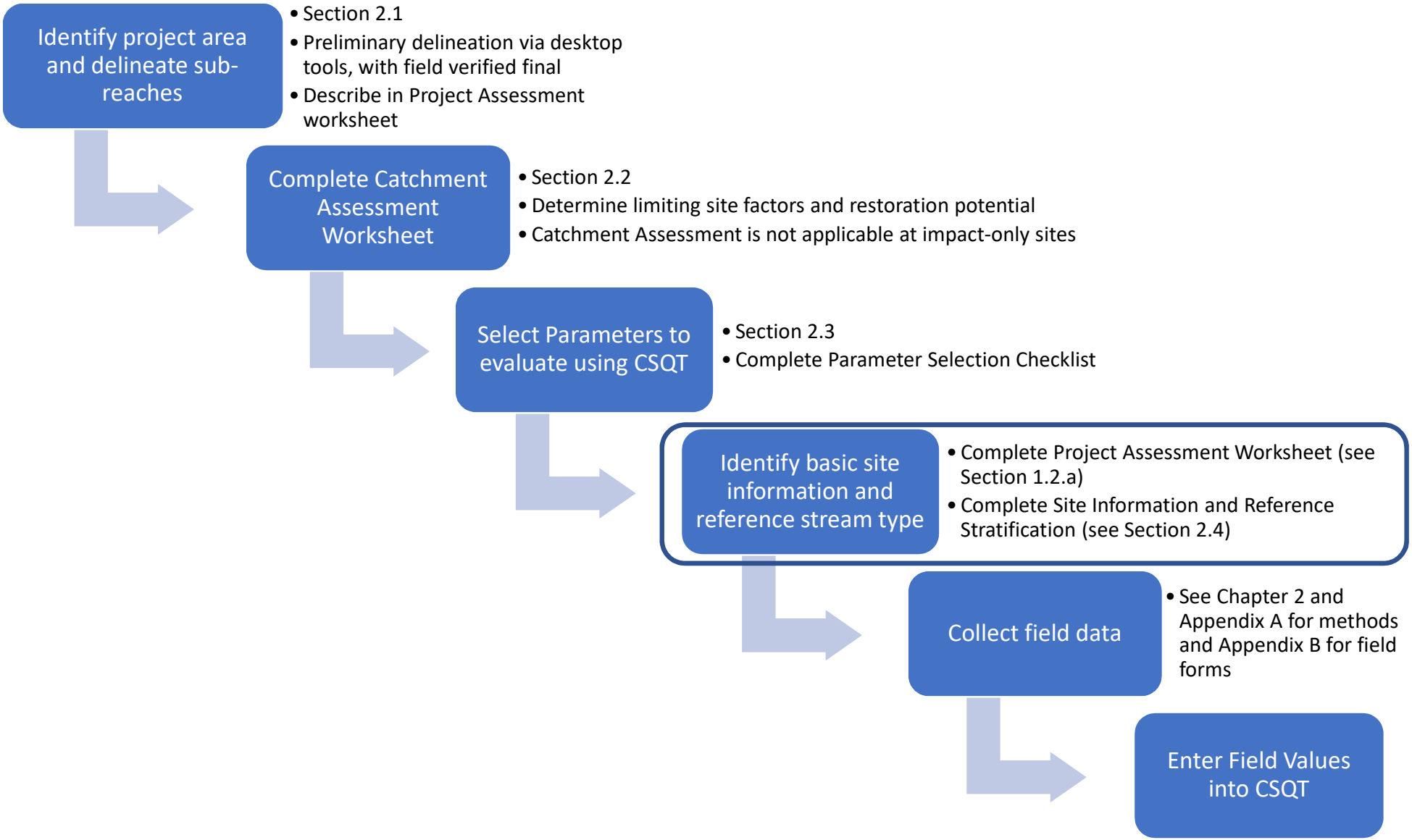
	Function-Based Parameter		Metric(s)	Datasheets for Field-based Metrics
☑	Reach Runoff*	☐	Land Use Coefficient (D) **AND** Concentrated Flow Points (F)	Project Reach Form Section II(b)**
			or	
		☐	Impervious Cover (D) **AND** Concentrated Flow Points (F)	Project Reach Form Section II(b)**
			or	
		☐	Water Quality Capture Volume (D)	
☐	Baseflow Dynamics	☐	***Optional:*** Velocity **AND** Average Depth (D/F)	Cross Section Form
☑	Floodplain Connectivity*	☐	Bank Height Ratio **AND** Entrenchment Ratio (F)	Cross Section Form **OR** Rapid Survey Form**
			or	
		☐	Return Interval (D) **AND** Entrenchment Ratio (F)	Cross Section Form
		☐	***Optional:*** Percent Side Channels (F)	Project Reach Form Section II(d)**
☐	Large Woody Debris (LWD)	☐	***Optional:*** LWD Index (F)	LWDI Form or fillable workbook**
			or	
		☐	***Optional:*** No. of LWD Pieces/ 100 meters (F)	Project Reach Form Section VI**
☑	Lateral Migration*	☐	Dominant BEHI/NBS **AND** Percent Streambank Erosion (F)	Lateral Migration Form**
			or	
		☐	Greenline Stability Rating (F)	Available in Winward (2000)
		☐	***Optional:*** Percent Armoring (F)	Project Reach Form Section II(c)**
☐	Bed Material Characterization	☐	***Optional:*** Size Class Pebble Count Analyzer (F)	Pebble Count Form
☑	Bed Form Diversity*	☑	Pool Spacing Ratio **AND** Pool Depth Ratio **AND** Percent Riffle* (F)	Longitudinal Survey **OR** Rapid Survey Form**
		☐	***Optional:*** Aggradation Ratio (F)	Cross Section Form **OR** Rapid Survey Form**
☐	Plan Form	☐	***Optional:*** Sinuosity (F)	Project Reach Form Section II(e)**
☑	Riparian Vegetation*	☑	Riparian Width (D/F) **AND** Woody Vegetation Cover (F) **AND** Herbaceous Vegetation Cover (F) **AND** Percent Native Cover (F)*	Riparian Width and Riparian Vegetation Forms**
☐	Temperature	☐	***Optional:*** Daily Maximum Temperature (F) **AND** Maximum Weekly Average Temperature (F)	Sensor Log
☐	Dissolved Oxygen	☐	***Optional:*** Dissolved Oxygen Concentration (F)	Sensor Log
☐	Nutrients	☐	***Optional:*** Chlorophyll a (F)	Physicochemical and Biology Form
☐	Macroinvertebrates	☐	***Optional:*** Colorado Multi-Metric Index (F)	Physicochemical and Biology Form
☐	Fish	☐	***Optional:*** Native Fish Species Richness **AND** SGCN Absent (F)	Physicochemical and Biology Form
		☐	***Optional:*** Wild Trout Biomass (F)	Physicochemical and Biology Form
☐	Flow Alteration Module	☐	***Optional:*** Mean Annual Flow	Sensor Log
		☐	***Optional:*** Mean August **AND** September Flow	Sensor Log
		☐	***Optional:*** Mean January Flow	Sensor Log
		☐	***Optional:*** Mean Annual Peak Daily Flow	Sensor Log
		☐	***Optional:*** 7-Day Minimum	Sensor Log

* Include in all assessments
** Field values can be entered directly from field forms into CSQT; all other metrics require additional post-processing or analysis to calculate values.
(D) indicates metrics are calculated using desktop methods
(F) indicates metrics are calculated or verified using field methods

Parameter Selection

Applicable Parameters	Perennial	Intermittent	Ephemeral	Multi-thread Channels
Reach Runoff	x	x	x	x
Base Flow Dynamics	x	x		x
Floodplain Connectivity	x	x	x	x
Large Wood	x	x	x	x
Lateral Migration	x	x	x	x
Bed Material	x	x	x	x
Bedform Diversity	x	x		
Planform	x	x		
Riparian Vegetation	x	x	x	x
Temperature	x	Where baseflows extend through index period		x
Dissolved Oxygen	x			x
Nutrients	x			x
Macroinvertebrates	x			x
Fish	x	x		x
Flow Alteration Module	x			

Alternate field methodologies may be needed for some metrics when applied in multi-thread and non-wadeable stream systems.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Basic Site Information

Site Information and Reference Selection	
Project Name:	Halfmoon Example
Reach ID:	1
Restoration Potential:	Partial
Existing Stream Type:	C
Reference Stream Type:	Ba
Ecoregion:	Mountains
Biotype:	1
Drainage Area (sq.mi.):	23.4
Proposed Bankfull Width (ft):	25
Proposed Bed Material:	Gravel
Project Reach Stream Length - Existing (ft):	1000
Project Reach Stream Length - Proposed (ft):	1200
Stream Slope (%):	0.5
River Basin:	Arkansas
Stream Temperature:	WS-I
Reference Vegetation Cover:	Forested
Stream Productivity Class:	Moderate
Valley Type:	Confined Alluvial

Basic Site Information is entered on the Quantification Tool worksheet.

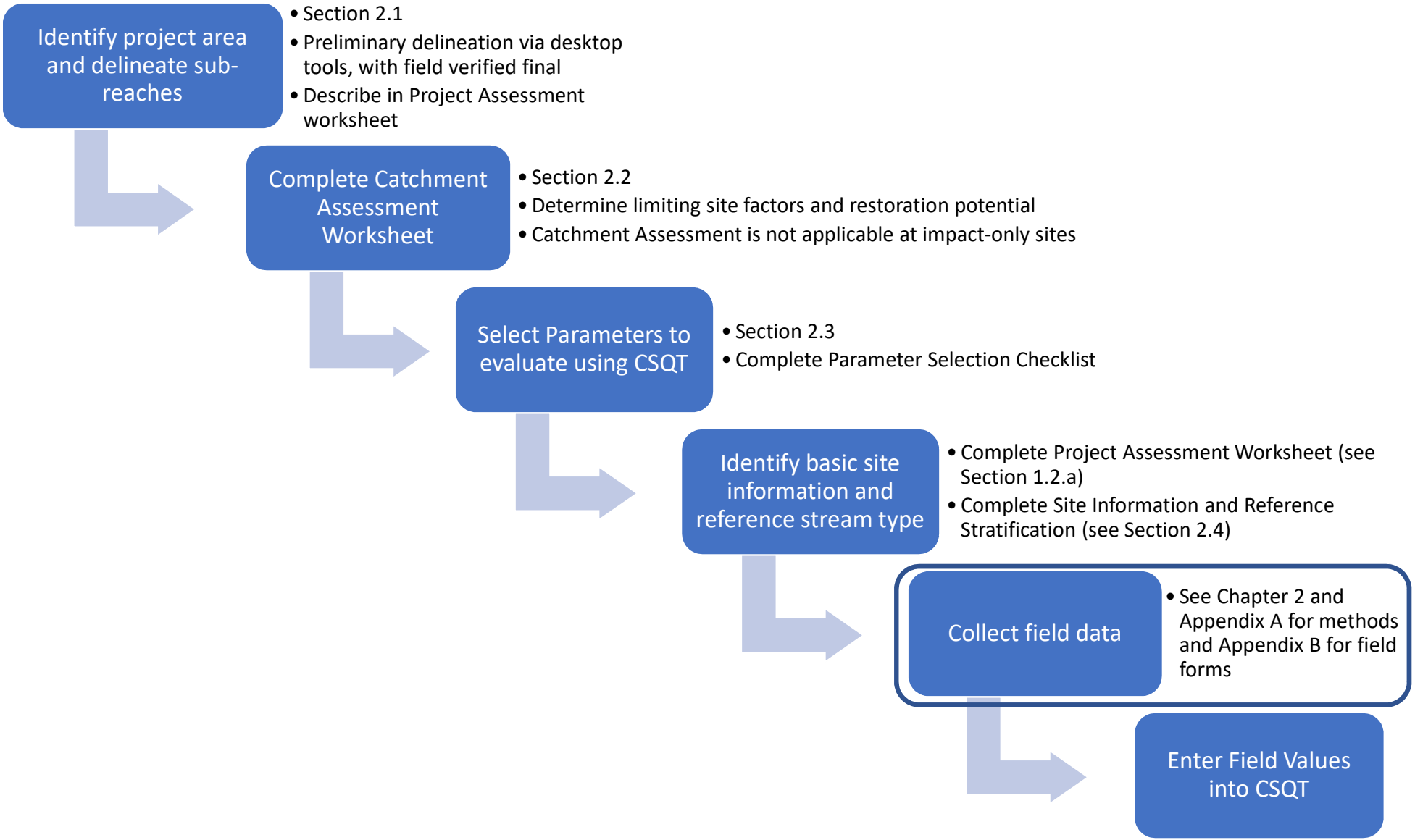
Information on each entry can be found in Section 2.4 of the CSQT User Manual.

Reference Stream Type

Stream Evolution Model Stages (Cluer and Thorne 2013)	Corresponding Rosgen Stream Types
Stage 0 - Anastomosing	DA
Stage 1 – Sinuous Single Thread	C, E
Stage 2 - Channelized	C, E, → Gc
Stage 3 - Degradation	Gc
Stage 3a – Arrested Degradation	Gc → F → Bc
Stage 4 – Degradation and Widening	Gc → F
Stage 5 – Aggradation and Widening	F → C
Stage 6 – Quasi Equilibrium	C, E
Stage 7 – Laterally Active	C, E, F
Stage 8 - Anastomosing	DA

Reference Stream Type is entered on the Project Assessment worksheet, which also includes space to describe rationale used to select reference stream type.

Information on determining stream type can be found in Section 2.4 of the CSQT User Manual.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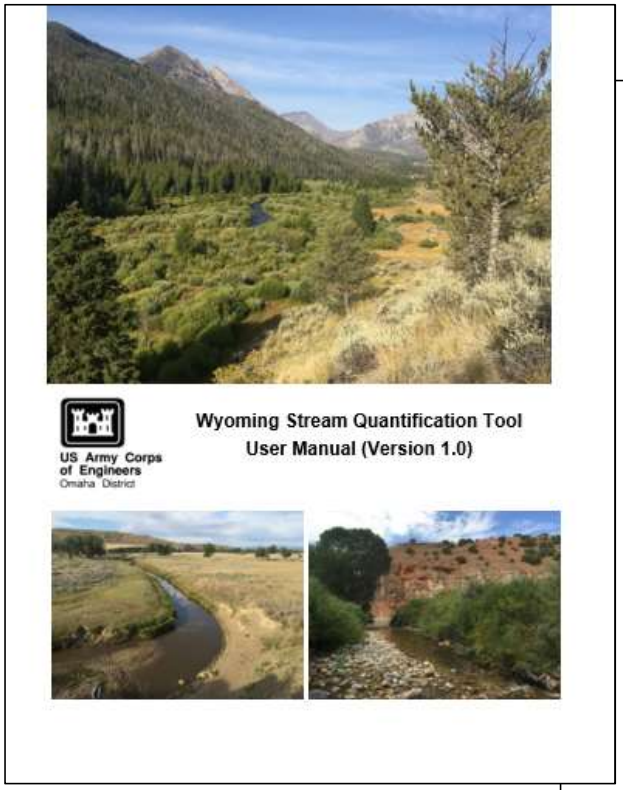
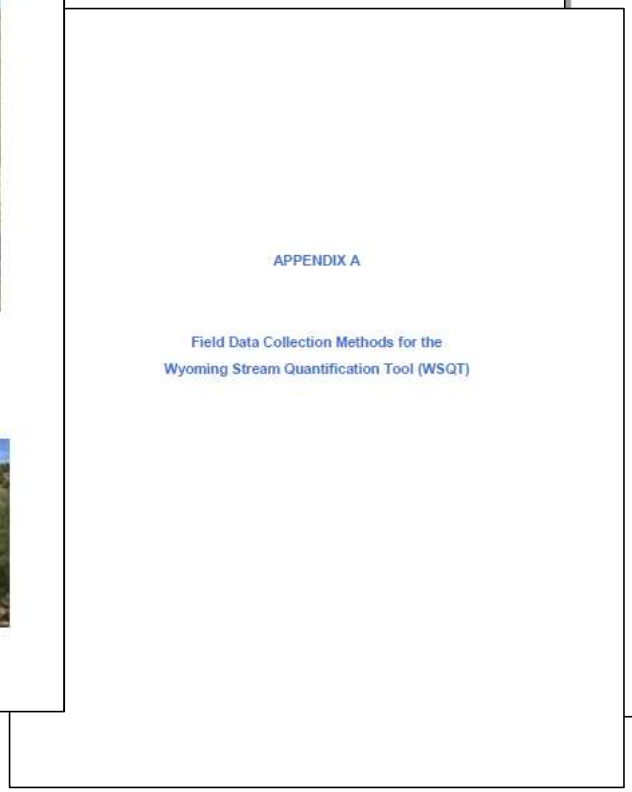
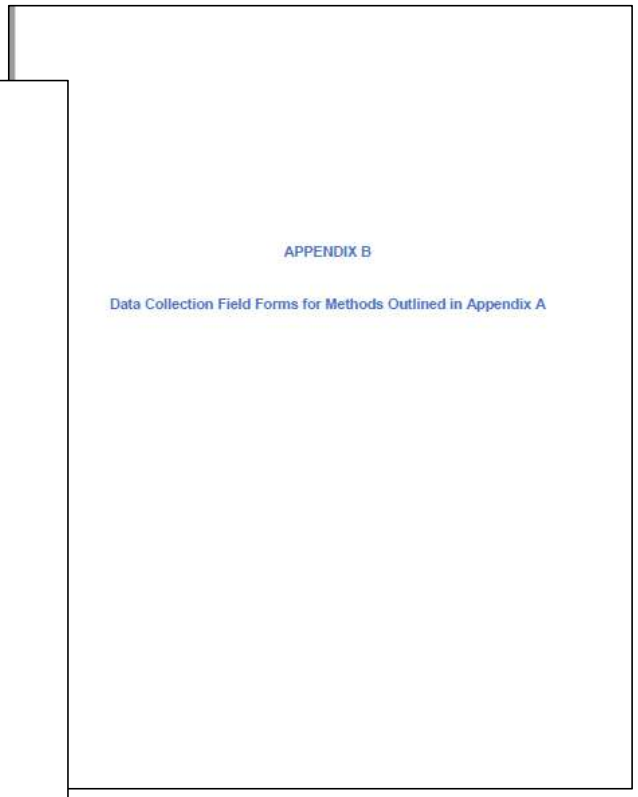
Colorado SQT User Manual



User Manual – how to select and calculate metrics, enter data into tool, and calculate functional lift/loss



Appendix A – field data collection methods

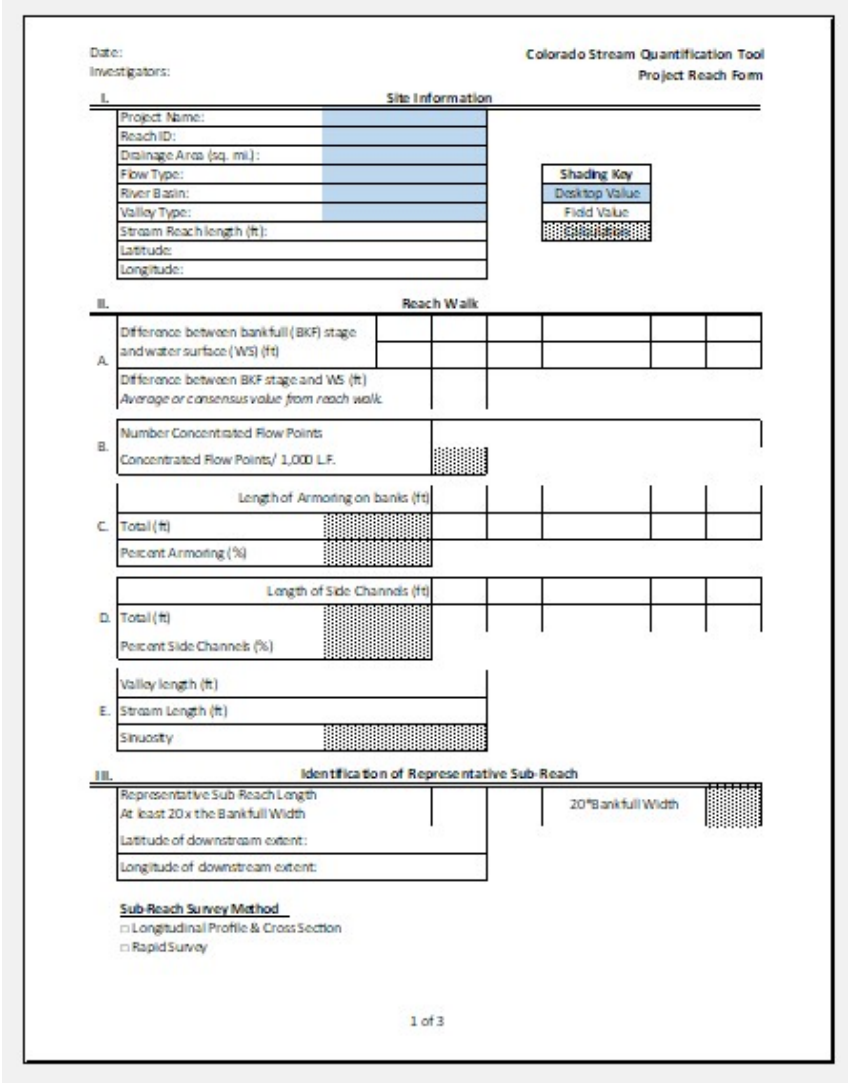


Appendix B – field data forms

Appendix B Field Forms

- Parameter Selection Checklist
- Project Reach Form
- Longitudinal Survey Form
- Standard Cross-Section Form
- Rapid Survey Form
- Lateral Migration Form
- Riparian Width Form
- Riparian Veg Form
- Physicochemical and Biological Form
- Pebble Count Form
- Sensor Log

Note: The Parameter Selection Checklist indicates which forms should be completed for each selected metric



Date:
Investigators:

Colorado Stream Quantification Tool
Project Reach Form

I. Site Information

Project Name:	
Reach ID:	
Drainage Area (sq. mi.):	
Flow Type:	
River Basin:	
Valley Type:	
Stream Reach length (ft):	
Latitude:	
Longitude:	

Shading Key
Desktop Value
Field Value

II. Reach Walk

A. Difference between bankfull (BKF) stage and water surface (WS) (ft)

Difference between BKF stage and WS (ft)
Average or consensus value from reach walk

B. Number Concentrated Flow Points
Concentrated Flow Points/ 1,000 L.F.

C. Length of Armoring on banks (ft)
Total (ft)
Percent Armoring (%)

D. Length of Side Channels (ft)
Total (ft)
Percent Side Channels (%)

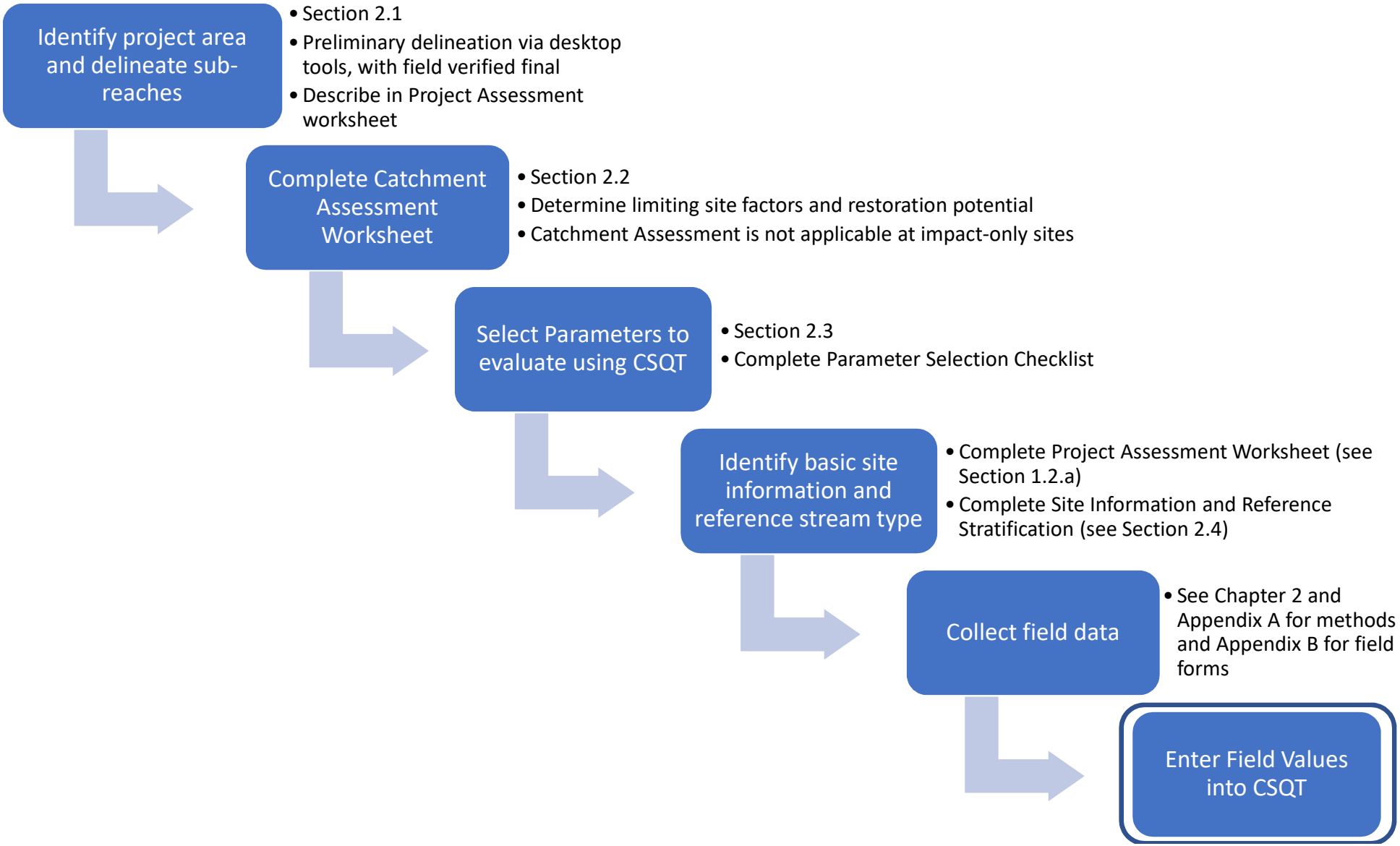
E. Valley length (ft)
Stream Length (ft)
Sinuosity

III. Identification of Representative Sub-Reach

Representative Sub Reach Length At least 20x the Bankfull Width	20*Bankfull Width
Latitude of downstream extent:	
Longitude of downstream extent:	

Sub-Reach Survey Method
□ Longitudinal Profile & Cross Section
□ Rapid Survey

1 of 3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• Complete Project Assessment Worksheet (see Section 1.2.a)
• Complete Site Information and Reference Stratification (see Section 2.4)
Collect field data
• See Chapter 2 and Appendix A for methods and Appendix B for field forms
Enter Field Values into CSQT

Functional Category	Function-Based Parameter	Metric	Field Value	Index Value
Reach Hydrology & Hydraulics	Reach Runoff	Land Use Coefficient Impervious Cover (%) Concentrated Flow Points (#/1000 LF) Water Quality Capture Volume		
	Baseflow Dynamics	Average Velocity (fps) Average Depth (ft)		--
	Floodplain Connectivity	Return Interval (yr) Bank Height Ratio Entrenchment Ratio Percent Side Channels (%)		
Geomorphology	Large Woody Debris	LWD Index No. of LWD Pieces/ 100 meters		
	Lateral Migration	Greenline Stability Rating Dominant BEHI/NBS Percent Streambank Erosion (%) Percent Armoring (%)		
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)		
	Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle (%) Aggradation Ratio		
	Plan Form	Sinuosity		
	Riparian Vegetation	Riparian Width (%) Woody Vegetation Cover (%) Herbaceous Vegetation Cover (%) Percent Native Cover (%)		
Physicochemical	Temperature	Daily Maximum Temperature (^{o}C) MWAT (^{o}C)		
	Dissolved Oxygen	Dissolved Oxygen Concentration (mg/L)		
	Nutrients	Chlorophyll a (mg/m2)		
Biology	Macroinvertebrates	CO MMI		
	Fish	Native Fish Species Richness (% of Expected) SGCN Absent Score Wild Trout Biomass (% Change)		

Field Values are calculated, then entered into the Existing Condition section of the Quantification Tool worksheet

Estimating Proposed Condition Field Values

- Field values are entered into the Proposed Condition section of the Quantification Tool worksheet.
- Proposed condition field values should consist of reasonable values for restored and impacted conditions. Users should rely on available data to estimate proposed condition field values, including project design studies and calculations, drawings, field investigations, and best available science.
- The same parameters used to calculate the existing condition score must also be used to estimate the proposed condition score.
- Proposed condition scores need to be verified using as-built and post-project monitoring data

Function-Based Parameter	Metric	Field Value
Reach Runoff	Land Use Coefficient Impervious Cover (%) Concentrated Flow Points (#/1000 LF) Water Quality Capture Volume	
Baseflow Dynamics	Average Velocity (fps) Average Depth (ft)	
Floodplain Connectivity	Return Interval (yr) Bank Height Ratio Entrenchment Ratio Percent Side Channels (%)	
Large Woody Debris	LWD Index No. of LWD Pieces/ 100 meters	
Lateral Migration	Greenline Stability Rating Dominant BEHI/NBS Percent Streambank Erosion (%) Percent Armoring (%)	
Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)	
Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle (%) Aggradation Ratio	
Plan Form	Sinuosity	
Riparian Vegetation	Riparian Width (%) Woody Vegetation Cover (%) Herbaceous Vegetation Cover (%) Percent Native Cover (%)	
Temperature	Daily Maximum Temperature (^{o}C) MWAT (^{o}C)	
Dissolved Oxygen	Dissolved Oxygen Concentration (mg/L)	
Nutrients	Chlorophyll a (mg/m2)	
Macroinvertebrates	CO MMI	
Fish	Native Fish Species Richness (% of Expected) SGCN Absent Score Wild Trout Biomass (% Change)	

Functional Category	Function-Based Parameter	Parameter	Category	Category
Reach Hydrology & Hydraulics	Reach Runoff	0.46	0.50	Functioning At Risk
	Baseflow Dynamics	0.59		
	Floodplain Connectivity	0.44		
Geomorphology	Large Woody Debris	0.16	0.31	Functioning At Risk
	Lateral Migration	0.30		
	Bed Material Characterization			
	Bed Form Diversity	0.23		
	Plan Form	0.36		
	Riparian Vegetation	0.49		
Physicochemical	Temperature	0.39	0.40	Functioning At Risk
	Dissolved Oxygen	0.47		
	Nutrients	0.35		
Biology	Macroinvertebrates	0.07	0.13	Not Functioning
	Fish	0.19		

Index values for each metric are averaged for a parameter score

Parameter scores are averaged for a category score

Functional category scores are weighted and summed to create an overall reach score

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FUNCTION BASED PARAMETERS SUMMARY

Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Reach Hydrology & Hydraulics	Reach Runoff	0.46	0.46
	Baseflow Dynamics	0.59	1.00
	Floodplain Connectivity	0.44	0.94
Geomorphology	Large Woody Debris	0.16	0.32
	Lateral Migration	0.40	1.00
	Bed Material Characterization		
	Bed Form Diversity	0.23	0.89
	Plan Form	0.36	1.00
	Riparian Vegetation	0.49	0.80
Physicochemical	Temperature	0.39	0.89
	Dissolved Oxygen	0.47	0.70
	Nutrients	0.35	0.35
Biology	Macroinvertebrates	0.07	0.12
	Fish	0.19	0.19

FUNCTIONAL CHANGE SUMMARY

Existing Condition Score (ECS)	0.44
Proposed Condition Score (PCS)	0.75
Change in Functional Condition (PCS - ECS)	0.31
Existing Stream Length (ft)	2000
Proposed Stream Length (ft)	2500
Change in Stream Length (ft)	500
Existing Functional Feet (FF)	880
Proposed Functional Feet (FF)	1875
Proposed FF - Existing FF (ΔFF)	995
Percent Change in FF (%)	113%
ΔFF from Flow Alteration Module	441.70
Total Proposed FF - Existing FF (ΔFF)	1436.70

FUNCTIONAL CATEGORY REPORT CARD

Functional Category	ECS	PCS	Functional Change
Reach Hydrology & Hydraulics	0.50	0.80	0.30
Geomorphology	0.33	0.80	0.47
Physicochemical	0.40	0.65	0.25
Biology	0.13	0.15	0.02

	Existing Condition:	**Proposed Condition:**
SCORE	Existing Condition Score: 0.21	Proposed Condition Score: 0.75
X QUANTITY	Existing Stream Length: 1600 Ft	Proposed Stream Length: 1640 Ft
FUNCTIONAL FEET (FF)	FF = 336 Functional Feet	FF = 1,230 Functional Feet

Functional Change (ΔFunctional Feet) = 1,230 – 336 = 894

Slide credit: Will Harman

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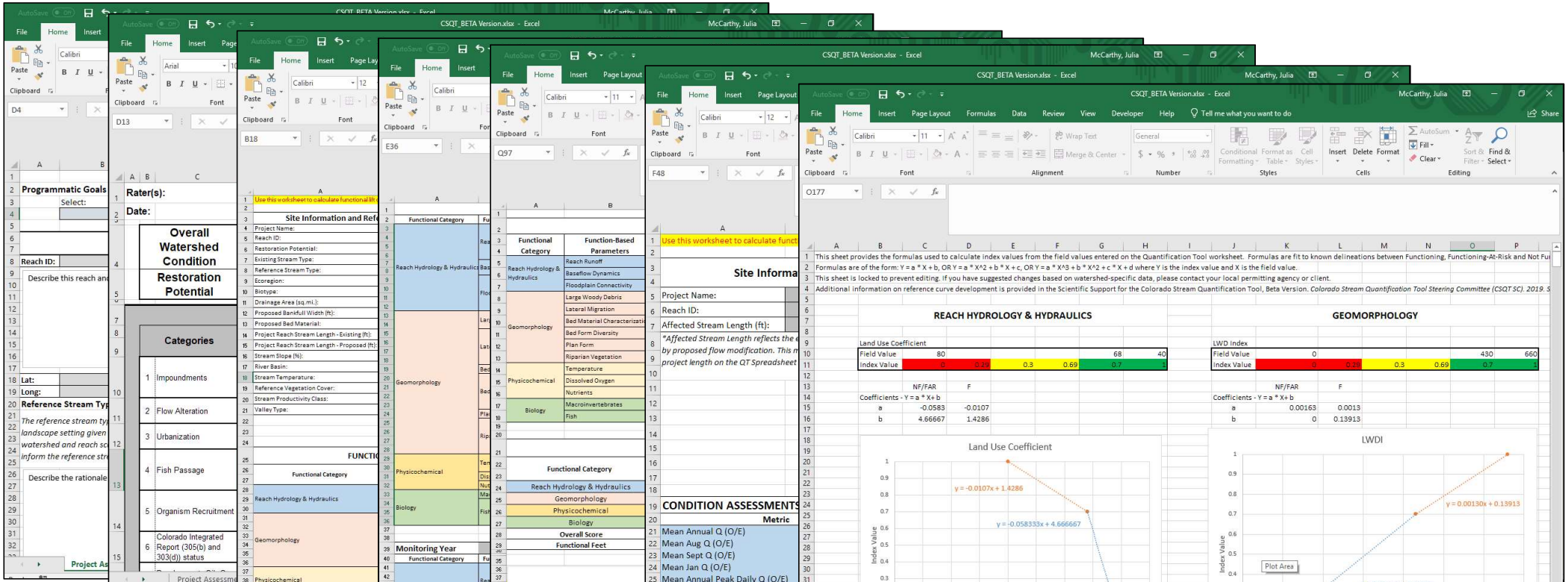

*Use this workbook in reaches where an improved stream condition is anticipated and monitoring will be completed