Design Memorandum

Fourmile Canyon Creek Stream Restoration 30% Design

Wagonwheel Gap Road & Lee Hill Drive to Anne U White Trailhead

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Project Location & Watershed Description

The Fourmile Canyon Creek restoration project is located north of the City of Boulder near the intersection of Lee Hill Drive and Wagonwheel Gap Road. The project begins approximately 1,100 feet downstream of Wagonwheel Gap Road and extends upstream to the Anne U White Trailhead. The total length of this project is approximately 1.4 miles.

The drainage area of Fourmile Canyon Creek at the downstream extents of the project is 7.19 square miles and at the confluence with Lion Point tributary, near Lion Point, is 4.92 square miles. The watershed elevation varies between 5700 feet at the downstream end of the project to 8500 feet at the headwaters, just upstream of Sunshine Canyon Drive. The mean annual precipitation for this portion of the watershed is approximately 21 inches per year.

Geology in the watershed consists mostly of granite, with some siltstone and sandstone. This watershed is comprised of alluvial valleys with ranging widths. Most of the soils in the watershed can be classified as loamy or sandy alluvium and are typically well-drained soils meaning that they have a high rate of infiltration.

Existing vegetation in this watershed falls within three categories: Overstory (trees), understory (shrubs), and ground cover (herbaceous). Existing overstory vegetation is generally comprised of Ponderosa Pine, Douglas Fir, Willow, and Cottonwood. Understory vegetation is generally comprised of Willow, Mountain Ninebark, and Chokecherry. Ground cover vegetation is generally comprised of a variety of grasses, brome, rushes, and sedges. A complete description of all existing vegetation is provided in Appendix A.

Project Background

Fourmile Canyon Creek incurred significant damage during the September 2013 Flood. The flood and debris flow straightened the entire creek alignment, over widened the channel cross section, and modified the channel profile through the cutting and depositing of sediment. A heat map showing zones of erosion and deposition is provided in Appendix A. Aquatic and terrestrial habitat was severely impacted and/or destroyed and most riparian vegetation was removed by the flood.

This change in channel dimension (cross-section), pattern (planform), and profile (slope) has resulted in unstable channel conditions throughout the extents of this project. The resulting impact of these changes is a general inability of the existing channel to move water and sediment efficiently through the system without resulting in channel degradation, aggradation, and bank erosion.

Riparian and upland vegetation provides a substantial amount of natural earth stabilization for both the channel, floodplain, and valley. Much of this natural vegetation adjacent to Fourmile Canyon Creek was stripped during the flood event, which further reduced the overall stability of the existing stream system. Above average precipitation was received in the watershed, and along the Front Range of Colorado, during the summer of 2015. As a result, both natural and invasive vegetation has begun to grow back faster than expected. However, there is still a general lack of riparian vegetation in this system.

This project was derived from the adjacent Wagonwheel Gap Road project. Wagonwheel Gap Road was also severely damaged during the September 2013 Flood and Boulder County (County) secured funding to do both the design and reconstruction of Wagonwheel Gap Road between Lee Hill Drive and the Anne U White Trailhead. The County decided to develop restoration plans for this section of Fourmile Canyon Creek for two reasons:

1. There is a high degree of interaction between the road and creek and making site-specific improvements only at locations where the road crosses the creek puts these isolated improvements at risk of failing due to adjacent, unaddressed, instabilities in the creek.
2. A post-flood watershed master plan was not completed for the Fourmile Canyon Creek watershed. However, the Fourmile Canyon Creek watershed experienced significant damage during the September 2013 Flood. As a result, the County did not have the appropriate planning documents to apply for watershed restoration grants.

Funding has not yet been secured for the construction of Fourmile Canyon Creek. Ideally it will be secured and construction can be completed at the same time as the reconstruction of Wagonwheel Gap Road. This would provide both a time and cost savings to the County.

Goals & Objectives

The general philosophy towards restoring Fourmile Canyon Creek was to implement the principles of natural channel design. The definition of natural channel design is to establish the physical, chemical, and biological functions of the river system that are self-regulating and emulate the natural stable form within the constraints imposed by the larger landscape conditions (Wildland Hydrology, 2006). It is important to restore all components of a stream system that are required to make it sustainable, rather than just focusing on what is visible. A river system includes not only the river channel but also its related components, including adjacent floodplains, wetlands, and associated riparian and biological communities. Defining the natural, stable form of a river involves re-establishing a physical stability that integrates the processes responsible for creating and maintaining the dimension, pattern and profile of river channels.

A project kickoff meeting was held with the County on March 10th, 2015 to discuss project goals and objectives, which are in alignment with the definition of natural channel design, and consist of:

- Restoring the natural channel to the extent practical and within the current watershed setting
- Restoring aquatic and terrestrial habitat
- Restoring ecological connectivity
- Reducing flood risk
- Integrating the above restoration strategies with the adjacent Wagonwheel Gap Road project

Stream Assessments

Project reach assessments were performed over a period of ten days using protocols outlined in Watershed Assessment of River Stability and Sediment Supply (Wildland Hydrology, 2006) to quantify the degree of impairment for the existing creek system related to hydrologic, geomorphic, ecologic, and biologic conditions. Results of the assessment are provided in Appendix A.

General project reach assessments included:

- Initial site assessment to document existing conditions with field notes and photographs.

- A review of historical, pre- and post-flood aerial photography to evaluate changes in channel and floodplain conditions over time.
- A review of pre- and post-flood LiDAR data to evaluate changes in channel and floodplain conditions over time along with zones of channel erosion and deposition.
- Identification of vertical and lateral controls, such as roadways and utilities, in the vicinity of the project reach.
- Identification of flood debris.

Detailed project reach assessments consisted of the following:

- Hydrologic – To evaluate flow regime and peak flow characteristics.
- Geomorphic – To evaluate existing channel dimension, pattern, and profile characteristics including classification of existing and potential stream type.
- Ecologic – To evaluate riparian and upland vegetation along with the identification of wetlands
- Biologic – To evaluate quality of in-stream habitat, presence of fish species, and presence of macro invertebrates.
- Stability – To evaluate vertical and lateral channel stability processes that are leading to erosion, deposition, and bank erosion.

Additionally, a tree survey was performed to identify large trees adjacent to the creek. The purpose of performing the survey was to identify large, well established, trees that would be ideal to save during the implementation of this restoration project. Both coniferous and deciduous trees were surveyed and classified in three different diameter classes: larger than 4 inches, larger than 8 inches, and larger than 12 inches.

Reference reach information was obtained, and used as a starting point, for developing design parameters for restoring impaired reaches. A reference reach is a stable stream that has adjusted to existing watershed conditions in such a way as to be self-maintaining. Reference reaches do not need to be pristine systems, rather, they need to have been stable over a long period of time and in a similar watershed setting as the project reach. All assessment information that is collected for the project reach is also collected for the Reference Reach. Then, both data sets are compared, and scaled design parameters are developed for use as a starting point for restoring stable channel geometry for the project reach. Reference reach information can be obtained from the following locations, in order of preference:

1. Immediately upstream or downstream of the project reach
2. In same watershed as the project reach
3. In the same hydrophysiographic region as the project reach

Reference reach assessment information was collected from the North Fork of North Elk Creek and the East Fork of the Arkansas River. Both of which are stable stream systems in a similar watershed settings as Fourmile Canyon Creek. This information was used to develop design parameters for restoring natural channel geomorphic, ecologic, and biologic conditions. Reference reach information is summarized in Appendix A.

In addition to collecting reference reach information, a pre-flood assessment of Fourmile Canyon Creek geometry was performed. This assessment was performed using pre-flood LiDAR and aerial photographs to quantify stable planform geometry, channel width, and slope that existed prior to the September 2013 flood and was used as a reference during the design process. This assessment, along with reference reach information, is provided in Appendix A.

Design Hydrology

Hydrologic analyses were performed to determine flood flows and bankfull flow for the project site.

Flood Flow Estimation

USGS StreamStats

The United States Geological Survey (USGS) StreamStats was used to calculate a range of peak flows that could be expected to occur in this watershed. This analysis estimates peak flows by using regression equations developed for different geographic areas. In this case, regression equations are available for both Mountain Regions and Plains Regions. Since portions of the Fourmile Canyon Creek watershed exist in both regions, an area-averaged peak flow was calculated. A summary of this analysis is provided in Appendix A and summarized in Table 1.

Table 1: Summary of USGS StreamStats Analysis

Recurrence	Upstream of Lion Point (cfs)	Downstream of Lion Point (cfs)
	DA=4.92 mi^2	DA=7.19 mi^2
2-year	60	75
5-year	140	183
10-year	210	284
25-year	345	476
50-year	464	646
100-year	630	885

Data from USGS StreamStats was used for reference when estimating bankfull flow for this watershed and comparison to Federal Emergency Management Agency (FEMA) regulatory 100-year flows.

FEMA Regulatory Flows

The effective FIS peak discharges were developed from the Flood Hazard Area Delineation study completed by Greenehorne and O'Mara in 1987. The peak discharge values not listed in the FIS report were obtained from the effective HEC-2 hydraulic model and used throughout the Fourmile Canyon Creek analysis. While the discharge values were evaluated approximately every 800 to 1,200 feet in the effective study, a summary of the effective values at the project upstream and downstream locations are shown in Table 2. The FEMA Flood Insurance Rate Map (FIRM) is provided in Appendix A for reference.

Table 2: Summary of FEMA Regulatory Flows

Location	Peak Flow (cfs)			
	10-Year	50-year	100-Year	500-Year
Upstream end of project	420	1,380	2,010	4,595
Downstream end of project	695	2,270	3,175	7,170

Bankfull Flow Estimation

Bankfull flow is a frequently occurring peak flow that occurs at a stage within the channel that corresponds to the incipient point of flooding. Bankfull flow is generally associated with a flood return period of 1-2 years and is generally responsible for moving the most sediment within the channel system over time. The role of the bankfull discharge in shaping the morphology of all alluvial channels is the fundamental principle behind natural channel design (Wildland Hydrology, 2006) and, therefore, needs to be estimated prior to beginning any design work. Estimations of bankfull flow, and bankfull cross section area, were made using the following methods:

- Regional curves developed for Central Colorado that provide a means to estimate bankfull flow.
- Field-based estimations that rely on presence of bankfull indicators and measurements of channel slope and cross section area. Bankfull stage indicators include:
    - The point at which the stream begins to spread out on the floodplain (requires knowledge of how the geomorphic floodplain should be configured)
    - Highest active depositional feature
    - Slope breaks in the channel bank/floodplain
    - Change in particle size distribution
    - Change in vegetation type
    - Staining of rocks
- Statistical analysis of gage data
- Comparison to the Elk Creek Reference Reach site

Regional Curves

Regional curves of Drainage Area vs. Cross Section Area and Drainage Area vs. Bankfull Flow were obtained for Central Colorado (Wildland Hydrology 2007) to estimate bankfull flow and bankfull channel cross section area. A summary of estimated bankfull flow and cross section area are provided in Table 3. Regional curves are provided in Appendix A. Note that there are two regional curves that represent different precipitation regimes. The high precipitation curve is valid for areas that receive between 18 to 40 inches of rainfall per year. The Fourmile Canyon Creek watershed within the extents of this project receives about 21 inches of rainfall per year so the high precipitation curve is valid for this watershed.

Table 3: Regional Curve Estimations of Bankfull Flow & Area

Location	Bankfull Flow (cfs)	Bankfull Cross Section Area (ft^2)
Upstream of Lion Point (DA=4.92 mi2)	50-120	20-30
Downstream of Lion Point (DA=7.19 mi^2)	60-130	25-35

Field-Based Estimation

In damaged stream systems bankfull indicators are difficult to identify, and in some cases may not be present. Furthermore, only two years have elapsed since the September 2013 flood which is at the upper limit for the return period on a typical bankfull flow event meaning that statistically very few bankfull flow events could have been experienced since the flood. As a result, bankfull features may not have had a significant amount of time to reestablish since the flood and may not be obvious within impaired watersheds. Regardless of this, observed bankfull features were surveyed and estimations of bankfull flow and cross section area were made at several locations along Fourmile Canyon Creek. Collected survey measurements were compared against regional curves of Drainage Area vs. Cross Section Area and Drainage Area vs. Bankfull Flow for the Central Colorado Mountains, both of which are provided in Appendix A. There were three data points from the field survey that correlated fairly well with the regional curve data which confirmed applicability of the regional curve data to this project and further provided basis for determining the appropriate bankfull flow and bankfull cross section area as shown in Table 4.

Table 4: Field-Based Estimations of Bankfull Flow & Area

Location	Bankfull Flow (cfs)	Bankfull Cross Section Area (ft^2)
Upstream of Lion Point (DA=4.92 mi2)	120	24
Downstream of Lion Point (DA=7.19 mi^2)	130	28

Statistical Analysis of Gage Data

A statistical analysis of gage data was performed using the USGS PeakFQ software to calculate peak flows for the flood recurrences typically associated with the bankfull flow. This analysis was performed at gages in similar hydrophysiographic regions with a sufficient period of record to estimate the 1.25- to 2-year flow events. A total of ten gages were used to develop a regression equation of Drainage Area vs. Peak Flow. The results of the analysis were then applied to this project and are presented in Table 5. The regression analysis of the gage data, along with a comparison to the Central Colorado regional curve, is provided in Appendix A.

Table 5: Peak Flows Derived from Regression Analysis

Location	1.25-Year (cfs)	1.50-Year (cfs)	2-Year (cfs)
Upstream of Lion Point (DA=4.92 mi2)	101	114	129
Downstream of Lion Point (DA=7.19 mi^2)	122	140	159

Comparison to Reference Reach Survey

Bankfull flow estimations were made during the reference reach survey performed at the North Fork of North Elk Creek. This reference reach was selected because it is in a similar hydrophysiographic region as Fourmile Canyon Creek. Both the drainage area (4.38 square miles) and annual precipitation (26 inches) of the reference reach site are similar to that of this project. Typical bankfull characteristics of the reference reach site are provided in Table 6 and are similar to what is predicted using the Central Colorado regional curves. Estimations of bankfull flow and bankfull cross section were plotted against the regional curves for Central Colorado and are provided in Appendix A.

Table 6: North Fork of North Elk Creek Typical Bankfull Characteristics

Location	Bankfull Flow (cfs)	Bankfull Cross Section Area (ft^2)
North Fork of North Elk Creek	110	18.3

Bankfull Flow Summary

The selected bankfull flow and bankfull cross section area for the design of Fourmile Canyon Creek are provided in Table 7.

Table 7: Selected Bankfull Channel Flow & Cross Section Area

Location	Bankfull Flow (cfs)	Bankfull Cross Section Area (ft^2)
Upstream of Lion Point (DA=4.92 mi2)	120	25
Downstream of Lion Point (DA=7.19 mi^2)	130	27

Field-based estimations of bankfull flow are near the upper limit of what would be predicted by the Central Colorado regional curve while field-based estimations of bankfull cross section area are near the lower limit of what would be predicted by the Central Colorado regional curve. These findings were initially believed to be a result of working in a post-flood stream system that lacks clear bankfull indicators. However, the results of the reference reach survey performed at the North Fork of North Elk Creek compared similarly to the Central Colorado regional curve. Therefore, it is assumed that these results are characteristic of mountain streams that exist on the Front Range and that the field-based estimations of bankfull flow and bankfull cross section area are valid for this project. Additionally, the bankfull flows provided in Table 7 correspond to a flood recurrence between the 1.25- and 1.5-year flood events, which is common for bankfull flow.

Natural Channel Design Approach

A toolbox methodology was employed for restoring Fourmile Canyon Creek which included:

1. Developing estimations of stable channel geometry obtained through reference reach surveys for application to the proposed design for Fourmile Canyon Creek design.
2. Developing hydraulic and sediment transport modeling to ensure long-term stability of the proposed design.

The approach towards restoring Fourmile Canyon Creek was to:

- Restore Fourmile Canyon Creek in the post-flood channel corridor, to the extent practical, in order to minimize earthwork and disturbance to vegetation that has become established since the 2013 Flood.
- Restore the natural channel dimension (cross section), pattern (planform), and profile (slope) to the extent practical to maximize stream stability at a lower cost, improve aquatic and terrestrial habitat, and optimize sediment transport and flood conveyance.
- Reconnect the channel to the adjacent floodplain to restore ecological connectivity and improve flood conveyance.
- Revegetate the channel and riparian zone with ecotypic plant species to restore habitat and ecological connectivity.
- Implement structure only where necessary to stabilize channel banks at risk of erosion, provide additional aquatic habitat, and protect adjacent roadway infrastructure.

The design of the proposed channel dimension, pattern, and profile were based on reference reach data previously described along with information obtained from the pre-flood assessment of Fourmile

Canyon Creek. Ideally, when restoring a stream system, there are no limitations on what modifications can be made to channel geometry. The intent is that if the channel geometry can be fully restored to a stable state structural stabilization may not be required. However, numerous constraints exist within the Fourmile Canyon Creek watershed that limit the ability to make changes to exiting channel geometry. These constraints include:

- Preserving existing, well-established trees
- Preserving existing, well-established vegetation
- Minimizing impact to existing and proposed roadway infrastructure
- Aligning the creek with existing and proposed roadway crossings
- Minimizing impact to private property and protecting homes
- A desire to restore the creek in the post-flood channel corridor to the extent practical

These constraints mostly impact the ability to add sinuosity to the stream and fully restore the need floodplain width. The result is a channel with higher than desirable channel slopes and narrower floodplain than needed. The resultant consequence is higher channel velocity, shear stress, and stream power. As a result, structure in the form of bank protection and in-stream features are added to mitigate against these variables. Structures were also added to improve stream complexity and aquatic habitat conditions. All structures consist of natural materials found within this watershed.

The following in-stream features were included in the restoration of Fourmile Canyon Creek:

- Log Vane – Used in areas of sharp channel bends and potentially extreme hydraulic conditions to reduce near bank stress, channel bank erosion, and assist with turning the channel thalweg. Log vanes also provide aquatic habitat through the formation of scour pools and in-stream cover. These structures can be made with on-site material where available.
- Cross Vane – Used in areas of sharp channel bends and potentially extreme hydraulic conditions to reduce near bank stress, channel bank erosion, and assist with turning the channel thalweg. Rock cross vanes were used instead of log vanes in confined areas which tend to have more extreme hydraulic conditions that could lead to logs becoming mobilized. These structure typically require imported boulders, but can be constructed with on-site material if available.
- Step-Pool – Used in segments of steep channel slopes to transition channel grade, provide grade control, and allow for aquatic organism passage. These structures can be made with on-site material where available, but sometimes require imported materials be used.
- Rock Wings – Incorporated into longer riffles to add thalweg complexity. These structures can be made with on-site material where available.
- Boulder Clusters – Incorporated into longer riffles to add thalweg complexity and aquatic habitat. Boulder clusters were typically only used in long riffles leading into a bend with a cross vane structure where thalweg movement is not desirable. These structures can be made with on-site material where available.
- Converging Boulder Clusters – Placed at the head of riffles where additional grade control would be beneficial. These features also provide in-stream complexity, and aquatic habitat. These structures can be made with on-site material where available.

The following bank protection features were included in the restoration of Fourmile Canyon Creek. Note that bank protection was not added in areas where channel bank erosion will likely not cause an adverse impact to infrastructure and/or private residences. Additionally, channel bank protection was not added adjacent to steep geologic features and areas dominated by boulders and cobble due to the low risk of failure and potential challenges with construction.

- Boulder Bank Protection – Used in confined corridors and tight channel bends close to infrastructure and private residences.
- Toe Wood – Used in most places where bank protection is needed because of its proven effectiveness and benefit to in-stream habitat. This is also the most cost effective bank stabilization method compared to other options suitable for this watershed.
- Root Wads – Used only in areas where sufficient room adjacent to the creek exists for construction and where channel bank materials are conducive to easy excavation.

The riffle-pool and step-pool sequence shown on the proposed plans is consistent with what was observed during reference reach surveys and assessment of pre-flood channel conditions. All riffle and pool locations are shown on the planset and are intended to be constructed with native, in-stream channel bed material only. In other words, the import of additional material is not required to construct these features. Pool locations are shown on both the inside and middle of channel bend to add complexity and based on in-stream structures being used adjacent to the pool.

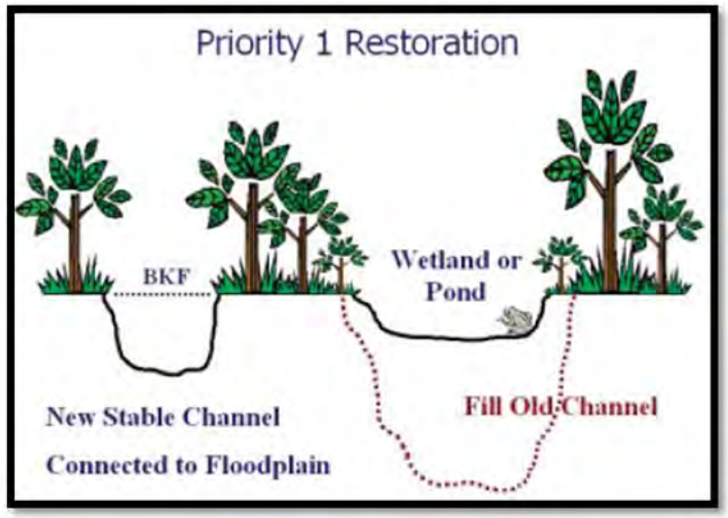
Geomorphic floodplain benches were incorporated at different flood stages to improve stream function, aquatic and terrestrial habitat conditions, flood conveyance, and assist with ecologic restoration. Floodplain benches were incorporated adjacent to the low-flow channel and adjacent to the bankfull channel to the extent possible based on existing site constraints.

When restoring incised channels, such as most of Fourmile Canyon Creek, there are four different approaches (Priority 1 through Priority 4) for doing so as outlined in Stream Restoration – A Natural Channel Design Handbook (NC State University) and summarized below. This methodology is also further described, and referenced, in River Restoration & Natural Channel Design (Wildland Hydrology, 2013). All restoration approaches discussed below do not require import of fill material, and both Priority 1 and Priority 3 approaches do not require exporting material. The Priority 2 restoration approach may generate excess material that needs to be exported, however, in most instances the material can be disposed of on-site to fill the relic channel and/or avulsions that exist within the valley bottom. The Priority 4 restoration approach is to stabilize channel banks-in place. This method was not used in Fourmile Canyon Creek.

Earthwork is typically the most expensive component of a channel restoration project. As a result, the proposed channel profile and cross section were designed so that earthwork was minimized. Every attempt was made to balance earthwork quantities resulting from profile and cross section modifications. However, most of the proposed design was based on post-flood LiDAR information obtained in November 2014. As a result, there are associated inaccuracies with the use of LiDAR which could result in a difference in earthwork quantities compared to what is reported for this project.

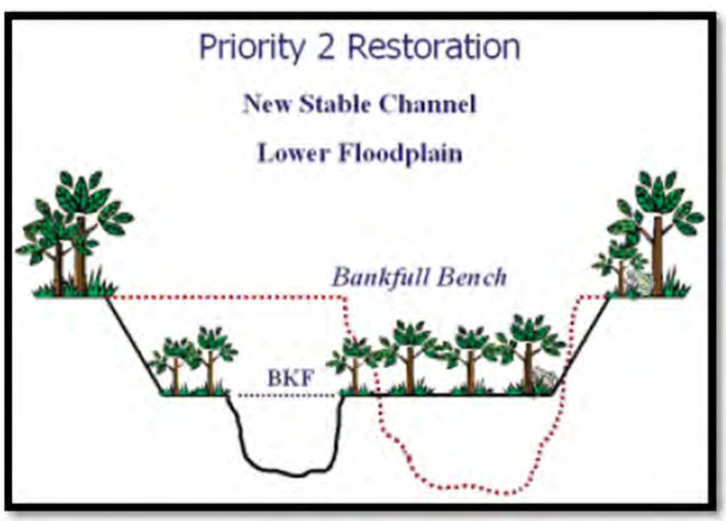
Priority 1 – Establish Bankfull Stage at the Historical Floodplain Elevation

The objective of a Priority 1 project is to replace the incised channel with a new, stable stream at a higher elevation. This is accomplished by excavating a new channel with the appropriate dimension, pattern and profile (based on reference reach data) to fit the watershed and valley type. The bankfull stage of the new channel is located at the ground surface of the original floodplain. The increase in streambed elevation also will raise the water table, in many cases restoring or enhancing wetland conditions in the floodplain. Surrounding land uses can limit the use of a Priority 1 approach if there are concerns about increased flooding or widening of the stream corridor. Most Priority 1 projects will result in higher flood stages above bankfull discharge in the immediate vicinity of the project and possibly downstream.



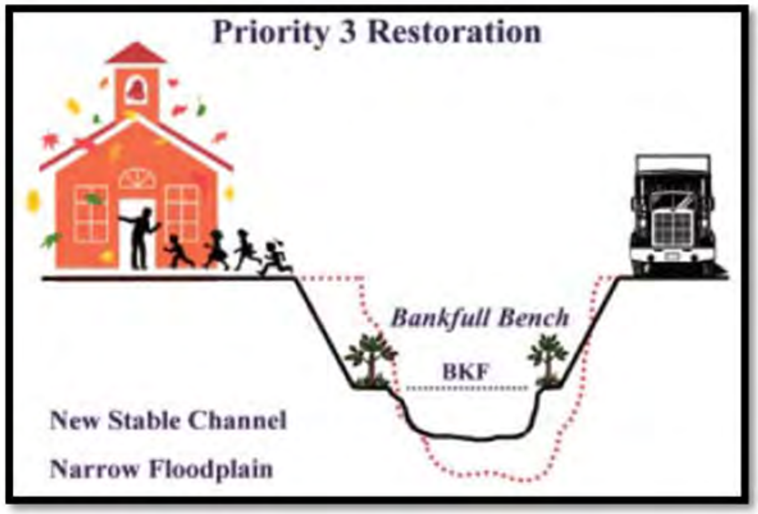
Priority 2 – Create a New Floodplain and Pattern with Stream Bed Remaining at the Existing Elevation

The objective of a Priority 2 project is to create a new, stable stream and floodplain at the existing channel-bed elevation. This is accomplished by excavating a new floodplain and stream channel at the elevation of the existing incised stream. The new channel is designed with the appropriate dimension, pattern and profile (based on reference reach data) to fit the watershed. The bankfull stage of the new channel is located at the elevation of the newly excavated floodplain. Because the new floodplain is excavated at a lower elevation, Priority 2 projects do not increase—and may decrease—the potential for flooding.



Priority 3 – Widen the Floodplain at the Existing Bankfull Elevation

Priority 3 is similar to Priority 2 in its objective to widen the floodplain at the existing channel elevation to reduce shear stress. This is accomplished by excavating a floodplain bench on one or both sides of the existing stream channel at the elevation of the existing bankfull stage. The existing channel may be modified to enhance its dimension and profile based on reference reach data. The bankfull stage of the new channel is located at the elevation of the newly widened floodplain. Priority 3 projects typically do not increase sinuosity to a large extent because of land constraints. These projects typically have little impact on flooding potential unless there are large changes in channel dimension.



Reach Description

This section of Fourmile Canyon Creek was subdivided into 10 reaches based on change in valley type, change stream type, and presence of road crossings. All reaches are defined on the plan set titled Fourmile Canyon Creek: 30% Stream Restoration Plans.

Reach 1

A Priority 2 restoration is recommended for this reach. Low-flow and bankfull geomorphic benches will be re-established along the existing channel alignment using material within the channel generated from expanding the channel section and excavating pools. The floodplain on the left bank of the channel can be widened to increase floodplain width. Flood impacts will likely be reduced by increasing channel cross section area, widening the floodplain, and reattaching the channel to the floodplain.

The major design constraint in this reach is the need to keep the channel in the existing alignment. The two properties adjacent to the reach may be bought-out in the future, but the status of this I s unknown. An alternative alignment was provided in the event that the property acquisition happens.

Reach 2

A Priority 1 restoration is recommended for this reach as much of the channel can be realigned to increase sinuosity. Low-flow and bankfull geomorphic benches will be re-established along the entire reach. Overall floodplain width is only constrained by the bottom width of the valley between the two eroded terrace banks. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

The only constraint to design in this reach is that the channel alignment is constrained by the bottom width of the valley between the two eroded terrace banks.

Reach 3

A Priority 1 restoration is recommended for this reach as much of the channel can be realigned to increase sinuosity. Low-flow and bankfull geomorphic benches will be re-established along the entire reach. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

The only constraint to design in this reach is that the channel alignment needs to cross Bow Mountain Road at a prescribed location identified in the Wagonwheel Gap Road reconstruction project.

Reach 4

The upstream and downstream portions of this reach will be realigned out of the existing channel alignment and will follow a Priority 1 restoration approach. Low-flow and bankfull geomorphic benches will be re-established along both reach segments. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

The constraint to design in these segments of Reach 4 are because of modifications that will be made to two roadway crossings identified in the Wagonwheel Gap Road reconstruction project that will require the channel to be realigned.

The remainder of Reach 4 between these two segments will follow a Priority 3 restoration approach in the existing channel alignment. Low-flow and bankfull geomorphic benches will be re-established along the entire reach. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

Design constraints in this portion of Reach 4 are the need to preserve existing vegetation. A substantial amount of vegetation has rejuvenated during the summer of 2015 and there are numerous trees adjacent to the existing channel alignment. Both the vegetation and trees provide great channel bank stability, and for this reason should be preserved. Furthermore, adding additional sinuosity is limited by the adjacent road.

Reach 5

The upstream and downstream portions of this reach will be realigned out of the existing channel alignment and will follow a Priority 1 restoration approach. Low-flow and bankfull geomorphic benches will be re-established along both reach segments. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

The constraint to design in these segments of Reach 5 are because of modifications that will be made to two roadway crossings identified in the Wagonwheel Gap Road reconstruction project that will require the channel to be realigned.

The remainder of Reach 5 between these two segments will follow a Priority 3 restoration approach in the existing channel alignment. Low-flow and bankfull geomorphic benches will be re-established along the entire reach. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

Design constraints in this portion of Reach 5 are the need to preserve existing vegetation. A substantial amount of vegetation has rejuvenated during the summer of 2015 and there are numerous trees adjacent to the existing channel alignment. Both the vegetation and trees provide great channel bank stability, and for this reason should be preserved. Furthermore, adding additional sinuosity is limited by the adjacent homes.

Reach 6

The upstream portion of this reach will be realigned out of the existing channel alignment and will follow a Priority 1 restoration approach. Low-flow and bankfull geomorphic benches will be re-established along the entire reach segment. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

The constraint to design in this segment of Reach 6 is because of modifications that will be made to the upstream roadway crossings identified in the Wagonwheel Gap Road reconstruction project that will require the channel to be realigned.

The remainder of Reach 6 between will follow a Priority 3 restoration approach in the existing channel alignment. Low-flow and bankfull geomorphic benches will be re-established along the entire reach. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

Design constraints in this portion of Reach 6 are the need to preserve existing vegetation. A substantial amount of vegetation has rejuvenated during the summer of 2015 and there are numerous trees adjacent to the existing channel alignment. Both the vegetation and trees provide great channel bank stability, and for this reason should be preserved. Furthermore, adding additional sinuosity is limited by the adjacent road, home, and private driveway crossing.

Reach 7

Reach 7 between will follow a Priority 3 restoration approach in the existing channel alignment. Low-flow and bankfull geomorphic benches will be re-established along the entire reach. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

There are two design constraints in this reach. One is the need to preserve existing vegetation. A substantial amount of vegetation has rejuvenated during the summer of 2015 and there are numerous trees adjacent to the existing channel alignment. Both the vegetation and trees provide great channel bank stability, and for this reason should be preserved. The other design constraint is the narrow canyon that the existing channel alignment is in, which limits the opportunity to add sinuosity.

Reach 8

Reach 8 between will follow a Priority 3 restoration approach in the existing channel alignment. Low-flow and bankfull geomorphic benches will be re-established along the entire reach. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

There are two design constraints in this reach. One is the need to preserve existing vegetation. A substantial amount of vegetation has rejuvenated during the summer of 2015 and there are numerous trees adjacent to the existing channel alignment. Both the vegetation and trees provide great channel bank stability, and for this reason should be preserved. The other design constraint is the narrow canyon that the existing channel alignment is in, which limits the opportunity to add sinuosity. The channel alignment is also constrained by the presence of private driveway crossings.

Reach 9

This reach will follow a Priority 1 restoration approach for the entire length. Low-flow and bankfull geomorphic benches will be re-established along both reach segments. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

The constraint to Reach 9 is that it needs to be completely realigned in a new location due to the Wagonwheel Gap Road reconstruction project.

Reach 10

The upstream and middle portions of this reach will be realigned out of the existing channel alignment and will follow a Priority 1 restoration approach. Low-flow and bankfull geomorphic benches will be re-established along both reach segments. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

The constraint to design in these segments of Reach 10 are because of modifications that will be made to two roadway crossings identified in the Wagonwheel Gap Road reconstruction project that will require the channel to be realigned.

The remainder of Reach 10 will follow a Priority 3 restoration approach in the existing channel alignment. Low-flow and bankfull geomorphic benches will be re-established along the entire reach. Flood impacts will likely be reduced by increasing channel cross section area and re-attaching the channel to the floodplain.

Design constraints in this portion of Reach 4 are the need to preserve existing vegetation. A substantial amount of vegetation has rejuvenated during the summer of 2015 and there are numerous trees adjacent to the existing channel alignment. Both the vegetation and trees provide great channel bank stability, and for this reason should be preserved. Furthermore, adding additional sinuosity is limited by the adjacent road and the presence of private driveway crossings.

Hydraulic Modeling

Hydraulic modeling was performed using HEC-RAS and normal depth calculations for the purposes of estimating:

- Flow velocities and shear stress
- Sizing boulders and engineered channel material
- Estimating scour depths
- Sizing culvert crossings

A summary of the above results is provided in Appendix A.

A detailed hydraulic model of the entire proposed design is being completed as a part of separate task order for the Conditional Letter of Map Revision (CLOMR) submittal.

Sediment Transport Modeling

While information obtained during the reference reach and project reach survey largely influences the final restoration design, sediment transport modeling is performed to validate the design and ensure that the proposed project will remain stable under the anticipated sediment loading and hydrologic regime.

Two different types of sediment transport analyses were performed: competence analysis and capacity analysis. Sediment competence is determined by comparing the size of a particle that the channel can move compared to the material found in the streambed. A channel is considered competent if it can move the D84 size particle. The capacity analysis evaluates the ability of the creek to move the total volume of sediment coming into the system and reveals whether the system will have the tendency to aggrade or degrade. Both analyses were performed with the RIVERMorph® software using protocols outlined in Watershed Assessment of River Stability and Sediment Supply (Wildland Hydrology 2009). Suspended load and bed load information was obtained from regional curves developed for Central Colorado (Wildland Hydrology 2007).

Results of the sediment competence and capacity analysis are provided in Appendix A. The proposed design is competent and has the capacity to move the anticipated volume of sediment entering the system. The proposed channel section was designed with a small amount of excess capacity to account for additional, and unforeseen, sediment loading entering the stream system. This excess capacity will allow for the channel section to naturally adjust over time while preserving the needed capacity to move the expected sediment load. Without a slight amount of excess capacity, any increase in sediment loading could cause the channel to aggrade.

A sediment continuity analysis was performed to ensure that the proposed channel section in each of the ten design reaches has similar competence and capacity values. This ensures that sediment moves through each reach similarly. Drastically different competence and capacity values between design reaches can lead to channel aggradation and/or degradation.

Ecologic Restoration

A custom wetland/riparian restoration design was developed for the restoration of Fourmile Canyon Creek. The design maximized the size of lower floodplain benches whenever possible. These benches were be designed to frequently flood during high flow events or be positioned low enough to consistently receive alluvial groundwater, which will provide the appropriate water regime to support a diverse and productive wetland and riparian system. The restored system will mimic the natural system that was lost or impaired during the flood event and is comprised of three vegetation "zones." These zones generally include channel edge (mainly herbaceous plants or emergent wetland), lower riparian (shrub-dominated, often wetlands, typically willow), and upper riparian (shrubs and trees--mainly willow and cottonwood but usually non-wetland). These habitats are essential for the health of any watershed and are mainly supported by high alluvial groundwater or regular overbank flooding. They provide key habitat for a myriad of wildlife species (including endangered species), serve as movement corridors to link areas of larger habitats, provide bank protection and overall channel stability, enhance water quality, reduce flooding in downstream areas, and promote groundwater recharge.

All of the wetland and riparian areas will be seeded and/or planted with plants native to the Fourmile Canyon Creek watershed, with a particular focus on plants sourced locally (local ecotypes). Introducing containerized plant material with living and robust root systems is the quickest way to stabilize each project and "jump start" the establishment of native plant communities. The use of local ecotypes ensures the presence of plant material that is adapted to the local environment while also avoiding the introduction of unknown genetics into the system.

Road Crossings

Road crossings were designed by the Wagonwheel Gap Road design team and were largely focused on hydraulic conveyance and adjacent site constraints. However, aquatic organism passage was considered as a part of this project at each of these crossings. Modifications to each of the road crossings was made to ensure that adequate flow depth is maintained in all locations and that no habitat barriers exist upstream, downstream, or within any of the crossings. Additional design is being performed at all crossing locations as a part of the final Wagonwheel Gap Road design.

Reach Prioritization

The purpose of doing this was to identify segments of stream that could be constructed individually without having to construct all 1.4 miles of Fourmile Canyon Creek. This benefits Boulder County in the event that they are only able to obtain partial funding for construction. A reach prioritization was completed to identify reaches that should be given first priority should construction funding become available. In addition to this ranking, priority should be given to constructing upstream reaches first over downstream reaches. This helps reduce the risk of damage to reaches that are restored near the downstream end of the project extents when construction is being completed upstream.

A summary of this prioritization is provided in Table 8 and summarized in more detail in Appendix A. Reaches were prioritized using the criteria outlined below:

- Reach Condition Rating – Overall reach condition assigned during the project reach assessment.
- Impact of Ongoing Erosion to Values-At-Risk – The degree to which ongoing, and unaddressed, erosion could impact adjacent homes and infrastructure if mitigation measures aren't put in place.
- Required for Road Construction – The requirement that a specific reach needs to be constructed as a part of Wagonwheel Gap Road construction.
- Accessibility/Ease of Construction – Represents ease of access to a specific reach along with how easy the recommended restoration can be constructed.
- Amount of Private Property Coordination

Table 8: Reach Prioritization

Priority	Reach	Priority	Reach
1	Reach 3	7	Reach 8
2	Reach 10	8	Reach 4
3	Reach 5	8	Reach 1
4	Reach 9	10	Reach 2
5	Reach 6		
6	Reach 7		

Opinion of Probable Construction Cost

Opinion of probable construction costs were based on an Association for the Advancement of Cost Engineering (AACE) International CLASS 3 Cost Estimate. Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. Typically engineering is from 10% to 40% complete, and would comprise a minimum of process flow diagrams, utility flow diagrams, preliminary piping and instrumentation diagrams, plot plan, developed layout drawings, and essentially complete engineered process and utility equipment lists. They are typically prepared to support full project funding requests, and become the first of the project phase "control estimates" against which all actual costs and resources will be monitored for variation to budget. Most Class 3 estimates involve more deterministic estimating methods than stochastic methods. Typical accuracy ranges for Class 3 estimates are from +/- 10% to 30% (sometimes higher), depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination.

The opinion of probable construction costs assume that some on-site material will be available for constructing channel features and in-stream structures. The availability of on-site material could impact the actual costs. Additionally, earthwork quantities were based on LiDAR information and actual quantities could differ significantly.

Next Steps

The proposed design for Fourmile Canyon Creek is at the 30% design level. The intent of this plan set was to identify all major design components and provide sufficient detail for a contractor to begin construction. If this plan is carried forward into construction the design engineer will need to be on-site daily to ensure the plans are being interpreted correctly, make field-fit modifications, and make design modifications. It is recommended that the following tasks be completed prior to beginning construction:

- An erosion control plan will need to be prepared.
- A monitoring plan will need to be prepared that includes both implementation monitoring and effectiveness monitoring.
  - Implementation monitoring is performed to determine if a project was constructed according to the design plans. Typically includes measurements/survey of:
    - Channel Geometry (dimension, pattern, profile)
    - Stream facet (width, depth, slope)
    - Structure location and layout
    - Vegetation density and type
  - Effectiveness monitoring is performed to determine the ecologic/biologic/geomorphic response of the restored system to compared to pre-project conditions. Typically includes measurements of:
    - Pertinent biologic indices
    - Pertinent water quality parameters
    - Channel bed load
    - Suspended load
    - Channel bank erosion rates
    - Change in Channel Geometry and Stream Facet over time

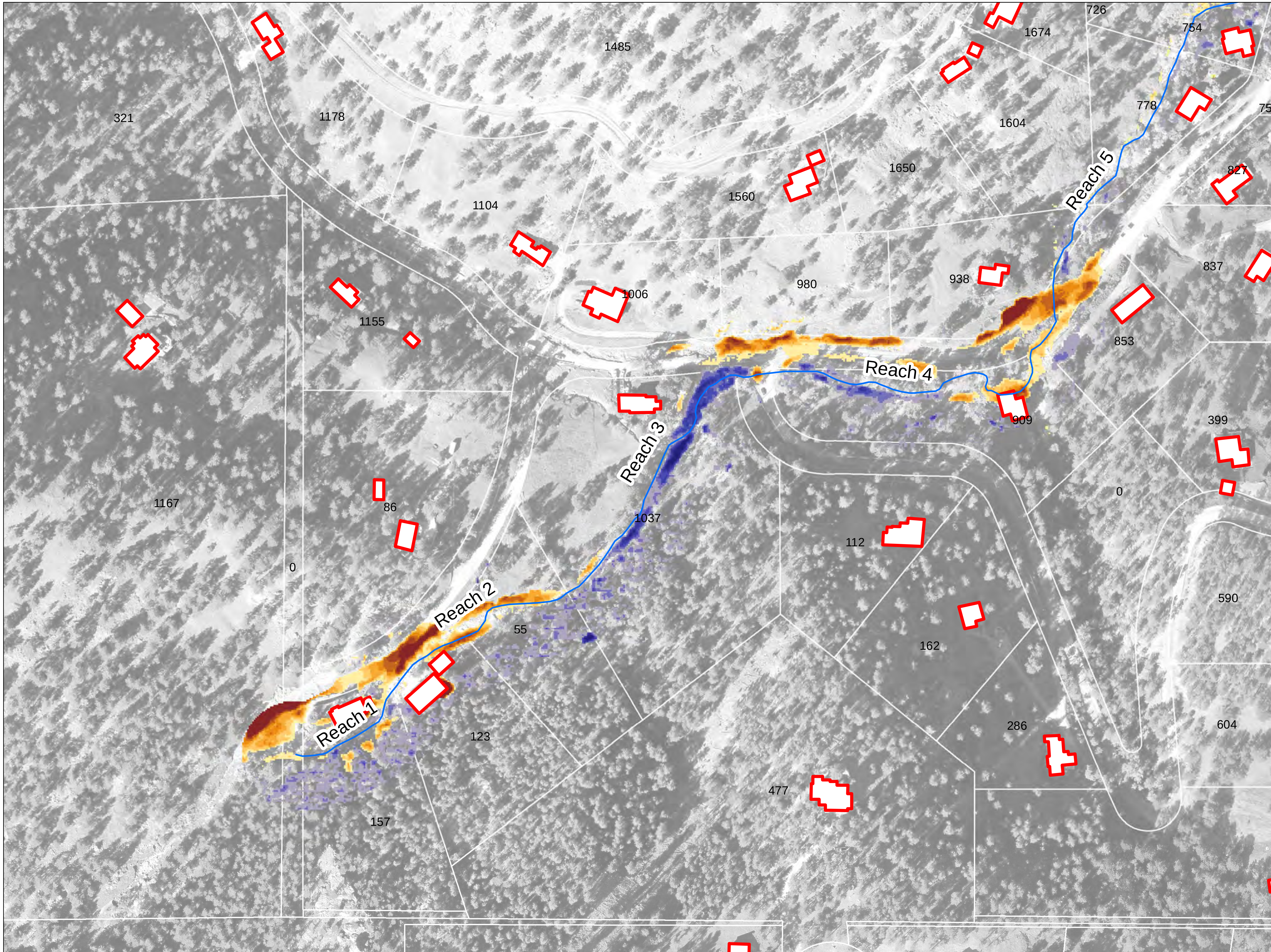
The following tasks will be completed as a part of the final design of the Wagonwheel Gap Road project:

- Final hydraulic modeling and the completion, and submittal, of the CLOMR.
- Additional design for aquatic organism passage in and around all road crossings.
- Additional stream restoration design in locations where Fourmile Canyon Creek needs to be modified due to roadway impacts. These locations are shown on the plans.

Appendix A

- Project Reach Assessment
    - Heat Map
    - Assessment Data
- Reference Reach Data
    - East Fork of Arkansas River
    - North Fork of North Elk Creek
    - Pre-Flood Assessment of Fourmile Canyon Creek
- USGS StreamStats Summary
- FEMA FIRM
- Regional Curves
- Statistical Analysis of USGS Gage Data
- Hydraulic Modeling Results
- Sediment Transport Modeling Results
- Reach Prioritization

Project Reach Assessment



Fourmile Canyon Creek Floodplain Erosion and Deposition Heatmap

Map **1 of 4**

LEGEND

Fourmile Canyon Creek

Structures

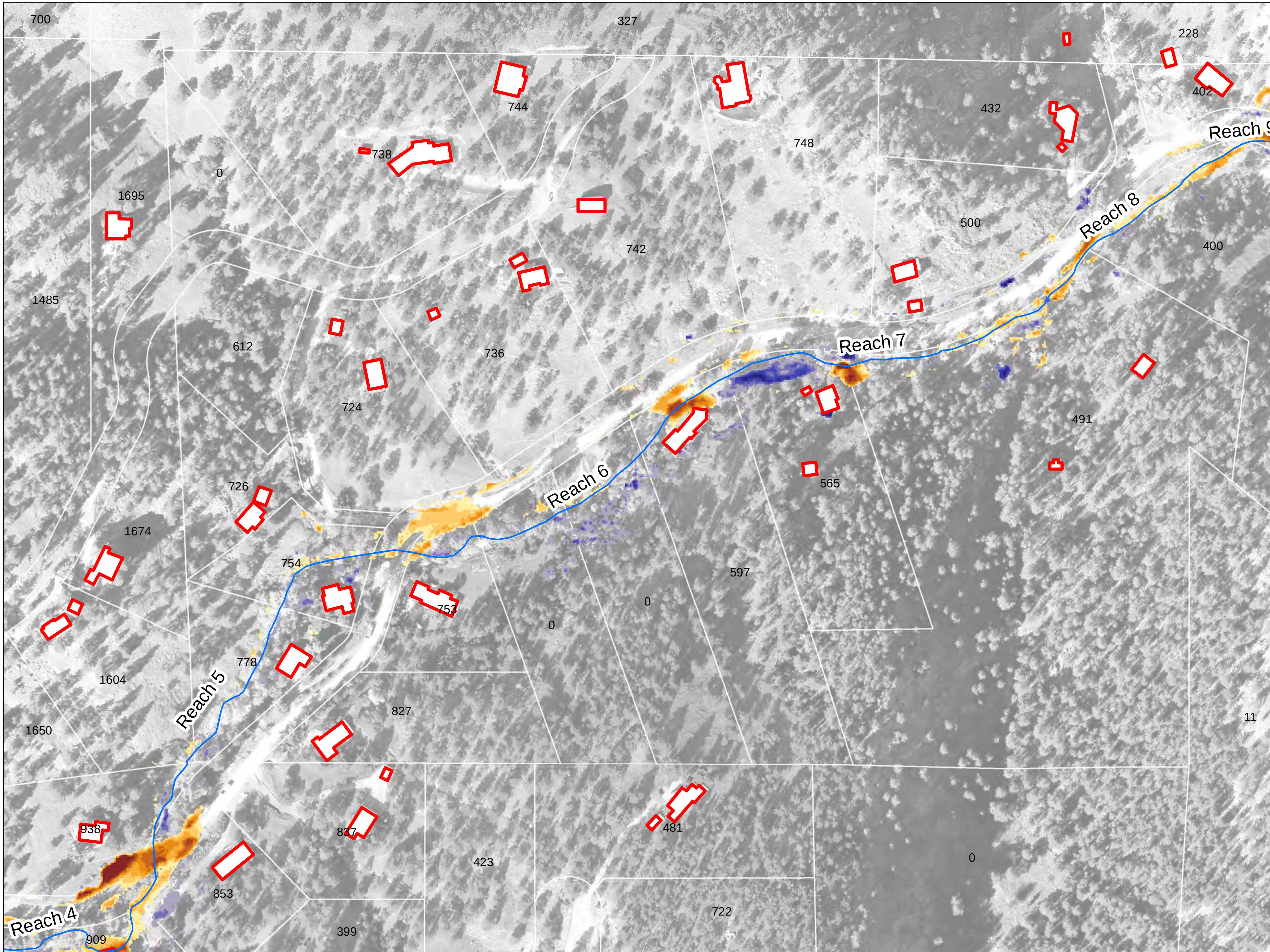
Erosion & Deposition Values

- < -8 ft.
- -7 to -8 ft.
- -6 to -7 ft.
- -5 to -6 ft.
- -4 to -5 ft.
- -3 to -4 ft.
- -2 to -3 ft.
- -2 to 2 ft. not displayed
- 2 to 3 ft.
- 3 to 4 ft.
- 4 to 5 ft.
- 5 to 6 ft.
- 6 to 7 ft.
- 7 to 8 ft.

Feet
0 200

Michael Baker INTERNATIONAL
165 S. UNION BLVD.
SUITE 200
LAKEWOOD, CO 80228
PHONE: 720-514-1100

LOCATOR MAP



Fourmile Canyon Creek Floodplain Erosion and Deposition Heatmap

Map **2 of 4**

LEGEND

- Fourmile Canyon Creek
- Structures

Erosion & Deposition Values

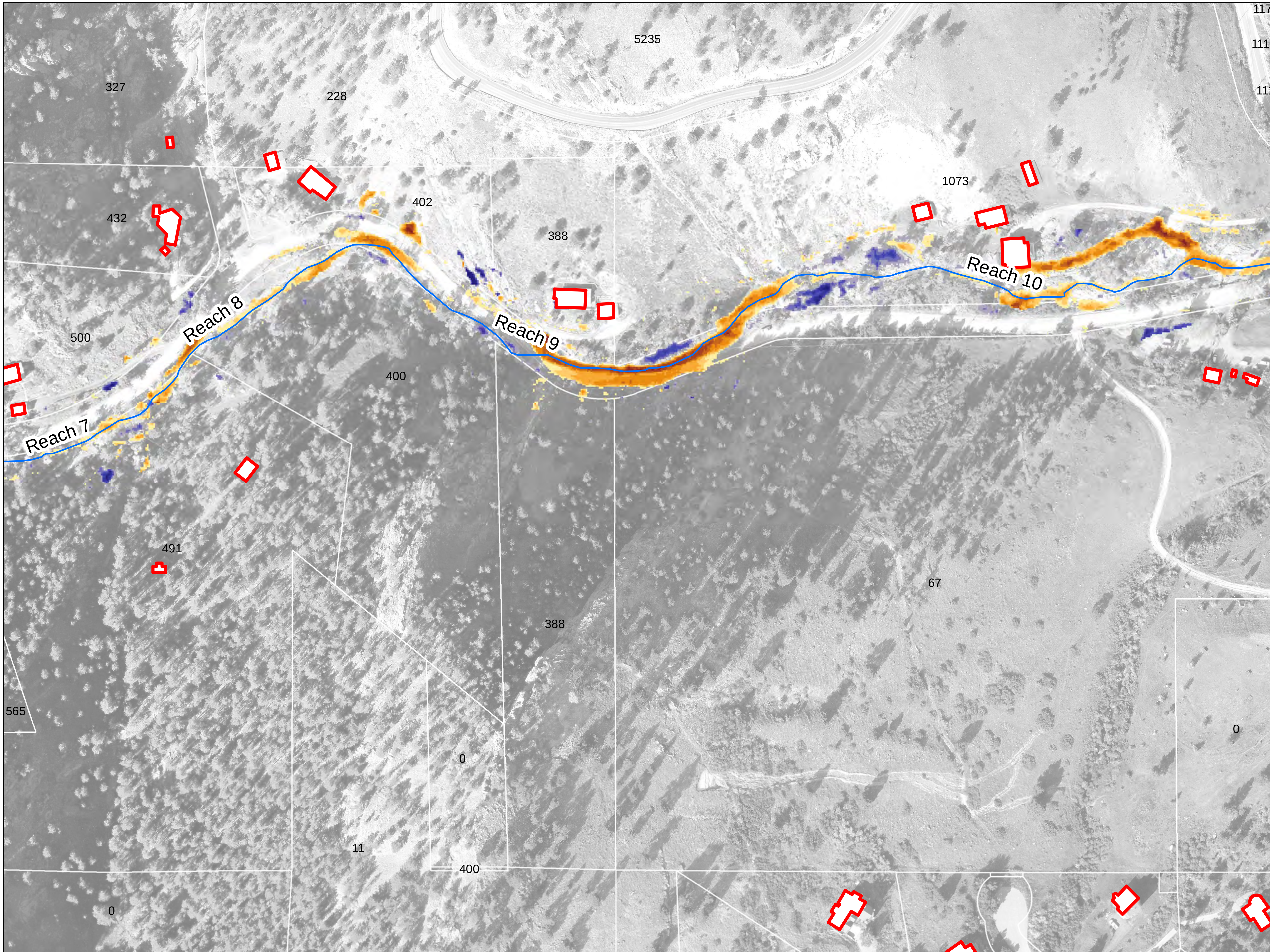
- < -8 ft.
- -7 to -8 ft.
- -6 to -7 ft.
- -5 to -6 ft.
- -4 to -5 ft.
- -3 to -4 ft.
- -2 to -3 ft.
- -2 to 2 ft. not displayed
- 2 to 3 ft.
- 3 to 4 ft.
- 4 to 5 ft.
- 5 to 6 ft.
- 6 to 7 ft.
- 7 to 8 ft.

Feet
0 200

N

Michael Baker INTERNATIONAL
165 S. UNION BLVD.
SUITE 200
LAKEWOOD, CO 80228
PHONE: 720-514-1100

LOCATOR MAP



Fourmile Canyon Creek Floodplain Erosion and Deposition Heatmap

Map **3 of 4**

LEGEND

Fourmile Canyon Creek
Structures

Erosion & Deposition Values

- < -8 ft.
- -7 to -8 ft.
- -6 to -7 ft.
- -5 to -6 ft.
- -4 to -5 ft.
- -3 to -4 ft.
- -2 to -3 ft.
- -2 to 2 ft. not displayed
- 2 to 3 ft.
- 3 to 4 ft.
- 4 to 5 ft.
- 5 to 6 ft.
- 6 to 7 ft.
- 7 to 8 ft.

Feet
0 200

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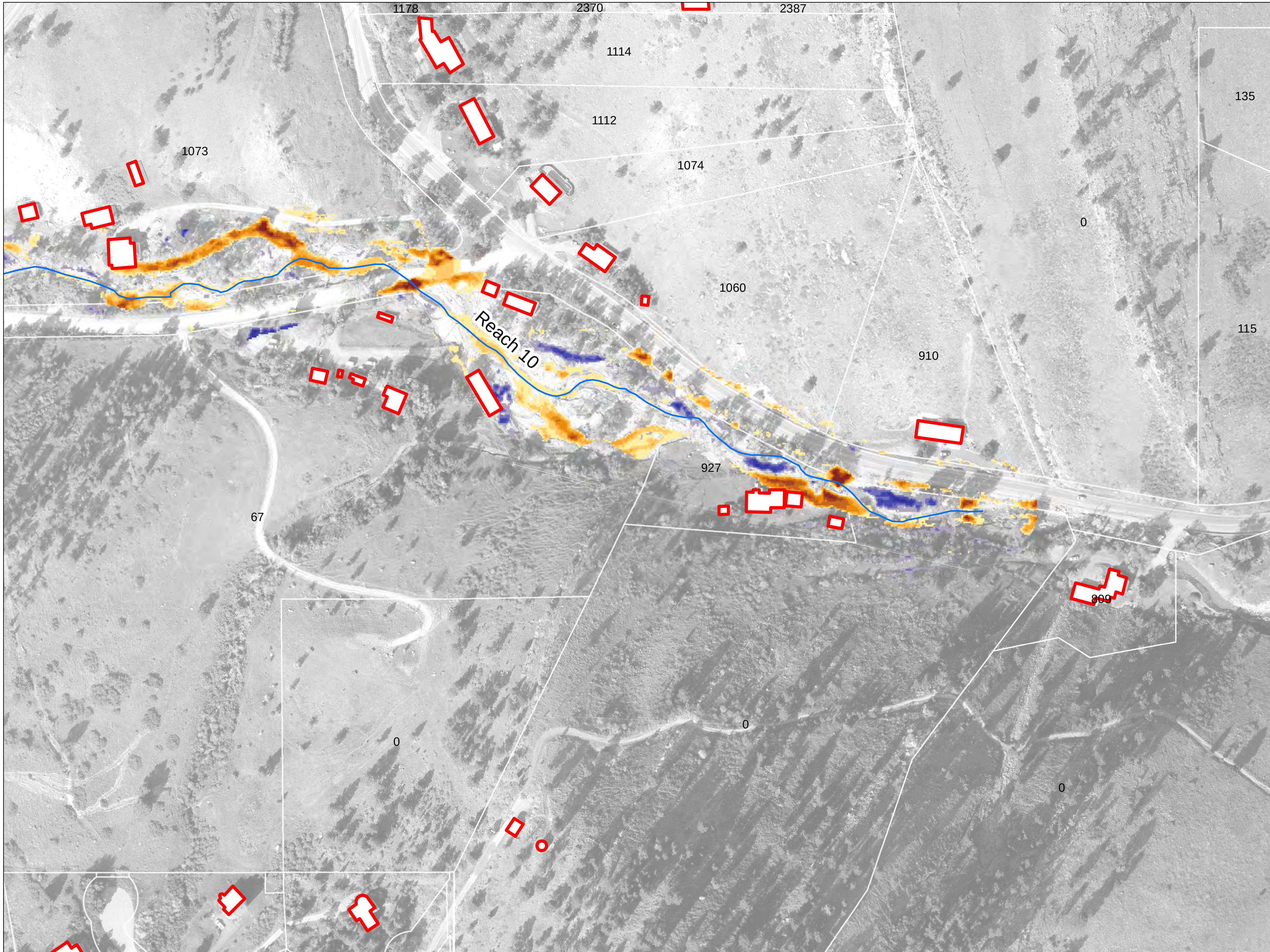
LOCATOR MAP



Fourmile Canyon Creek Floodplain Erosion and Deposition Heatmap

Map **4 of 4**

LEGEND

Fourmile Canyon Creek
Structures

Erosion & Deposition Values

- < -8 ft.
- -7 to -8 ft.
- -6 to -7 ft.
- -5 to -6 ft.
- -4 to -5 ft.
- -3 to -4 ft.
- -2 to -3 ft.
- -2 to 2 ft. not displayed
- 2 to 3 ft.
- 3 to 4 ft.
- 4 to 5 ft.
- 5 to 6 ft.
- 6 to 7 ft.
- 7 to 8 ft.

Feet
0 200

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LOCATOR MAP

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 1
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	6
Mass Wasting:	9
Debris Jam Potential:	4
Vegetative Protection:	12

Lower Bank

Channel Capacity:	4
Bank Rock Content:	6
Obstructions to Flow:	4
Cutting:	6
Deposition:	8

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	8
Scouring and Deposition:	12
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	Moderate
Stream Bed Stability:	Stable
W/D Condition:	Normal
Stream Type:	C4B

Rating - 93
Condition - Fair

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream: **Fourmile Canyon Creek, Reach - Reach 1**	
Basin:	Drainage Area: **2860.8** acres **4.47** mi^2
Location:	
Twp.&Rge: **;**	Sec.&Qtr.: **;**
Cross-Section Monuments (Lat./Long.): **40.05944 Lat / 105.31997 Long**	Date: **05/11/15**
Observers: **Lucas Babbitt**	Valley Type: VIII(a)

Parameter	Value	Unit
Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**17.36**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.95**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**16.56**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**18.27**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.79**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**102.28**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**5.89**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**35.91**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.03649**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.1**	

Stream Type → **C 4b** ← (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream:	**Fourmile Canyon Creek**				Location: **Reach - Reach 1**					
Observers:	**Lucas Babbitt**		Date: **05/11/15**		Valley Type: **VIII**			Stream Type: **C 4b**		

River Reach Dimension Summary Data.....1

Riffle Dimensions*, **, *** (Riffle Dimensions*, **, ***)

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	17.4	17.4	17.4	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	16.56	16.56	16.56
Mean Riffle Depth (d_{bkf})	0.95	0.95	0.95	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	18.27	18.27	18.27
Maximum Riffle Depth (d_{max})	1.79	1.79	1.79	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.884	1.884	1.884
Width of Flood-Prone Area (W_{fpa})	102	102	102	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	5.892	5.892	5.892
Riffle Inner Berm Width (W_{ib})	8.66	8.66	8.66	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.499	0.499	0.499
Riffle Inner Berm Depth (d_{ib})	0.64	0.64	0.64	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.669	0.669	0.669
Riffle Inner Berm Area (A_{ib})	5.5	5.5	5.5	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.332	0.332	0.332
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	13.6	13.6	13.6					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	12.3	12.3	12.3	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	0.706	0.706	0.706
Mean Pool Depth (d_{bkfp})	1.27	1.27	1.27	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	1.337	1.337	1.337
Pool Cross-Sectional Area (A_{bkfp})	15.6	15.6	15.6	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	0.939	0.939	0.939
Maximum Pool Depth (d_{maxp})	1.8	1.8	1.8	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	1.895	1.895	1.895
Pool Inner Berm Width (W_{ibp})	8.12	8.12	8.12	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.663	0.663	0.663
Pool Inner Berm Depth (d_{ibp})	0.4	0.4	0.4	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.314	0.314	0.314
Pool Inner Berm Area (A_{ibp})	3.23	3.23	3.23	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.208	0.208	0.208
Point Bar Slope (S_{pb})	0.282	0.282	0.282	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	####	####	####

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	15.2	15.2	15.2	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	0.877	0.877	0.877
Mean Run Depth (d_{bkfr})	0.83	0.83	0.83	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	0.874	0.874	0.874
Run Cross-Sectional Area (A_{bkfr})	12.7	12.7	12.7	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	0.764	0.764	0.764
Maximum Run Depth (d_{maxr})	2.21	2.21	2.21	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	2.326	2.326	2.326
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	18.4	18.4	18.4	ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	19.8	19.8	19.8	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	1.139	1.139	1.139
Mean Glide Depth (d_{bkfg})	1.23	1.23	1.23	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	1.295	1.295	1.295
Glide Cross-Sectional Area (A_{bkfg})	24.4	24.4	24.4	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	1.474	1.474	1.474
Maximum Glide Depth (d_{maxg})	1.78	1.78	1.78	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.874	1.874	1.874
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	16.1	16.1	16.1	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	0.000	0.000	0.000
Glide Inner Berm Width (W_{ibg})	0	0	0	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Depth (d_{ibg})	0	0	0	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Area (A_{ibg})	0	0	0	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.000	0.000	0.000

Step**

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	0	0	0	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	0.000	0.000	0.000
Mean Step Depth (d_{bkfs})	0	0	0	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	0.000	0.000	0.000
Step Cross-Sectional Area (A_{bkfs})	0	0	0	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	0.000	0.000	0.000
Maximum Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0.000	0.000	0.000
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	0	0	0					

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek** Location: **Reach - Reach 1**

Observers: **Lucas Babbitt** Date: **05/11/15** Valley Type: **VIII** Stream Type: **C 4b**

River Reach Summary Data.....2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	5.8	ft/sec	Estimation Method	U/U*	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	96.09	cfs	Drainage Area	4.47	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	128	128	128	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	7.373	7.373	7.373
Stream Meander Length (L_m)	184	184	184	ft	Stream Meander Length Ratio (L_m / W_{bkf})	#####	#####	####
Radius of Curvature (R_c)	34	33	36	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	1.959	1.901	2.074
Belt Width (W_{blt})	23	23	23	ft	Meander Width Ratio (W_{blt} / W_{bkf})	1.325	1.325	1.325
Arc Length (L_a)	0	0	0	ft	Arc Length to Riffle Width (L_a / W_{bkf})	0.000	0.000	0.000
Riffle Length (L_r)	6.82	6.24	7.39	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	0.393	0.359	0.426
Individual Pool Length (L_p)	13.3	6.67	22.8	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	0.768	0.384	1.316
Pool to Pool Spacing (P_s)	74.1	38.3	110	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	4.270	2.207	6.333

Channel Profile

Valley Slope (S_{val})	0.0403	ft/ft	Average Water Surface Slope (S)	0.03649	ft/ft	Sinuosity (S_{val} / S)	1.1
Stream Length (SL)	233	ft	Valley Length (VL)	214	ft	Sinuosity (SL / VL)	1.09
Low Bank Height (LBH)	start 6.1 ft; end 4.94 ft		Max Depth (d_{max})	start 1.67 ft; end 1.69 ft		Bank-Height Ratio (BHR) (LBH / d_{max})	start 3.65; end 2.92

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.052	0.041	0.063	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	1.424	1.129	1.719
Run Slope (S_{run})	0.098	0.088	0.108	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	2.692	2.418	2.966
Pool Slope (S_p)	0.009	0.008	0.013	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	0.260	0.213	0.353
Glide Slope (S_g)	0.038	0.026	0.051	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	1.030	0.706	1.397
Step Slope (S_s)	0.000	0.000	0.000	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	0.000	0.000	0.000

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	1.73	1.72	1.73	ft	Max Riffle Depth to Mean Riffle Depth (d_{maxrif} / d_{bkf})	1.821	1.811	1.82
Max Run Depth (d_{maxrun})	1.95	1.87	2.03	ft	Max Run Depth to Mean Riffle Depth (d_{maxrun} / d_{bkf})	2.053	1.968	2.14
Max Pool Depth (d_{maxp})	2.74	2.26	3.38	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	2.884	2.379	3.56
Max Glide Depth (d_{maxg})	1.55	1.07	1.88	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.632	1.126	1.98
Max Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0	0	0

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	0.99	0		D_{16}	1.35	11.3			mm
% Sand	20.79	7		D_{35}	5.23	27.89			mm
% Gravel	47.53	63		D_{50}	35.91	39.43			mm
% Cobble	27.72	27		D_{84}	103.26	86.75			mm
% Boulder	1.98	3		D_{95}	169.07	205.33			mm
% Bedrock	0.99	0		D_{100}	Bedrock	362			mm

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.

[b] Composite sample of riffles and pools within the designated reach. [c] Active bed of a riffle. [d] Height of roughness feature above bed.

Worksheet 3-1. Riparian vegetation composition/density used for channel stability assessment.

Riparian Vegetation

Stream: **Fourmile Canyon Creek**			Location: **Reach 1**	
Observers: **Lucas Babbitt**	Reference reach: [ ]	Disturbed (impacted reach): **X**	Date: **05/13/15**	
Existing species composition: **See description**			Potential species composition: **Same as existing native species**	

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**5%**	**1%**	**Ponderosa pine (Pinus**	**100%**
					0%
					0%
					0%
					0%
					0%
					100%
2. Understory	Shrub layer		**1%**	**Willow (Salix sp.)**	**100%**
					0%
					0%
					0%
					0%
					0%
					100%
3. Ground level	Herbaceous		**30%**	**Reed canary grass (Phalaris**	**25%**
				Downy brome (Bromus	**15%**
				Bluegrass (Poa sp.)	**15%**
				White clover (Trifolium	**15%**
				Dandelion (Taraxacum	**15%**
				Common mullein	**15%**
					100%
	Leaf or needle litter		**10%**		
	Bare ground		**58%**		
			Column Total = 100%		

*Based on crown closure.
**Based on basal area to surface area.

Remarks:
Condition, vigor and/or usage of existing reach:
Density and potentially some species impacted by 2013 flood

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek**	Location: **Reach 1**							
Observers: **Lucas Babbitt**	Date: **5/11/2015**							
List ALL COMBINATIONS that APPLY..............☞	**P**	**1**	**2**	**8**				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order

Stream:	**Fourmile Canyon Creek**
Location:	**Reach 1**
Observers:	**Lucas Babbitt**
Date:	**5/11/2015**
Stream Size Category and Order ☞	**S-4(2)**

Category	STREAM SIZE: Bankfull width		Check (✓) appropriate category
	meters	feet	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐

Stream Order

Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).

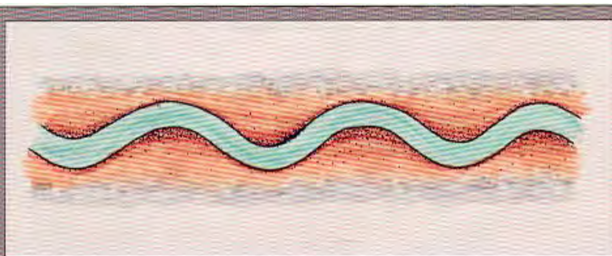
Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

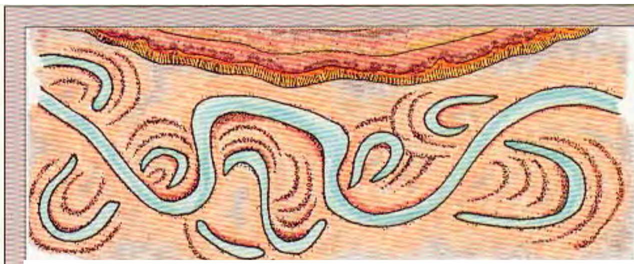
Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 1**
Observers:	**Lucas Babbitt**	Date:	**5/11/2015**

List ALL CATEGORIES that APPLY ☞	**M1**	**M4**			

Various Meander Pattern variables modified from Galay et al. (1973)

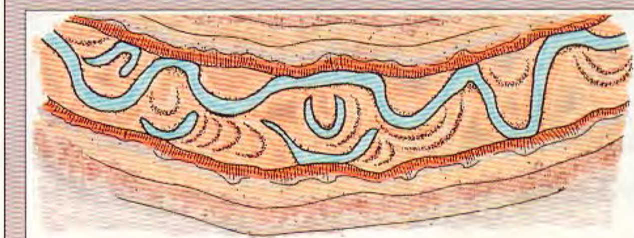


M1 REGULAR MEANDERS



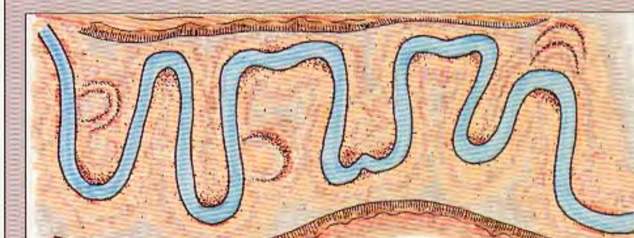
M5 UNCONFINED MEANDER SCROLLS

M2 TORTUOUS MEANDERS

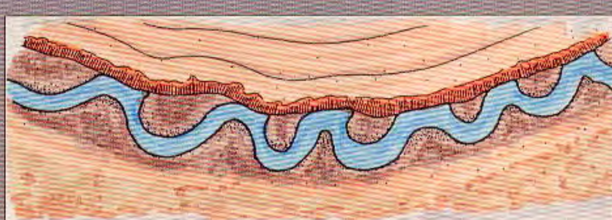


M6 CONFINED MEANDER SCROLLS

M3 IRREGULAR MEANDERS



M7 DISTORTED MEANDER LOOPS



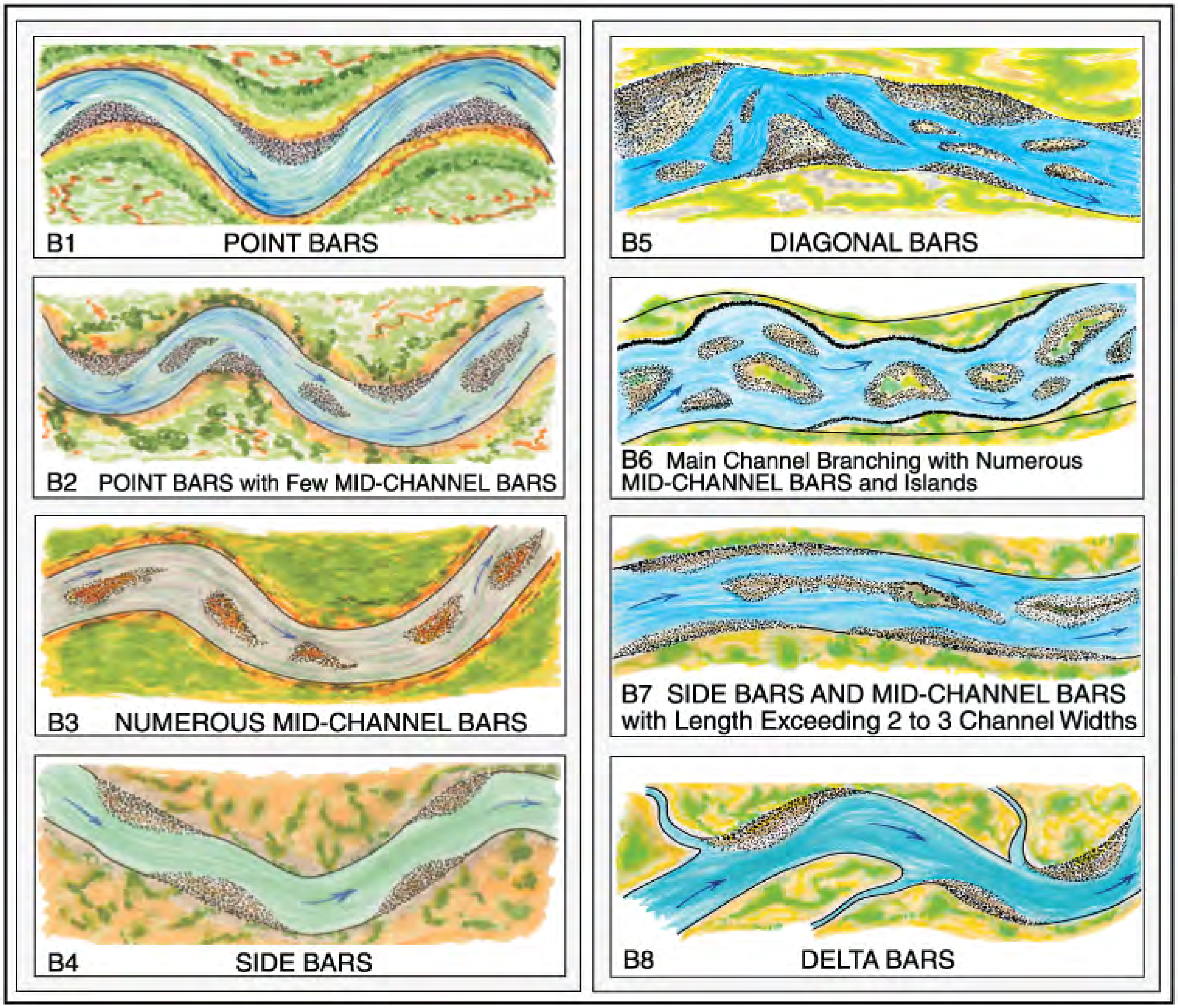
M4 TRUNCATED MEANDERS

M8 IRREGULAR MEANDERS with oxbows and

Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns					
Stream: **Fourmile Canyon Creek**		Reach: **Reach 1**			
Observers: **Lucas Babbitt**		Date: **5/11/2015**			
List ALL CATEGORIES that APPLY ☞	**B1**	**B5**			

Various Depositional Features modified from Galay et al. (1973)



Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream: **Fourmile Canyon Creek**		Location: **Reach 1**	
Observers: **Lucas Babbitt**		Date: **5/11/2015**	
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☑
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☐
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

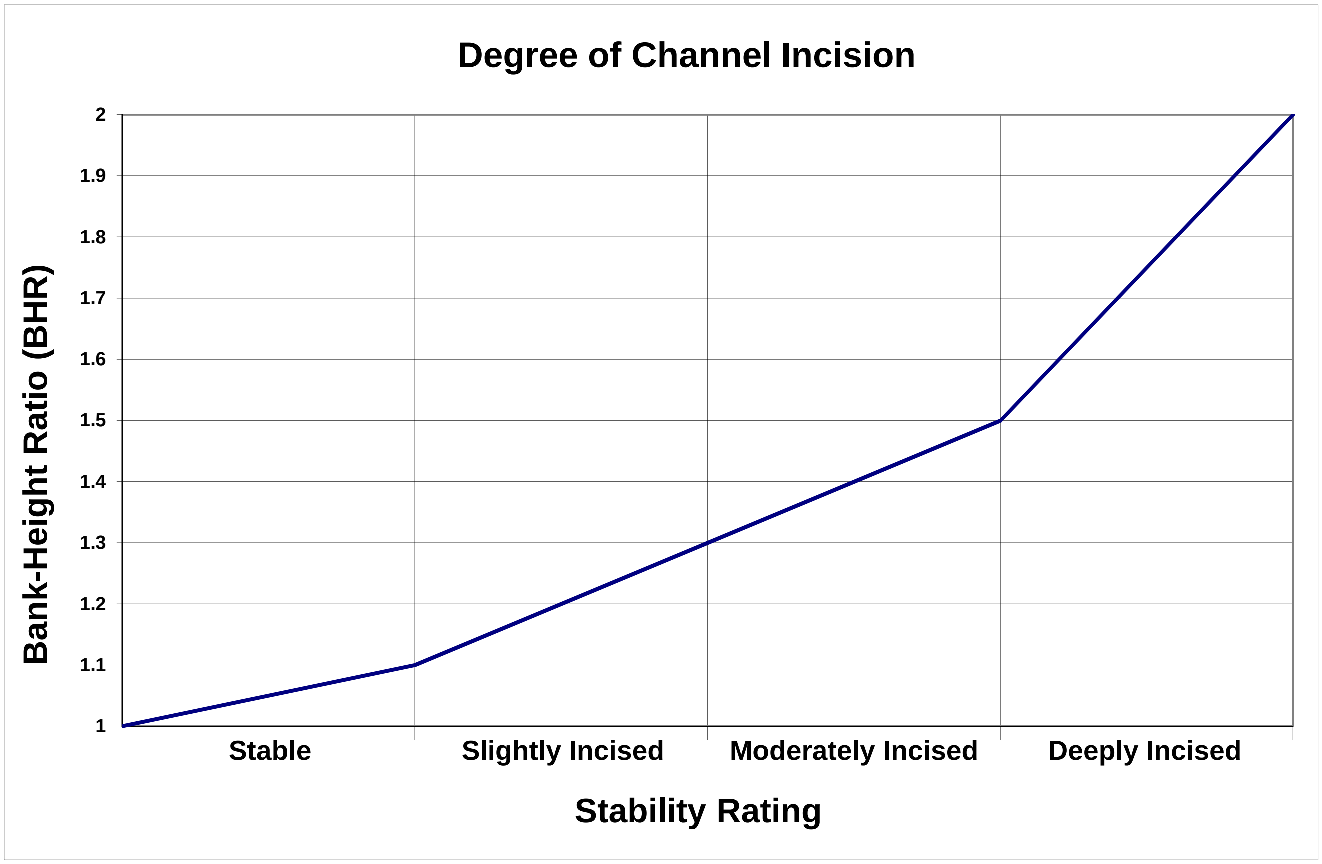
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision

Low Bank Height:	**6.41**
Max Bankfull Depth:	**1.72**

Bank-Height Ratio:	**3.7**

Degree of Channel Incision Stability Rating ☞	**Deeply Incised**

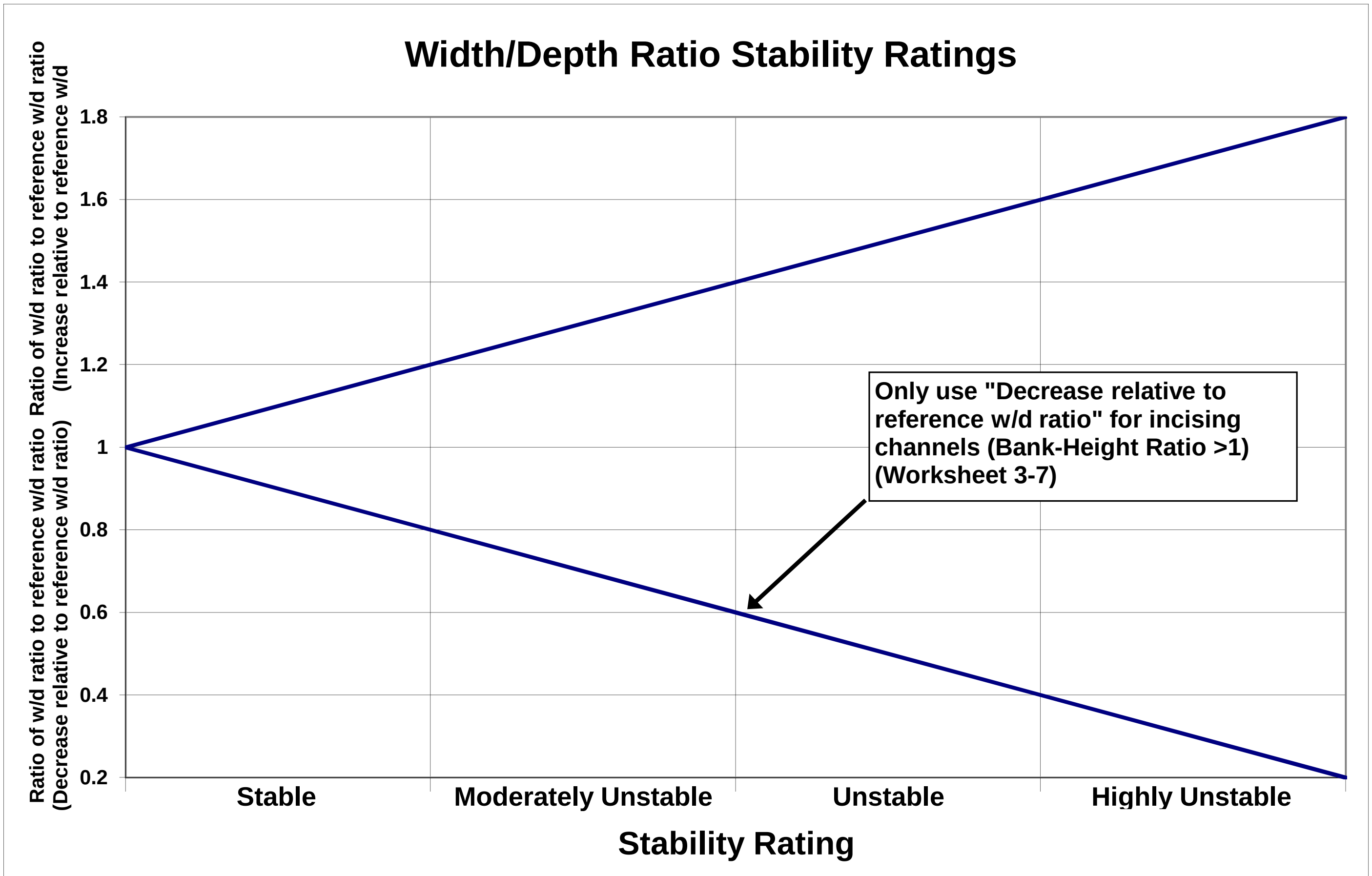


Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State

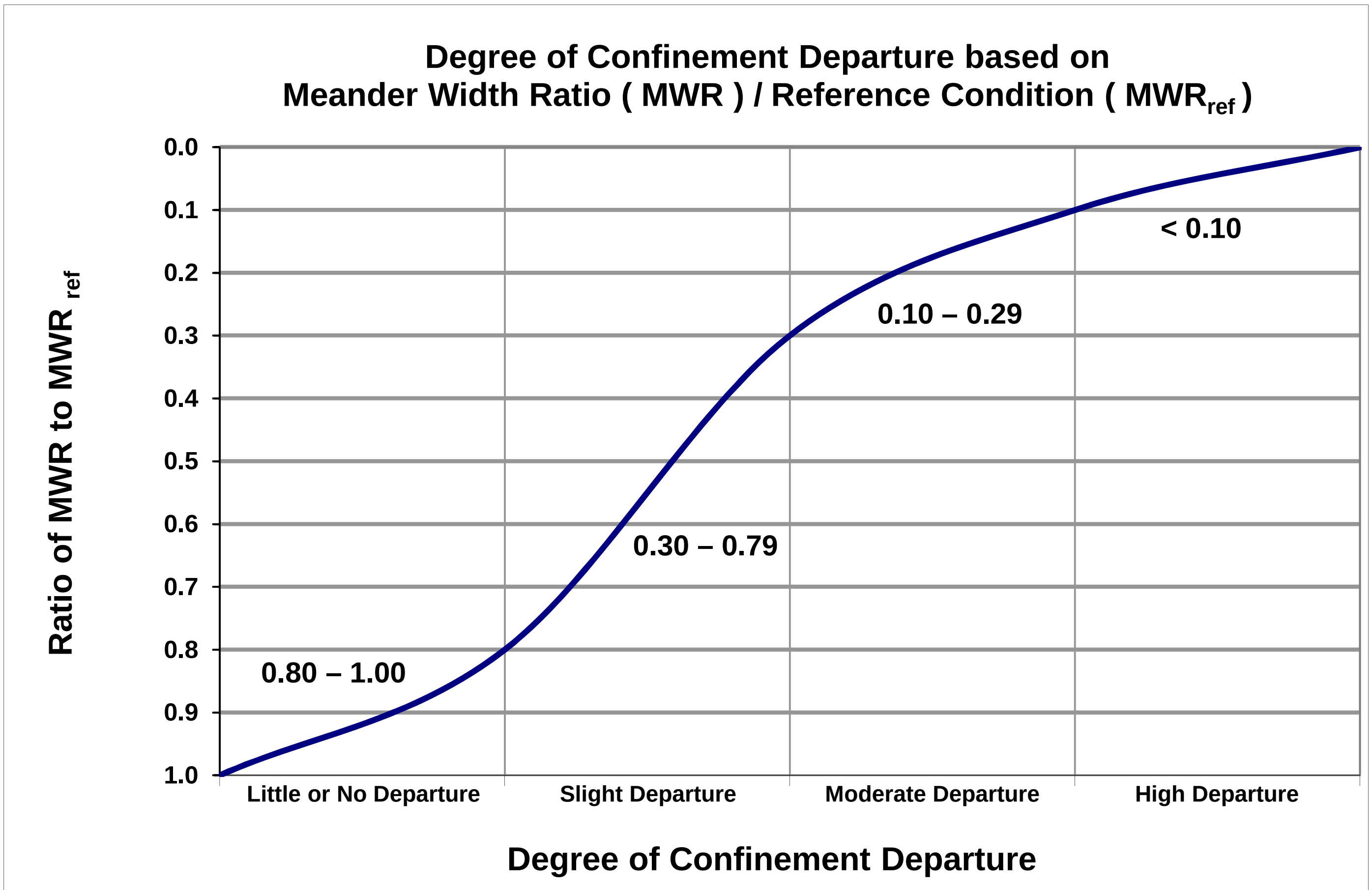
Existing Width/Depth Ratio:	**18.27**	Ratio of existing W/d to reference W/d:	**0.79**
Reference Width/Depth Ratio:	**23**		

Width/Depth Ratio State Stability Rating ☞ **Stable**



Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement	
Existing Meander Width Ratio (MWR):	**1.73**
Reference Meander Width Ratio (MWR_{ref}):	**5**
Ratio of MWR to MWR_{ref}:	**0.35**
Degree of Confinement Stability Rating ☞	**Moderately Confined**



Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C 4b**
Location:	**Reach 1**	Valley Type:	**VIII**
Observers:	**Lucas Babbitt**	Date:	**05/11/2015**

Enter Required Information for Existing Condition

39.4	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.854	D_{max}	Largest particle from bar sample (ft)	**260.35**	**(mm)**	304.8 mm/ft
0.03649	S	Existing bankfull water surface slope (ft/ft)			
0.95	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
6.60	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \frac{\tau^* (\gamma_s - 1) D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^* (\gamma_s - 1) D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Sediment Competence Using Dimensional Shear Stress

Shields	CO	
2.163		Bankfull shear stress $\tau = \gamma d S$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
174.2	**268.1**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
3.181	**2.078**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
1.40	**0.91**	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope; $d = \frac{\tau}{\gamma S}$
0.0537	**0.0351**	Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, d = existing depth; $S = \frac{\tau}{\gamma d}$

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Fourmile Canyon Creek**	Stream Type: **C 4b**
Location: **Reach 1**	Valley Type: **VIII**
Observers: **Lucas Babbitt**	Date: **05/11/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☑ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☐ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☐ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Fourmile Canyon Creek**			Stream Type:	**C 4b**	
Location:	**Reach 1**			Valley Type:	**VIII**	
Observers:	**Lucas Babbitt**			Date:	**05/11/2015**	
Lateral stability criteria (choose one stability category for each criterion 1–5)		**Lateral Stability Categories**				**Selected Points (from each row)**
		Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1	**W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**2**
2	**Depositional Patterns (Worksheet 3-5)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**4**
3	**Meander Patterns (Worksheet 3-4)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**1**
4	**Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)**	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5	**Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**2**
					Total Points	**9**
		Lateral Stability Category Point Range				
Overall Lateral Stability Category (use total points and check stability rating)		***Stable*** **< 10** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐	

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C 4b**
Location:	**Reach 1**	Valley Type:	**VIII**
Observers:	**Lucas Babbitt**	Date:	**05/11/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points** (from each row)
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 **Sediment competence (Worksheet 3-14)**	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope-slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	**2**
2 **Sediment Capacity (POWERSED)**	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	**2**
3 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**2**
4 **Stream Succession States (Worksheet 3-16)**	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	**2**
5 **Depositional Patterns (Worksheet 3-5)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 3-6)**	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**4**
				Total Points	**13**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **< 15** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C 4b**
Location:	**Reach 1**	Valley Type:	**VIII**
Observers:	**Lucas Babbitt**	Date:	**05/11/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points (from each row)**
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 **Sediment Competence (Worksheet 3-14)**	Does not indicate excess competence **(2)**	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed **(4)**	D_{100} of bed moved **(6)**	Particles much larger than D_{100} of bed moved **(8)**	**2**
2 **Sediment Capacity (POWERSED)**	Does not indicate excess capacity **(2)**	Slight excess energy: up to 10% increase above reference **(4)**	Excess energy sufficient to increase load up to 50% of annual load **(6)**	Excess energy transporting more than 50% of annual load **(8)**	**2**
3 **Degree of Channel Incision (BHR) (Worksheet 3-7)**	1.00 – 1.10 **(2)**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**8**
4 **Stream Succession States (Worksheets 3-16 and 3-7)**	Does not indicate incision or degradation **(2)**	If BHR > 1.1 and stream type has W/d between 5–10 **(4)**	If BHR > 1.1 and stream type has W/d less than 5 **(6)**	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) **(8)**	**2**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**2**
				Total Points	**16**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **< 12** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Fourmile Canyon Creek**				Stream Type: **C 4b**	
Location: **Reach 1**				Valley Type: **VIII**	
Observers: **Lucas Babbitt**				Date: **05/11/2015**	
Channel Enlargement Prediction Criteria (choose one stability category for each criterion 1–4)	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 **Successional Stage Shift (Worksheet 3-16)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 3-17)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**2**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**4**
				Total Points	**10**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☑	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: **Fourmile Canyon Creek**		Stream Type:	**C 4b**
Location: **Reach 1**		Valley Type:	**VIII**
Observers:		Date:	**05/11/2015**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 3-17)	*Stable*	1	1
	Mod. Unstable	2	
	Unstable	3	
	Highly Unstable	4	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	*No Deposition*	1	1
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	*Not Incised*	1	2
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 Channel Enlargement Prediction (Worksheet 3-20)	*No Increase*	1	1
	Slight Increase	2	
	Mod. Increase	3	
	Extensive	4	
5 Pfankuch Channel Stability (Worksheet 3-10)	*Good: Stable*	1	2
	Fair: Mod. Unstable	2	
	Poor: Unstable	4	
		Total Points	7

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** < 6 ☐	***Moderate*** 6 – 10 ☑	***High*** 11 – 15 ☐	***Very High*** > 15 ☐

Worksheet 3-22. Summary of stability condition categories.

	A	B–AM
1	Stream:	**Fourmile Canyon Creek** — Location: **Reach 1**
2	Observers:	**Lucas Babbitt** — Date: **5/11/2015** — Stream Type: **C 4B** — Valley Type: **VIII**
3–4	**Channel Dimension**	Mean Bankfull Depth (ft): **0.95** — Bankfull Width (ft): **17.36** — Cross-Sectional Area (ft^2): **16.56** — Width/Depth Ratio: **18.27** — Entrenchment Ratio: **5.89**
5–6	**Channel Pattern**	Mean: / Range: — λ/W_{bkf}: **7.37** / **7.37 - 7.37** — L_m/W_{bkf}: **10.6** / **10.60 - 10.60** — R_c/W_{bkf}: **1.96** / **1.90 - 2.07** — MWR: **1.32** / **1.32 - 1.32** — Sinuosity: **1.1**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec): **5.8** — Bankfull Discharge (Q_{bkf}): **96.09** — Estimation Method: **U/U*** — Drainage Area (mi^2): **4.47**
9	**River Profile & Bed Features**	Check: ☑ Riffle/Pool ☐ Step/Pool ☐ Plane Bed ☐ Convergence/Divergence ☐ Dunes/Antidunes/Smooth Bed
10–12		Max Bankfull Depth (ft): Riffle **1.79**, Pool **1.8** — Depth Ratio (max to mean): Riffle **1.88**, Pool **1.42** — Pool-to-Pool Spacing: Ratio **74.13** — Slope: Valley: **0.0403**, Water Surface: **0.03649**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation — Current Composition/Density: **See description** — Potential Composition/Density: **Same as existing native speci** — Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**
15–16		Flow Regime: **P 1 2 8** — Stream Size & Order: **S-4(2)** — Meander Patterns: **M1 M4** — Depositional Patterns: **B1 B5** — Debris/Channel Blockages: **D2 D10**
17–18		Degree of Incision (Bank-Height Ratio): **3.73** — Degree of Incision Stability Rating: **Deeply Incised** — Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **93 - Fair**
19–20		Width/depth Ratio (W/d): **18.27** — Reference W/d Ratio (W/d_{ref}): **23** — Width/Depth Ratio State (W/d) / (W/d_{ref}): **0.79** — W/d Ratio State Stability Rating: **Stable**
21–22		Meander Width Ratio (MWR): **1.73** — Reference MWR_{ref}: **5** — Degree of confinement (MWR / MWR_{ref}): **0.346** — MWR / MWR_{ref} Stability Rating: **Stable**
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft): **0** — Annual Streambank Erosion Rate: **0** (tons/yr) **0** (tons/yr/ft) — Curve Used: — Remarks:
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity ☐ Insufficient Capacity ☐ Excess Capacity — Remarks:
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm): **260.35** — $\tau =$ **2.078** — $\tau^* =$ **0** — Existing Depth: **0.95** — Required Depth: **0.91** — Existing Slope: **####** — Required Slope: **####**
28–29	**Successional Stage Shift**	**C** → **C** → → → → — Existing Stream State (Type): **C 4b** — Potential Stream State (Type): **C4b**
30	**Lateral Stability**	☑ *Stable* ☐ *Mod. Unstable* ☐ *Unstable* ☐ *Highly Unstable* — Remarks/causes:
31	**Vertical Stability (Aggradation)**	☑ *No Deposition* ☐ *Mod. Deposition* ☐ *Ex. Deposition* ☐ *Aggradation* — Remarks/causes:
32	**Vertical Stability (Degradation)**	☐ *Not Incised* ☑ *Slightly Incised* ☐ *Mod. Incised* ☐ *Degradation* — Remarks/causes:
33	**Channel Enlargement**	☑ *No Increase* ☐ *Slight Increase* ☐ *Mod. Increase* ☐ *Extensive* — Remarks/causes:
34–35	**Sediment Supply (Channel Source)**	☐ *Low* ☑ *Moderate* ☐ *High* ☐ *Very High* — Remarks/causes:

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 2
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	8
Mass Wasting:	12
Debris Jam Potential:	6
Vegetative Protection:	12

Lower Bank

Channel Capacity:	4
Bank Rock Content:	2
Obstructions to Flow:	8
Cutting:	12
Deposition:	16

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	12
Scouring and Deposition:	24
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	High
Stream Bed Stability:	Aggrading
W/D Condition:	Very High
Stream Type:	D4A

Rating - 130
Condition - Fair

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream: **Fourmile Canyon Creek, Reach - Reach 2**	
Basin:	Drainage Area: **2860.8** acres **4.47** mi^2
Location:	
Twp.&Rge: **;**	Sec.&Qtr.: **;**
Cross-Section Monuments (Lat./Long.): **40.05939 Lat / 105.3176 Long**	Date: **05/11/15**
Observers: **Lucas Babbitt**	Valley Type: VIII(b)

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**22.57**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.71**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**15.95**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**31.79**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.42**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**34.39**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.52**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**23.19**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.04583**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.16**	

Stream Type **D4a** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek** Location: **Reach - Reach 2**

Observers: **Lucas Babbitt** Date: **05/11/15** Valley Type: **XIII** Stream Type: **D4a**

River Reach Dimension Summary Data.....1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	22.6	22.6	22.6	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	15.95	15.95	15.95
Mean Riffle Depth (d_{bkf})	0.71	0.71	0.71	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	31.79	31.79	31.79
Maximum Riffle Depth (d_{max})	1.42	1.42	1.42	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	2.000	2.000	2.000
Width of Flood-Prone Area (W_{fpa})	34.4	34.4	34.4	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	1.524	1.524	1.524
Riffle Inner Berm Width (W_{ib})	0	0	0	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.000	0.000	0.000
Riffle Inner Berm Depth (d_{ib})	0	0	0	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.000	0.000	0.000
Riffle Inner Berm Area (A_{ib})	0	0	0	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.000	0.000	0.000
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	0	0	0					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	28.4	28.4	28.4	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	1.257	1.257	1.257
Mean Pool Depth (d_{bkfp})	0.55	0.55	0.55	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	0.775	0.775	0.775
Pool Cross-Sectional Area (A_{bkfp})	15.5	15.5	15.5	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	0.973	0.973	0.973
Maximum Pool Depth (d_{maxp})	1.15	1.15	1.15	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	1.620	1.620	1.620
Pool Inner Berm Width (W_{ibp})	0	0	0	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.000	0.000	0.000
Pool Inner Berm Depth (d_{ibp})	0	0	0	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.000	0.000	0.000
Pool Inner Berm Area (A_{ibp})	0	0	0	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.000	0.000	0.000
Point Bar Slope (S_{pb})	0.000	0.000	0.000	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	0.000	0.000	0.000

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	24	24	24	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	1.064	1.064	1.064
Mean Run Depth (d_{bkfr})	0.99	0.99	0.99	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	1.394	1.394	1.394
Run Cross-Sectional Area (A_{bkfr})	23.8	23.8	23.8	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	1.489	1.489	1.489
Maximum Run Depth (d_{maxr})	1.58	1.58	1.58	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	2.225	2.225	2.225
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	24.3	24.3	24.3	ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	18.9	18.9	18.9	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	0.838	0.838	0.838
Mean Glide Depth (d_{bkfg})	1.03	1.03	1.03	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	1.451	1.451	1.451
Glide Cross-Sectional Area (A_{bkfg})	19.5	19.5	19.5	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	1.220	1.220	1.220
Maximum Glide Depth (d_{maxg})	2.04	2.04	2.04	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	2.873	2.873	2.873
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	18.4	18.4	18.4	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	0.000	0.000	0.000
Glide Inner Berm Width (W_{ibg})	0	0	0	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Depth (d_{ibg})	0	0	0	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Area (A_{ibg})	0	0	0	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.000	0.000	0.000

Step**

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	0	0	0	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	0.000	0.000	0.000
Mean Step Depth (d_{bkfs})	0	0	0	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	0.000	0.000	0.000
Step Cross-Sectional Area (A_{bkfs})	0	0	0	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	0.000	0.000	0.000
Maximum Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0.000	0.000	0.000
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	0	0	0					

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream:	**Fourmile Canyon Creek**		Location: **Reach - Reach 2**		
Observers:	**Lucas Babbitt**	Date: **05/11/15**	Valley Type: **XIII**	Stream Type: **D4a**	

River Reach Summary Data.....2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**4.736**	ft/sec	Estimation Method	**U/U***	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**75.539**	cfs	Drainage Area	**4.47**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**172**	**171**	**174**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**7.621**	**7.576**	**7.709**
Stream Meander Length (L_m)	**180**	**180**	**180**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**7.975**	**7.975**	**7.975**
Radius of Curvature (R_c)	**42**	**23**	**75**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**1.861**	**1.019**	**3.323**
Belt Width (W_{blt})	**35**	**23**	**43**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**1.551**	**1.019**	**1.905**
Arc Length (L_a)	**0**	**0**	**0**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**0.000**	**0.000**	**0.000**
Riffle Length (L_r)	**10.1**	**4.72**	**14.4**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**0.447**	**0.209**	**0.638**
Individual Pool Length (L_p)	**12.9**	**10.5**	**15.1**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**0.570**	**0.464**	**0.669**
Pool to Pool Spacing (P_s)	**156**	**95.5**	**216**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**6.891**	**4.231**	**9.551**

Channel Profile

Valley Slope (S_{val})	**0.05333**	ft/ft	Average Water Surface Slope (S)	**0.04583**	ft/ft	Sinuosity (S_{val} / S)	**1.16**
Stream Length (SL)	**395**	ft	Valley Length (VL)	**372**	ft	Sinuosity (SL / VL)	**1.06**
Low Bank Height (LBH)	start **10.3** ft; end **7.99** ft		Max Depth (d_{max})	start **1.66** ft; end **1.66** ft		Bank-Height Ratio (BHR) (LBH / d_{max})	start **6.22**; end **4.81**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.080**	**0.035**	**0.152**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.744**	**0.765**	**3.311**
Run Slope (S_{run})	**0.107**	**0.051**	**0.171**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**2.343**	**1.114**	**3.721**
Pool Slope (S_p)	**0.014**	**0.007**	**0.018**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.304**	**0.156**	**0.394**
Glide Slope (S_g)	**0.065**	**0.042**	**0.088**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**1.414**	**0.910**	**1.919**
Step Slope (S_s)	**0.000**	**0.000**	**0.000**	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	**0.000**	**0.000**	**0.000**

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	**1.49**	**1.38**	**1.6**	ft	Max Riffle Depth to Mean Riffle Depth (d_{maxrif} / d_{bkf})	**2.099**	**1.944**	**2.25**
Max Run Depth (d_{maxrun})	**2.07**	**1.9**	**2.23**	ft	Max Run Depth to Mean Riffle Depth (d_{maxrun} / d_{bkf})	**2.915**	**2.676**	**3.14**
Max Pool Depth (d_{maxp})	**2.13**	**1.38**	**2.94**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**3**	**1.944**	**4.14**
Max Glide Depth (d_{maxg})	**0.91**	**0.77**	**1.04**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**1.282**	**1.085**	**1.46**
Max Step Depth (d_{maxs})	**0**	**0**	**0**	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	**0**	**0**	**0**

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**	**0**		D_{16}	**1.72**	**9.32**			mm
% Sand	**18.1**	**11**		D_{35}	**14.3**	**22.6**			mm
% Gravel	**53.33**	**62**		D_{50}	**23.19**	**33**			mm
% Cobble	**21.9**	**24**		D_{84}	**110.94**	**90**			mm
% Boulder	**6.67**	**3**		D_{95}	**399.56**	**170.55**			mm
% Bedrock	**0**	**0**		D_{100}	**512**	**362**			mm

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.

[b] Composite sample of riffles and pools within the designated reach. [c] Active bed of a riffle. [d] Height of roughness feature above bed.

Worksheet 3-1. Riparian vegetation composition/density used for channel stability assessment.

Riparian Vegetation

Stream: **Fourmile Canyon Creek**		Location: **Reach 2**	
Observers: **Lucas Babbitt**	Reference reach: [ ]	Disturbed (impacted reach): **X**	Date: **05/13/15**
Existing species composition: **See description**		Potential species composition: **Same as existing native species**	

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**25%**	**5%**	**Ponderosa pine (Pinus**	**0%**
				Douglas fir (Pseudotsuga	**0%**
					0%
					0%
					0%
					0%
					0%
2. Understory	Shrub layer		**5%**	**Willow (Salix sp.)**	**0%**
				Mountain ninebark	**0%**
				Lilac (Syringa	**0%**
					0%
					0%
					0%
					0%
3. Ground level	Herbaceous		**80%**	**Downy brom (Bromus**	**0%**
				Bluegrass (Poa Sp.)	**0%**
				Reed canarygrass (Phalaris	**0%**
				White clover (Trifolium	**0%**
				Dandelion (Taraxacum	**0%**
				Common mullein	**0%**
					0%
	Leaf or needle litter		**5%**		
	Bare ground		**5%**		
			Column Total = 100%		

*Based on crown closure.
**Based on basal area to surface area.

Remarks:
Condition, vigor and/or usage of existing reach:
Density and potentially some species impacted by 2013 flood

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**		Stream Type:	**D4a**	
Location:	**Reach 2**		Valley Type:	**XIII**	
Observers:	**Lucas Babbitt**		Date:	**05/11/2015**	
Enter Required Information for Existing Condition					
33.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.781	D_{max}	Largest particle from bar sample (ft)	**238.125**	**(mm)**	304.8 mm/ft
0.04583	S	Existing bankfull water surface slope (ft/ft)			
0.71	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress				
0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
7.22	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample				
	d	Required bankfull mean depth (ft)	$d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample				
	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Sediment Competence Using Dimensional Shear Stress			
2.031		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft²) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope	
Shields **163.1**	CO **255.9**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**	
Shields **2.92**	CO **1.841**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**	
Shields **1.02**	CO **0.64**	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope	$d = \frac{\tau}{\gamma S}$
Shields **0.0659**	CO **0.0415**	Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, d = existing depth	$S = \frac{\tau}{\gamma d}$

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek**	Location: **Reach 2**							
Observers: **Lucas Babbitt**	Date: **5/11/2015**							
List ALL COMBINATIONS that APPLY..............☞	**P**	**1**	**2**	**8**				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order

Stream:	**Fourmile Canyon Creek**
Location:	**Reach 2**
Observers:	**Lucas Babbitt**
Date:	**5/11/2015**

Stream Size Category and Order ☞ **S-4(2)**

Category	STREAM SIZE: Bankfull width		Check (✓) appropriate category
	meters	feet	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐

Stream Order

Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).

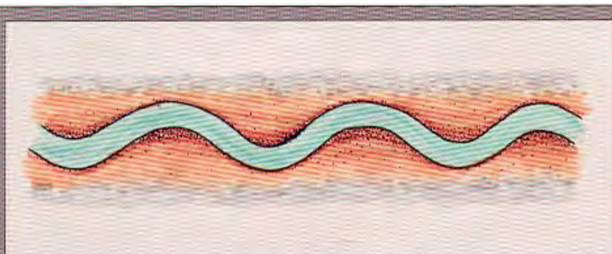
Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 2**
Observers:	**Lucas Babbitt**	Date:	**5/11/2015**

List ALL CATEGORIES that APPLY ☞	**M3**	**M4**			

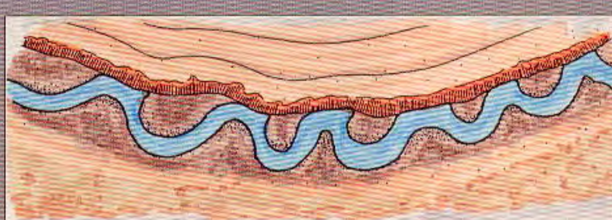
Various Meander Pattern variables modified from Galay et al. (1973)



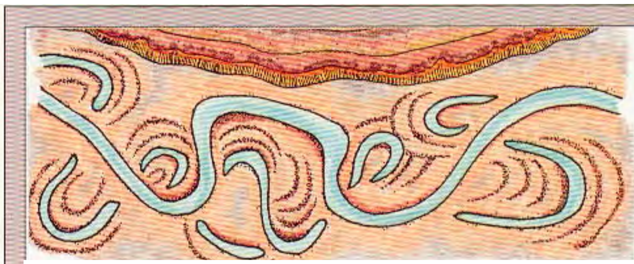
M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

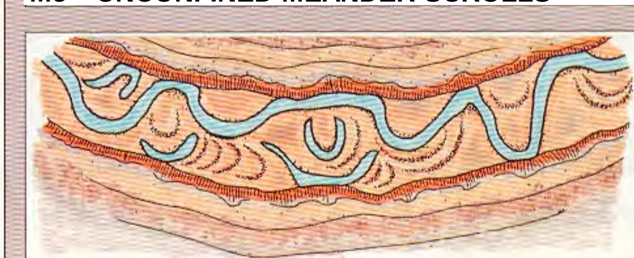
M3 IRREGULAR MEANDERS



M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS

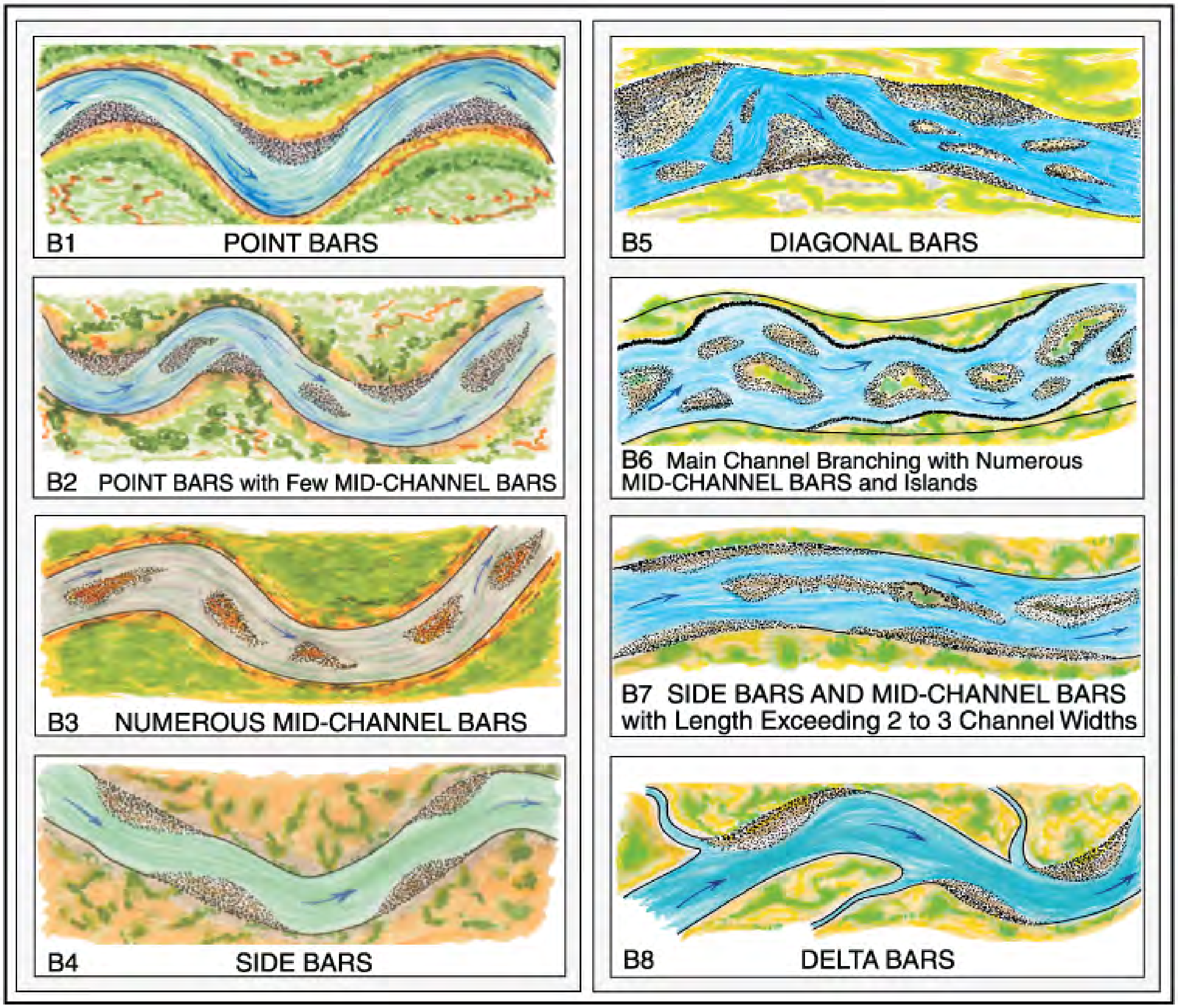
M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns						
Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 2**			
Observers:	**Lucas Babbitt**	Date:	**5/11/2015**			
List ALL CATEGORIES that APPLY ☞	**B1**	**B5**	**B7**			

Various Depositional Features modified from Galay et al. (1973)

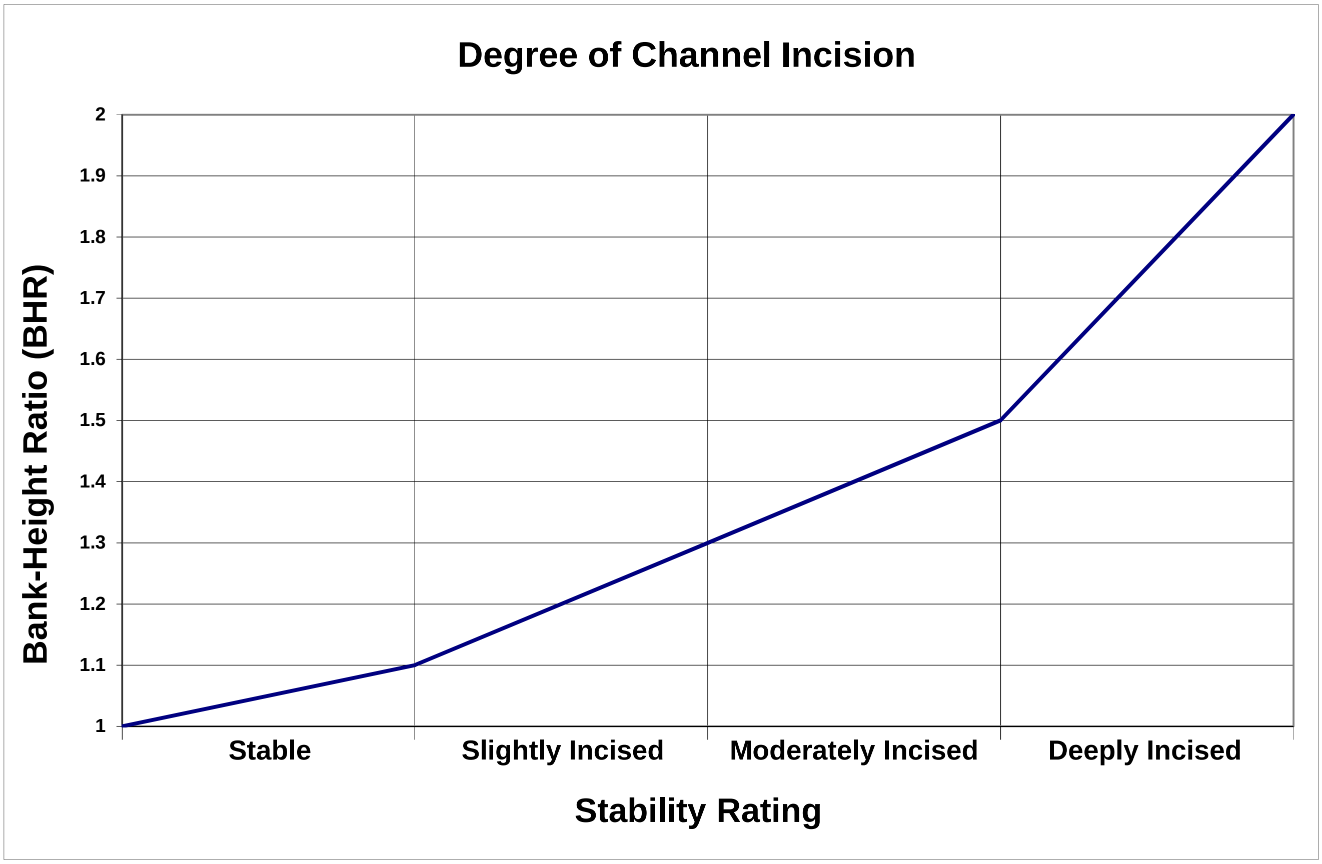


Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages		
Stream: **Fourmile Canyon Creek**	Location: **Reach 2**	
Observers: **Lucas Babbitt**	Date: **5/11/2015**	
Description/extent	**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1 None	Minor amounts of small, floatable material.	☐
D2 Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☐
D3 Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☑
D4 Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5 Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6 Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7 Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8 Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9 Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10 Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☐

Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision			
Low Bank Height:	10.33	Bank-Height Ratio:	0.0
Max Bankfull Depth:	0		
Degree of Channel Incision Stability Rating ☞			

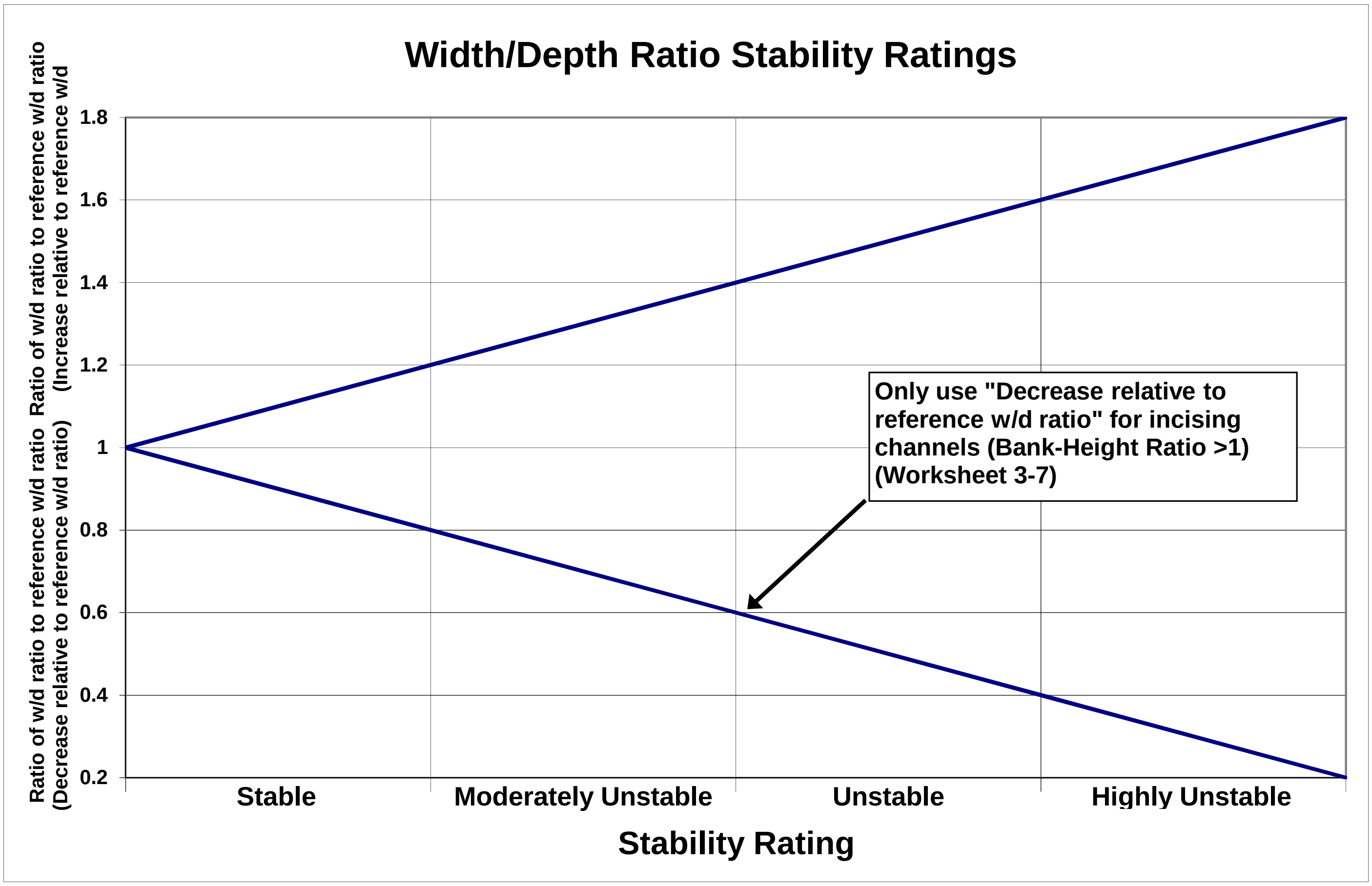


Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State

Existing Width/Depth Ratio:	**31.79**	Ratio of existing W/d to reference W/d:	**1.38**
Reference Width/Depth Ratio:	**23**		

Width/Depth Ratio State Stability Rating ☞	**Moderately Unstable**

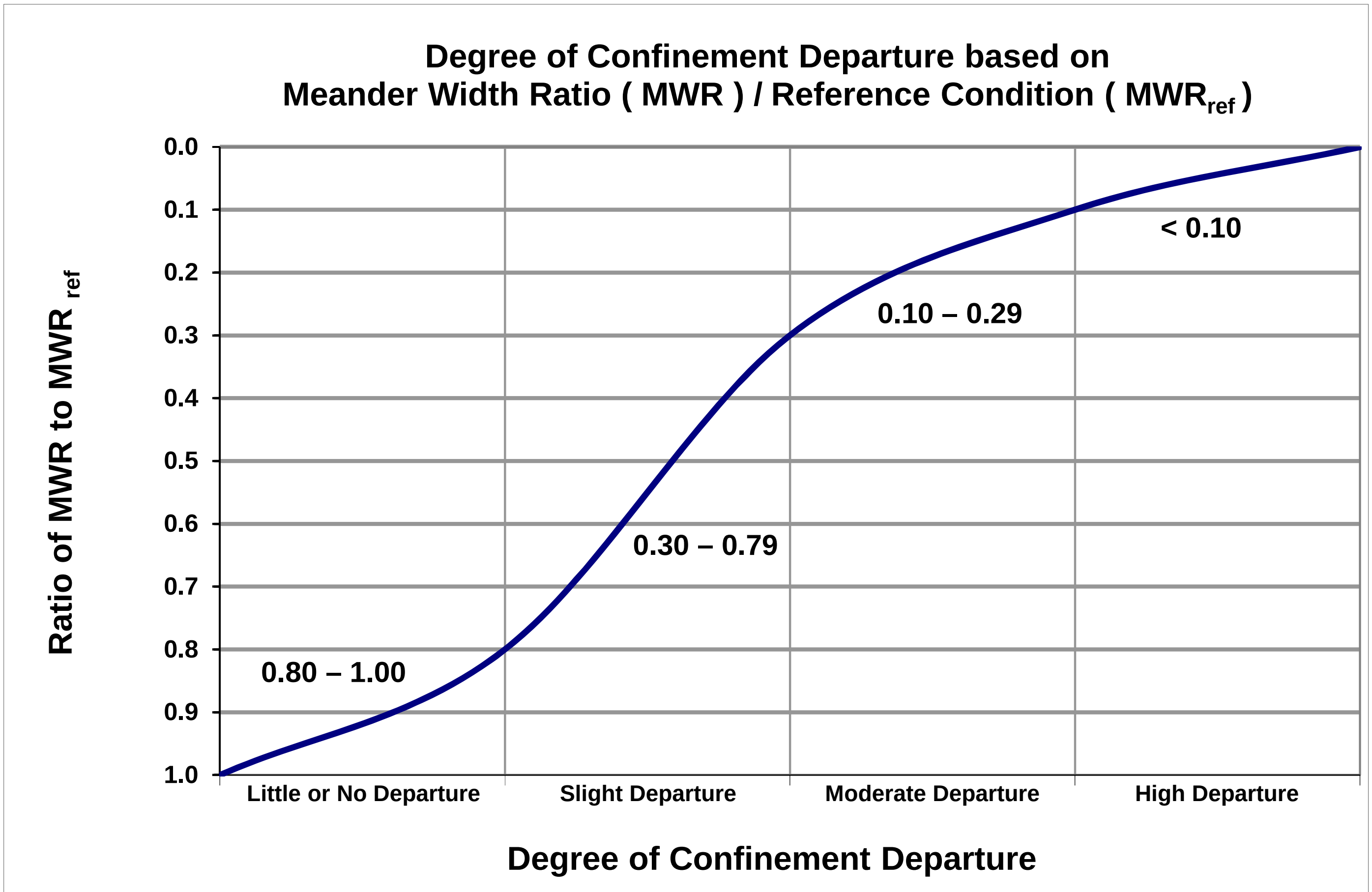


Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**1.55**		Ratio of MWR to MWR_{ref}:	**0.39**
Reference Meander Width Ratio (MWR_{ref}):	**4**			

Degree of Confinement Stability Rating ☞	



Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Fourmile Canyon Creek**	Stream Type: **D4a**
Location: **Reach 2**	Valley Type: **XIII**
Observers: **Lucas Babbitt**	Date: **05/11/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☐ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☐ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☑ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**D4a**
Location:	**Reach 2**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**05/11/2015**

Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**4**
2 **Depositional Patterns (Worksheet 3-5)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**4**
3 **Meander Patterns (Worksheet 3-4)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)**	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	
				Total Points	**9**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **< 10** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: **Fourmile Canyon Creek**			Stream Type: **D4a**		
Location: **Reach 2**			Valley Type: **XIII**		
Observers: **Lucas Babbitt**			Date: **05/11/2015**		
Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points (from each row)**
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 Sediment competence (Worksheet 3-14)	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope-slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	
2 Sediment Capacity (POWERSED)	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	
3 W/d Ratio State (Worksheet 3-8)	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**4**
4 Stream Succession States (Worksheet 3-16)	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	
5 Depositional Patterns (Worksheet 3-5)	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 Debris / Blockages (Worksheet 3-6)	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**1**
				Total Points	**6**
	Vertical Stability Category Point Range for Excess Deposition / Aggradation				
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **< 15** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐	

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**D4a**
Location:	**Reach 2**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**05/11/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points (from each row)**
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 **Sediment Competence (Worksheet 3-14)**	Does not indicate excess competence	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed	D_{100} of bed moved	Particles much larger than D_{100} of bed moved	
	(2)	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED)**	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	
	(2)	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 3-7)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	
	(2)	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 3-16 and 3-7)**	Does not indicate incision or degradation	If BHR > 1.1 and stream type has W/d between 5–10	If BHR > 1.1 and stream type has W/d less than 5	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A)	
	(2)	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	
	(1)	**(2)**	**(3)**	**(4)**	
				Total Points	**0**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **< 12** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Fourmile Canyon Creek**			Stream Type: **D4a**		
Location: **Reach 2**			Valley Type: **XIII**		
Observers: **Lucas Babbitt**			Date: **05/11/2015**		
Channel Enlargement Prediction Criteria (choose one stability category for each criterion 1–4)	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 **Successional Stage Shift (Worksheet 3-16)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	
2 **Lateral Stability (Worksheet 3-17)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	2
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	
4 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	
				Total Points	**2**
	Category Point Range				
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐	

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: **Fourmile Canyon Creek**		Stream Type:	**D4a**
Location: **Reach 2**		Valley Type:	**XIII**
Observers:		Date:	**05/11/2015**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 3-17)**	***Stable***	1	1
	Mod. Unstable	2	
	Unstable	3	
	Highly Unstable	4	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	***No Deposition***	1	
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	***Not Incised***	1	
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 **Channel Enlargement Prediction (Worksheet 3-20)**	***No Increase***	1	
	Slight Increase	2	
	Mod. Increase	3	
	Extensive	4	
5 **Pfankuch Channel Stability (Worksheet 3-10)**	***Good: Stable***	1	
	Fair: Mod. Unstable	2	
	Poor: Unstable	4	
		Total Points	**1**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** < 6 ☐	***Moderate*** 6 – 10 ☐	***High*** 11 – 15 ☐	***Very High*** > 15 ☐

Worksheet 3-22. Summary of stability condition categories.

	A	
1	Stream:	**Fourmile Canyon Creek** — Location: **Reach 2**
2	Observers:	**Lucas Babbitt** — Date: **5/11/2015** — Stream Type: **D4A** — Valley Type: **XIII**
3–4	**Channel Dimension**	Mean Bankfull Depth (ft): **0.71** — Bankfull Width (ft): **22.57** — Cross-Sectional Area (ft^2): **15.95** — Width/Depth Ratio: **31.79** — Entrenchment Ratio: **1.52**
5–6	**Channel Pattern**	λ/W_{bkf}: Mean: **7.62**, Range: **7.58 - 7.71** — L_m/W_{bkf}: Mean: **7.98**, Range: **7.98 - 7.98** — R_c/W_{bkf}: Mean: **1.86**, Range: **1.02 - 3.32** — MWR: Mean: **1.55**, Range: **1.02 - 1.91** — Sinuosity: **1.16**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec): **4.736** — Bankfull Discharge (Q_{bkf}): **75.539** — Estimation Method: **U/U*** — Drainage Area (mi^2): **4.47**
9	**River Profile & Bed Features**	Check: ☐ Riffle/Pool ☐ Step/Pool ☐ Plane Bed ☐ Convergence/Divergence ☐ Dunes/Antidunes/Smooth Bed
10–12		Max Bankfull Depth (ft): Riffle **1.42**, Pool **1.15** — Depth Ratio (max to mean): Riffle **2**, Pool **2.09** — Pool-to-Pool Spacing: Ratio **155.5** — Slope: Valley: **0.05333**, Water Surface: **0.04583**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation — Current Composition/Density: **See description** — Potential Composition/Density: **Same as existing native speci** — Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**
15–16		Flow Regime: **P 1 2 8** — Stream Size & Order: **S-4(2)** — Meander Patterns: **M3 M4** — Depositional Patterns: **B1 B5 B7** — Debris/Channel Blockages: **D3**
17–18		Degree of Incision (Bank-Height Ratio): **0** — Degree of Incision Stability Rating: — Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **130 -**
19–20		Width/depth Ratio (W/d): **31.79** — Reference W/d Ratio (W/d_{ref}): **23** — Width/Depth Ratio State (W/d) / (W/d_{ref}): **1.38** — W/d Ratio State Stability Rating: **Moderately Unstable**
21–22		Meander Width Ratio (MWR): **1.55** — Reference MWR_{ref}: **4** — Degree of confinement (MWR / MWR_{ref}): **0.3875** — MWR / MWR_{ref} Stability Rating: **Highly Unstable**
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft): **0** — Annual Streambank Erosion Rate: **0** (tons/yr) **0** (tons/yr/ft) — Curve Used: — Remarks:
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity ☐ Insufficient Capacity ☐ Excess Capacity — Remarks:
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm): **238.125** — $\tau =$ **1.841** — $\tau^* =$ **0** — Existing Depth: **0.71** — Required Depth: **0.64** — Existing Slope: **####** — Required Slope: **####**
28–29	**Successional Stage Shift**	→ → → → → — Existing Stream State (Type): **D4a** — Potential Stream State (Type):
30	**Lateral Stability**	☑ *Stable* ☐ *Mod. Unstable* ☐ *Unstable* ☐ *Highly Unstable* — Remarks/causes:
31	**Vertical Stability (Aggradation)**	☐ *No Deposition* ☐ *Mod. Deposition* ☐ *Ex. Deposition* ☐ *Aggradation* — Remarks/causes:
32	**Vertical Stability (Degradation)**	☐ *Not Incised* ☐ *Slightly Incised* ☐ *Mod. Incised* ☐ *Degradation* — Remarks/causes:
33	**Channel Enlargement**	☐ *No Increase* ☐ *Slight Increase* ☐ *Mod. Increase* ☐ *Extensive* — Remarks/causes:
34–35	**Sediment Supply (Channel Source)**	☐ *Low* ☐ *Moderate* ☐ *High* ☐ *Very High* — Remarks/causes:

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 3
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	4
Mass Wasting:	6
Debris Jam Potential:	4
Vegetative Protection:	9

Lower Bank

Channel Capacity:	4
Bank Rock Content:	2
Obstructions to Flow:	4
Cutting:	4
Deposition:	8

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	8
Scouring and Deposition:	12
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	High
Stream Bed Stability:	
W/D Condition:	Normal
Stream Type:	F4B

Rating - 79
Condition - Good

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Fourmile Canyon Creek, Reach - Reach 3**		
Basin:	Drainage Area: **3148.8** acres	**4.92**	mi^2
Location:			
Twp.&Rge: **;**		Sec.&Qtr.: **;**	
Cross-Section Monuments (Lat./Long.):	**40.05992 Lat / 105.31812 Long**	Date:	**08/20/15**
Observers:	**Lucas Babbitt**	Valley Type:	VIII(b)

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**20.86**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.66**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**13.77**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**31.61**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**24.73**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.19**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**31.32**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.02886**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.25**	

Stream Type **F 4b** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek**		Location: **Reach - Reach 3**	
Observers: **Lucas Babbitt**	Date: **08/20/15**	Valley Type: **XIII**	Stream Type: **F 4b**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	20.9	20.9	20.9	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	13.77	13.77	13.77
Mean Riffle Depth (d_{bkf})	0.66	0.66	0.66	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	31.61	31.61	31.61
Maximum Riffle Depth (d_{max})	1	1	1	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.515	1.515	1.515
Width of Flood-Prone Area (W_{fpa})	24.7	24.7	24.7	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	1.186	1.186	1.186
Riffle Inner Berm Width (W_{ib})	14.2	14.2	14.2	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.682	0.682	0.682
Riffle Inner Berm Depth (d_{ib})	0.13	0.13	0.13	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.196	0.196	0.196
Riffle Inner Berm Area (A_{ib})	1.84	1.84	1.84	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.134	0.134	0.134
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	110	110	110					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	15.6	15.6	15.6	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	0.748	0.748	0.748
Mean Pool Depth (d_{bkfp})	1.74	1.74	1.74	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	2.636	2.636	2.636
Pool Cross-Sectional Area (A_{bkfp})	27.2	27.2	27.2	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.972	1.972	1.972
Maximum Pool Depth (d_{maxp})	2.71	2.71	2.71	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	4.106	4.106	4.106
Pool Inner Berm Width (W_{ibp})	0	0	0	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.000	0.000	0.000
Pool Inner Berm Depth (d_{ibp})	0	0	0	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.000	0.000	0.000
Pool Inner Berm Area (A_{ibp})	0	0	0	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.000	0.000	0.000
Point Bar Slope (S_{pb})	0.000	0.000	0.000	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	0.000	0.000	0.000

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	12.2	12.2	12.2	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	0.587	0.587	0.587
Mean Run Depth (d_{bkfr})	1.72	1.72	1.72	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	2.606	2.606	2.606
Run Cross-Sectional Area (A_{bkfr})	21	21	21	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	1.527	1.527	1.527
Maximum Run Depth (d_{maxr})	2.78	2.78	2.78	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	4.212	4.212	4.212
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	7.12	7.12	7.12	ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	0	0	0	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	0.000	0.000	0.000
Mean Glide Depth (d_{bkfg})	0	0	0	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.000	0.000	0.000
Glide Cross-Sectional Area (A_{bkfg})	0	0	0	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	0.000	0.000	0.000
Maximum Glide Depth (d_{maxg})	0	0	0	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	0.000	0.000	0.000
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	0	0	0	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	0.000	0.000	0.000
Glide Inner Berm Width (W_{ibg})	0	0	0	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Depth (d_{ibg})	0	0	0	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Area (A_{ibg})	0	0	0	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.000	0.000	0.000

Step**

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	0	0	0	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	0.000	0.000	0.000
Mean Step Depth (d_{bkfs})	0	0	0	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	0.000	0.000	0.000
Step Cross-Sectional Area (A_{bkfs})	0	0	0	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	0.000	0.000	0.000
Maximum Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0.000	0.000	0.000
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	0	0	0					

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream:	**Fourmile Canyon Creek**		Location: **Reach - Reach 3**			
Observers:	**Lucas Babbitt**	Date: **08/20/15**		Valley Type: **XIII**		Stream Type: **F 4b**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**3.582**	ft/sec	Estimation Method	**U/U***	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**49.324**	cfs	Drainage Area	**4.92**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	244	121	367	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	#####	5.801	####
Stream Meander Length (L_m)	154	154	154	ft	Stream Meander Length Ratio (L_m / W_{bkf})	7.383	7.383	7.383
Radius of Curvature (R_c)	43	36	49	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	2.061	1.726	2.349
Belt Width (W_{blt})	23	23	23	ft	Meander Width Ratio (W_{blt} / W_{bkf})	1.103	1.103	1.103
Arc Length (L_a)	0	0	0	ft	Arc Length to Riffle Width (L_a / W_{bkf})	0.000	0.000	0.000
Riffle Length (L_r)	19.8	12.8	26.8	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	0.948	0.612	1.284
Individual Pool Length (L_p)	10.4	2.5	16.3	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	0.500	0.120	0.781
Pool to Pool Spacing (P_s)	355	355	355	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	#####	#####	####

Channel Profile

Valley Slope (S_{val})	0.036	ft/ft	Average Water Surface Slope (S)	0.02886	ft/ft	Sinuosity (S_{val} / S)	1.25
Stream Length (SL)	579	ft	Valley Length (VL)	557	ft	Sinuosity (SL / VL)	1.04

Low Bank Height (LBH)	start	6.01 ft	Max Depth (d_{max})	start	1.2 ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	5.01
	end	4.17 ft		end	1.65 ft		end	2.53

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.051	0.041	0.061	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	1.765	1.430	2.099
Run Slope (S_{run})	0.094	0.053	0.134	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	3.241	1.843	4.639
Pool Slope (S_p)	0.012	0.008	0.015	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	0.404	0.273	0.535
Glide Slope (S_g)	0.010	0.003	0.018	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	0.363	0.108	0.618
Step Slope (S_s)	0.000	0.000	0.000	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	0.000	0.000	0.000

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	0.73	0.7	0.75	ft	Max Riffle Depth to Mean Riffle Depth (d_{maxrif} / d_{bkf})	1.106	1.061	1.14
Max Run Depth (d_{maxrun})	0.92	0.74	1.1	ft	Max Run Depth to Mean Riffle Depth (d_{maxrun} / d_{bkf})	1.394	1.121	1.67
Max Pool Depth (d_{maxp})	0.98	0.65	1.29	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	1.485	0.985	1.95
Max Glide Depth (d_{maxg})	0.77	0.49	1.04	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.167	0.742	1.58
Max Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0	0	0

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	0.99	0		D_{16}	0.24	7.36			mm
% Sand	23.76	6.93		D_{35}	12.36	26.69			mm
% Gravel	44.56	55.45		D_{50}	31.32	47.04			mm
% Cobble	30.69	37.62		D_{84}	98.99	114.82			mm
% Boulder	0	0		D_{95}	153.34	164.14			mm
% Bedrock	0	0		D_{100}	256	256			mm

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.

[b] Composite sample of riffles and pools within the designated reach. [c] Active bed of a riffle. [d] Height of roughness feature above bed.

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek** Location: **Reach 3**

Observers: **Lucas Babbitt** Date: **8/20/2015**

List ALL COMBINATIONS that APPLY............... ☞	P	1	2	8				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order

Stream:	**Fourmile Canyon Creek**
Location:	**Reach 3**
Observers:	**Lucas Babbitt**
Date:	**8/20/2015**
Stream Size Category and Order ☞	**S-4(2)**

Category	STREAM SIZE: Bankfull width		Check (✓) appropriate category
	meters	feet	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐

Stream Order

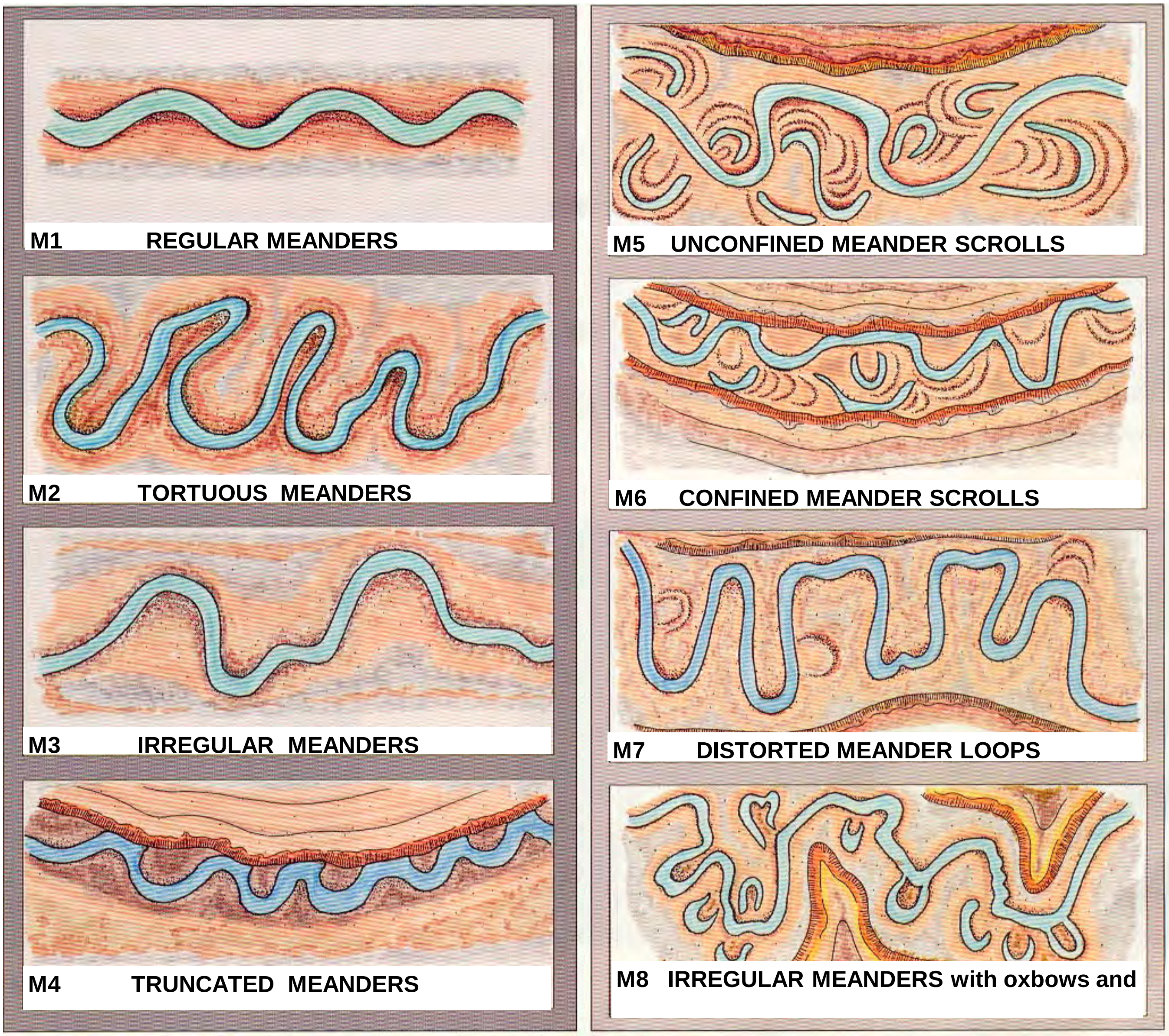
Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).

Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

Stream:	**Fourmile Canyon Creek**		Reach:	**Reach 3**	
Observers:	**Lucas Babbitt**		Date:	**8/20/2015**	
List ALL CATEGORIES that APPLY ☞	**M1**	**M4**			

Various Meander Pattern variables modified from Galay et al. (1973)



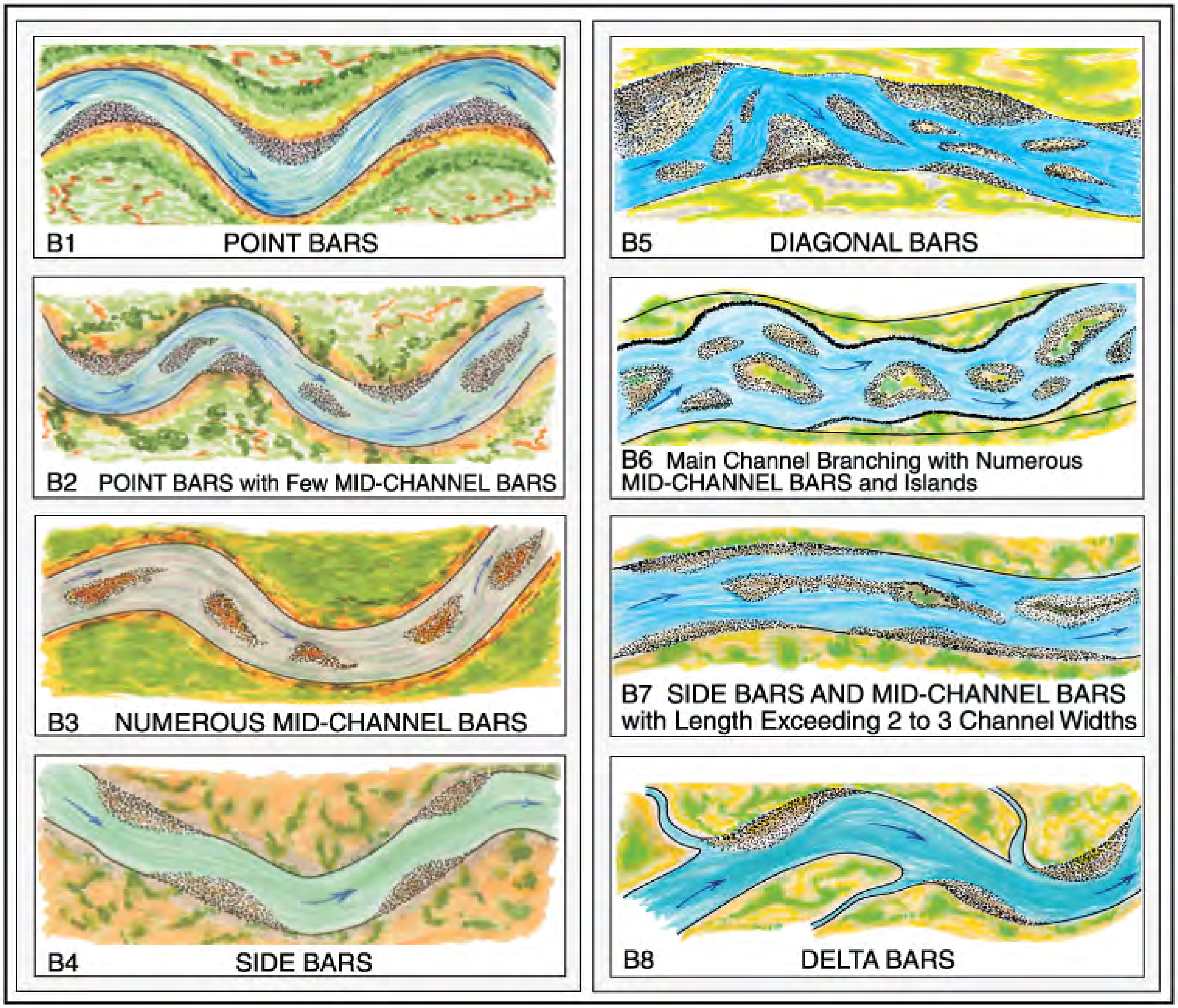
Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 3**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

List ALL CATEGORIES that APPLY ☞	**B1**				

Various Depositional Features modified from Galay et al. (1973)



Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages		
Stream: **Fourmile Canyon Creek**	Location: **Reach 3**	
Observers: **Lucas Babbitt**	Date: **8/20/2015**	
Description/extent	**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1 None	Minor amounts of small, floatable material.	☐
D2 Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☑
D3 Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☐
D4 Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5 Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6 Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7 Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8 Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9 Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10 Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

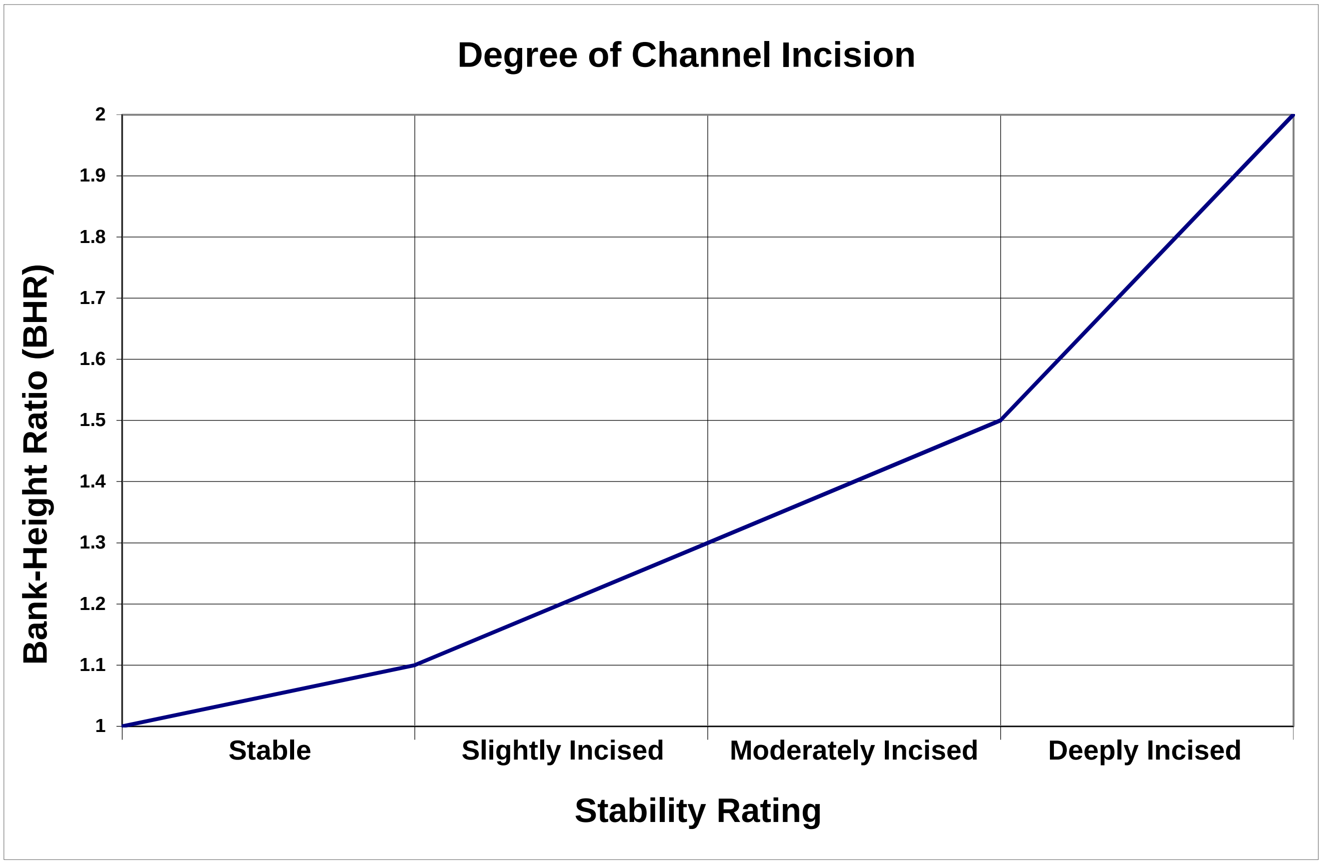
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision

Low Bank Height:	**6.01**
Max Bankfull Depth:	**1.2**

Bank-Height Ratio:	**5.0**

Degree of Channel Incision Stability Rating ☞ **Deeply Incised**

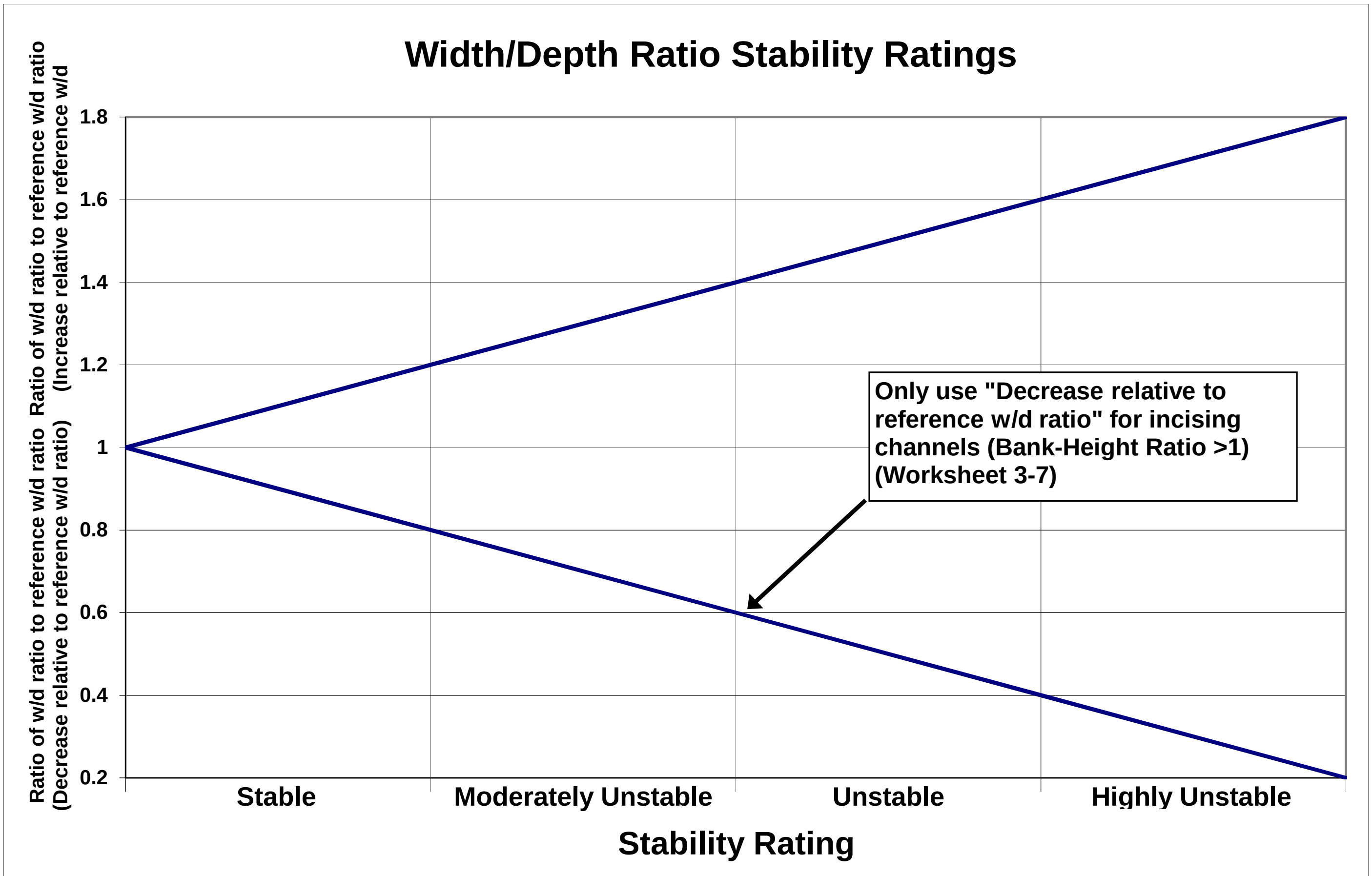


Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State

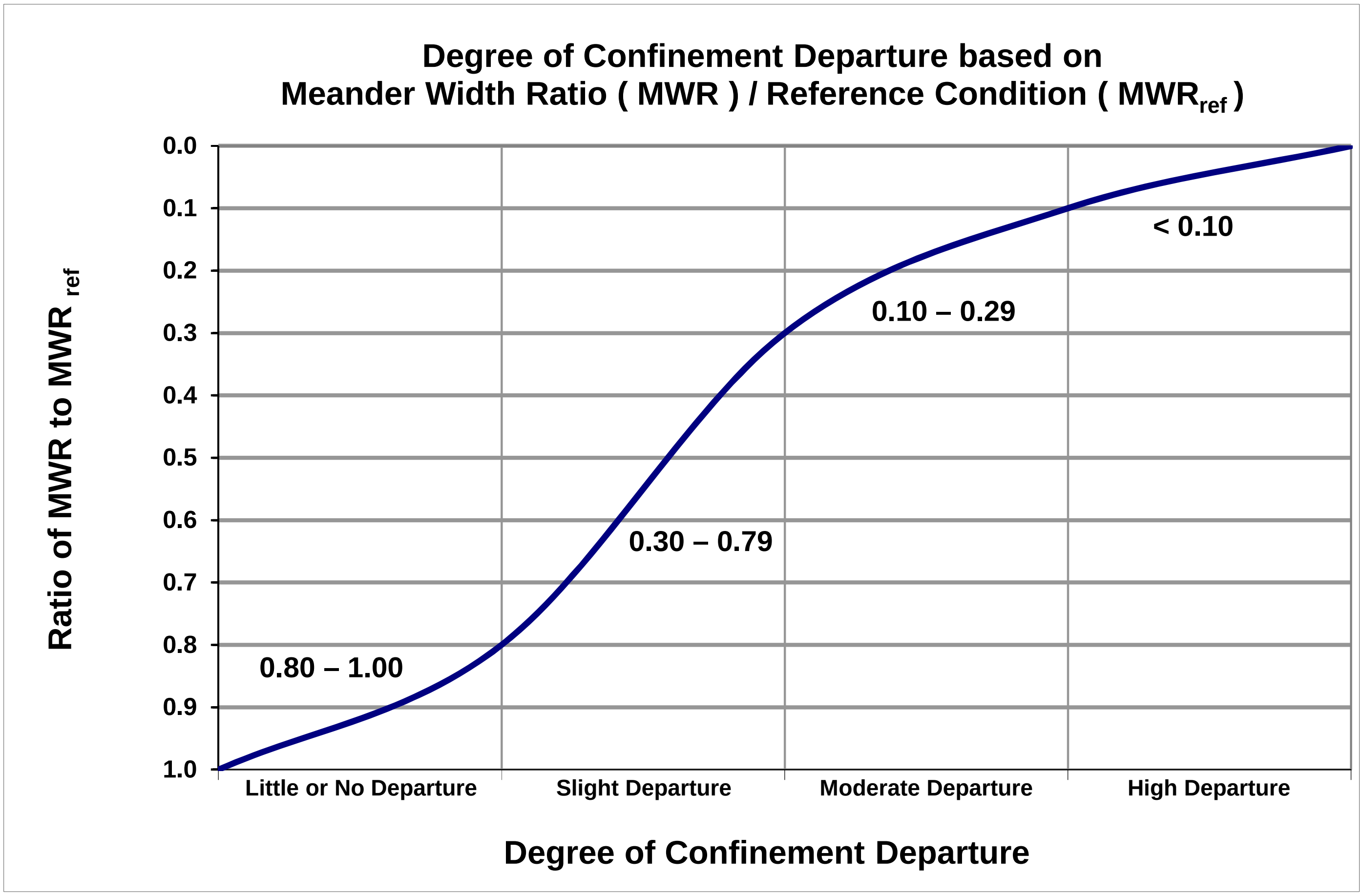
Existing Width/Depth Ratio:	**31.61**	Ratio of existing W/d to reference W/d:	**1.37**
Reference Width/Depth Ratio:	**23**		

Width/Depth Ratio State Stability Rating ☞	**Unstable**



Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement			
Existing Meander Width Ratio (MWR):	1.1	Ratio of MWR to MWR_{ref}:	0.28
Reference Meander Width Ratio (MWR_{ref}):	4		
Degree of Confinement Stability Rating ☞		Confined	



Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**F 4b**
Location:	**Reach 3**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Enter Required Information for Existing Condition

47.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.708	D_{max}	Largest particle from bar sample (ft)	**215.9**	**(mm)**	304.8 mm/ft
0.02886	S	Existing bankfull water surface slope (ft/ft)			
0.66	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
4.59	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \dfrac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \dfrac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☑ Aggrading ☐ Degrading

Sediment Competence Using Dimensional Shear Stress

1.189		Bankfull shear stress $\tau = \gamma d S$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **93.34**	CO **172.6**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.658**	CO **1.611**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **1.48**	CO **0.89**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \dfrac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0645**	CO **0.0391**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \dfrac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☐ Stable ☑ Aggrading ☐ Degrading

Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Fourmile Canyon Creek**	Stream Type: **F 4b**
Location: **Reach 3**	Valley Type: **XIII**
Observers: **Lucas Babbitt**	Date: **08/20/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☐ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☑ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**F 4b**
Location:	**Reach 3**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 W/d Ratio State (Worksheet 3-8)	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**6**
2 Depositional Patterns (Worksheet 3-5)	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**1**
3 Meander Patterns (Worksheet 3-4)	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**1**
4 Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5 Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**3**
				Total Points	**11**
	Lateral Stability Category Point Range				
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **< 10** ☐	***Moderately Unstable*** **10 – 12** ☑	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐	

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**F 4b**
Location:	**Reach 3**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points** (from each row)
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 **Sediment competence (Worksheet 3-14)**	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope-slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	**6**
2 **Sediment Capacity (POWERSED)**	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	
3 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**6**
4 **Stream Succession States (Worksheet 3-16)**	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	**6**
5 **Depositional Patterns (Worksheet 3-5)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 3-6)**	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**4**
				Total Points	**23**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **< 15** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**F 4b**
Location:	**Reach 3**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points** (from each row)
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 **Sediment Competence (Worksheet 3-14)**	Does not indicate excess competence **(2)**	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed **(4)**	D_{100} of bed moved **(6)**	Particles much larger than D_{100} of bed moved **(8)**	**2**
2 **Sediment Capacity (POWERSED)**	Does not indicate excess capacity **(2)**	Slight excess energy: up to 10% increase above reference **(4)**	Excess energy sufficient to increase load up to 50% of annual load **(6)**	Excess energy transporting more than 50% of annual load **(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 3-7)**	1.00 – 1.10 **(2)**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**8**
4 **Stream Succession States (Worksheets 3-16 and 3-7)**	Does not indicate incision or degradation **(2)**	If BHR > 1.1 and stream type has W/d between 5–10 **(4)**	If BHR > 1.1 and stream type has W/d less than 5 **(6)**	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) **(8)**	**2**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**3**
				Total Points	**15**

Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Channel Incision / Degradation**			
	Not Incised **< 12** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Fourmile Canyon Creek**			Stream Type: **F 4b**		
Location: **Reach 3**			Valley Type: **XIII**		
Observers: **Lucas Babbitt**			Date: **08/20/2015**		
Channel Enlargement Prediction Criteria **(choose one stability category for each criterion 1–4)**	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 **Successional Stage Shift (Worksheet 3-16)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	**8**
2 **Lateral Stability (Worksheet 3-17)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**4**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**6**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**4**
				Total Points	**22**
	Category Point Range				
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐	

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: **Fourmile Canyon Creek**		Stream Type:	**F 4b**
Location: **Reach 3**		Valley Type:	**XIII**
Observers:		Date:	**08/20/2015**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	Stability Rating	Points	Selected Points
1 Lateral Stability (Worksheet 3-17)	*Stable*	1	2
	Mod. Unstable	2	
	Unstable	3	
	Highly Unstable	4	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	*No Deposition*	1	3
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	*Not Incised*	1	2
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 Channel Enlargement Prediction (Worksheet 3-20)	*No Increase*	1	3
	Slight Increase	2	
	Mod. Increase	3	
	Extensive	4	
5 Pfankuch Channel Stability (Worksheet 3-10)	*Good: Stable*	1	2
	Fair: Mod. Unstable	2	
	Poor: Unstable	4	
		Total Points	**12**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** < 6 ☐	***Moderate*** 6 – 10 ☐	***High*** 11 – 15 ☑	***Very High*** > 15 ☐

Worksheet 3-22. Summary of stability condition categories.

1	Stream:	**Fourmile Canyon Creek** — Location: **Reach 3**
2	Observers:	**Lucas Babbitt** — Date: **8/20/2015** — Stream Type: **F 4B** — Valley Type: **XIII**
3–4	**Channel Dimension**	Mean Bankfull Depth (ft): **0.66** — Bankfull Width (ft): **20.86** — Cross-Sectional Area (ft^2): **13.77** — Width/Depth Ratio: **31.61** — Entrenchment Ratio: **1.19**
5–6	**Channel Pattern**	Mean / Range: λ/W_{bkf}: **11.7** / **5.80 - 17.59** — L_m/W_{bkf}: **7.38** / **7.38 - 7.38** — R_c/W_{bkf}: **2.06** / **1.73 - 2.35** — MWR: **1.1** / **1.10 - 1.10** — Sinuosity: **1.25**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec): **3.582** — Bankfull Discharge (Q_{bkf}): **49.324** — Estimation Method: **U/U*** — Drainage Area (mi^2): **4.92**
9	**River Profile & Bed Features**	Check: ☐ Riffle/Pool ☐ Step/Pool ☐ Plane Bed ☐ Convergence/Divergence ☐ Dunes/Antidunes/Smooth Bed
10–12		Max Bankfull Depth (ft): Riffle **1**, Pool **2.71** — Depth Ratio (max to mean): Riffle **1.52**, Pool **1.56** — Pool-to-Pool Spacing: Ratio **355.2** — Slope: Valley: **0.036**, Water Surface: **0.02886**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation — Current Composition/Density: **See description** — Potential Composition/Density: **Same as existing native speci** — Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**
15–16		Flow Regime: **P 1 2 8** — Stream Size & Order: **S-4(2)** — Meander Patterns: **M1 M4** — Depositional Patterns: **B1** — Debris/Channel Blockages: **D2 D10**
17–18		Degree of Incision (Bank-Height Ratio): **5.01** — Degree of Incision Stability Rating: **Deeply Incised** — Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **79 -**
19–20		Width/depth Ratio (W/d): **31.61** — Reference W/d Ratio (W/d_{ref}): **23** — Width/Depth Ratio State (W/d) / (W/d_{ref}): **1.37** — W/d Ratio State Stability Rating: **Unstable**
21–22		Meander Width Ratio (MWR): **1.1** — Reference MWR_{ref}: **4** — Degree of confinement (MWR / MWR_{ref}): **0.275** — MWR / MWR_{ref} Stability Rating: **Unstable**
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft): **0** — Annual Streambank Erosion Rate: **0** (tons/yr) **0** (tons/yr/ft) — Curve Used: — Remarks:
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity ☐ Insufficient Capacity ☐ Excess Capacity — Remarks:
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm): **215.9** — $\tau =$ **1.611** — $\tau^* =$ **0** — Existing Depth: **0.66** — Required Depth: **0.89** — Existing Slope: **####** — Required Slope: **####**
28–29	**Successional Stage Shift**	→ → → → → — Existing Stream State (Type): **F 4b** — Potential Stream State (Type):
30	**Lateral Stability**	☐ *Stable* ☑ *Mod. Unstable* ☐ *Unstable* ☐ *Highly Unstable* — Remarks/causes:
31	**Vertical Stability (Aggradation)**	☐ *No Deposition* ☐ *Mod. Deposition* ☑ *Ex. Deposition* ☐ *Aggradation* — Remarks/causes:
32	**Vertical Stability (Degradation)**	☐ *Not Incised* ☑ *Slightly Incised* ☐ *Mod. Incised* ☐ *Degradation* — Remarks/causes:
33	**Channel Enlargement**	☐ *No Increase* ☐ *Slight Increase* ☑ *Mod. Increase* ☐ *Extensive* — Remarks/causes:
34–35	**Sediment Supply (Channel Source)**	☐ *Low* ☐ *Moderate* ☑ *High* ☐ *Very High* — Remarks/causes:

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 4
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	4
Mass Wasting:	6
Debris Jam Potential:	4
Vegetative Protection:	9

Lower Bank

Channel Capacity:	3
Bank Rock Content:	6
Obstructions to Flow:	4
Cutting:	6
Deposition:	4

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	8
Scouring and Deposition:	12
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	High
Stream Bed Stability:	
W/D Condition:	
Stream Type:	B4

Rating - 80
Condition - Fair

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Fourmile Canyon Creek**	Location:	**Reach - Reach 4**
Date:	**5/13/2015**	Stream Type: **B4**	Valley Type: **VIII**
Observers:	**Lucas Babbitt**	HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**28.04**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**1.13**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**24.71**	W_{bkf} (ft)	Wetted PERIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	**25.46**	W_p (ft)
D_{84} at Riffle	**82.57**	Dia. (mm)	D_{84} (mm) / 304.8	**0.27**	D_{84} (ft)
Bankfull SLOPE	**0.0352**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**1.10**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**4.06**	R / D_{84}
Drainage Area	**4.9**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	**1.117**	u* (ft/sec)

ESTIMATION METHODS		Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness	$u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**7.01**	ft / sec	**196.69**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19)	$u = 1.49*R^{2/3}*S^{1/2} / n$; $n =$ **0.062**	**4.80**	ft / sec	**134.54**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20)	$u = 1.49*R^{2/3}*S^{1/2} / n$; $n =$ **0.062**	**4.80**	ft / sec	**134.54**	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3	$u = 1.49*R^{2/3}*S^{1/2} / n$; $n = 0.39*S^{0.38}*R^{-0.16}$; $n =$ **0.108**	**2.76**	ft / sec	**77.45**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)	**Darcy-Weisbach (Leopold, Wolman and Miller)**	**7.23**	ft / sec	**202.83**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)	**Chezy C**	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: a) Regional Curves **Return Period for Bankfull Discharge**	u = Q / A; Q = **0.0** year	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: b) USGS Gage Data	u = Q / A	**0.00**	ft / sec	**0.00**	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrusion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek**		Location: **Reach - Reach 4**	
Observers: **Lucas Babbitt**	Date: **08/20/15**	Valley Type: **XIII**	Stream Type: **B 4**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, *

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	12.4	0	24.7	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	14.02	0.00	28.04
Mean Riffle Depth (d_{bkf})	0.57	0	1.13	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	10.93	0.00	21.87
Maximum Riffle Depth (d_{max})	0.86	0	1.71	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	0.757	0.000	1.513
Width of Flood-Prone Area (W_{fpa})	23.3	0	46.6	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	0.944	0.000	1.887
Riffle Inner Berm Width (W_{ib})	0	0	0	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.000	0.000	0.000
Riffle Inner Berm Depth (d_{ib})	0	0	0	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.000	0.000	0.000
Riffle Inner Berm Area (A_{ib})	0	0	0	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.000	0.000	0.000
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	0	0	0					

Pool Dimensions*, **, *

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	9.77	9.77	9.77	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	0.790	0.790	0.790
Mean Pool Depth (d_{bkfp})	1.02	1.02	1.02	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	1.789	1.789	1.789
Pool Cross-Sectional Area (A_{bkfp})	10	10	10	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	0.714	0.714	0.714
Maximum Pool Depth (d_{maxp})	1.56	1.56	1.56	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	2.737	2.737	2.737
Pool Inner Berm Width (W_{ibp})	0	0	0	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.000	0.000	0.000
Pool Inner Berm Depth (d_{ibp})	0	0	0	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.000	0.000	0.000
Pool Inner Berm Area (A_{ibp})	0	0	0	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.000	0.000	0.000
Point Bar Slope (S_{pb})	0.000	0.000	0.000	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	0.000	0.000	0.000

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	24.7	24.7	24.7	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	1.999	1.999	1.999
Mean Run Depth (d_{bkfr})	1.13	1.13	1.13	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	1.982	1.982	1.982
Run Cross-Sectional Area (A_{bkfr})	28	28	28	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	2.000	2.000	2.000
Maximum Run Depth (d_{maxr})	1.71	1.71	1.71	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	3.000	3.000	3.000
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	21.9	21.9	21.9	ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	0	0	0	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	0.000	0.000	0.000
Mean Glide Depth (d_{bkfg})	0	0	0	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.000	0.000	0.000
Glide Cross-Sectional Area (A_{bkfg})	0	0	0	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	0.000	0.000	0.000
Maximum Glide Depth (d_{maxg})	0	0	0	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	0.000	0.000	0.000
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	0	0	0	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	0.000	0.000	0.000
Glide Inner Berm Width (W_{ibg})	0	0	0	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Depth (d_{ibg})	0	0	0	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Area (A_{ibg})	0	0	0	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.000	0.000	0.000

Step**

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	0	0	0	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	0.000	0.000	0.000
Mean Step Depth (d_{bkfs})	0	0	0	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	0.000	0.000	0.000
Step Cross-Sectional Area (A_{bkfs})	0	0	0	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	0.000	0.000	0.000
Maximum Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0.000	0.000	0.000
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	0	0	0					

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream:	Fourmile Canyon Creek		Location:	Reach - Reach 4		
Observers:	Lucas Babbitt	Date: 08/20/15		Valley Type: XIII	Stream Type: B 4	

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	4.798	ft/sec	Estimation Method		
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	134.536	cfs	Drainage Area	4.92	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	116	98	151	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	9.385	7.929	####
Stream Meander Length (L_m)	118	118	118	ft	Stream Meander Length Ratio (L_m / W_{bkf})	9.547	9.547	9.547
Radius of Curvature (R_c)	44	7	115	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	3.560	0.566	9.304
Belt Width (W_{blt})	18	13	23	ft	Meander Width Ratio (W_{blt} / W_{bkf})	1.456	1.052	1.861
Arc Length (L_a)	0	0	0	ft	Arc Length to Riffle Width (L_a / W_{bkf})	0.000	0.000	0.000
Riffle Length (L_r)	0	0	0	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	0.000	0.000	0.000
Individual Pool Length (L_p)	0	0	0	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	0.000	0.000	0.000
Pool to Pool Spacing (P_s)	0	0	0	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	0.000	0.000	0.000

Channel Profile

Valley Slope (S_{val})	0.033	ft/ft	Average Water Surface Slope (S)	0.03521	ft/ft	Sinuosity (S_{val} / S)	1.07
Stream Length (SL)	481	ft	Valley Length (VL)	435	ft	Sinuosity (SL / VL)	1.11
Low Bank Height (LBH)	start 0 ft; end 0 ft		Max Depth (d_{max})	start 0 ft; end 0 ft		Bank-Height Ratio (BHR) (LBH / d_{max})	start ; end

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.000	0.000	0.000	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	0.000	0.000	0.000
Run Slope (S_{run})	0.000	0.000	0.000	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	0.000	0.000	0.000
Pool Slope (S_p)	0.000	0.000	0.000	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	0.000	0.000	0.000
Glide Slope (S_g)	0.000	0.000	0.000	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	0.000	0.000	0.000
Step Slope (S_s)	0.000	0.000	0.000	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	0.000	0.000	0.000

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	0	0	0	ft	Max Riffle Depth to Mean Riffle Depth (d_{maxrif} / d_{bkf})	0	0	0
Max Run Depth (d_{maxrun})	0	0	0	ft	Max Run Depth to Mean Riffle Depth (d_{maxrun} / d_{bkf})	0	0	0
Max Pool Depth (d_{maxp})	0	0	0	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	0	0	0
Max Glide Depth (d_{maxg})	0	0	0	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	0	0	0
Max Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0	0	0

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	2.68	1		D_{16}	2.96	4			mm
% Sand	11.61	11		D_{35}	28.03	17.8			mm
% Gravel	55.35	67		D_{50}	41.94	28.58			mm
% Cobble	29.47	21		D_{84}	101.7	82.57			mm
% Boulder	0.89	0		D_{95}	156.07	128			mm
% Bedrock	0	0		D_{100}	361.99	180			mm

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.

[b] Composite sample of riffles and pools within the designated reach. [c] Active bed of a riffle. [d] Height of roughness feature above bed.

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek**	Location: **Reach 4**							
Observers: **Lucas Babbitt**					Date: **8/20/2015**			
List ALL COMBINATIONS that APPLY..............☞	**P**	**1**	**2**	**8**				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order			
Stream:	**Fourmile Canyon Creek**		
Location:	**Reach 4**		
Observers:	**Lucas Babbitt**		
Date:	**8/20/2015**		
Stream Size Category and Order ☞			**S-4(2)**
Category	**STREAM SIZE: Bankfull width**		**Check (✓) appropriate category**
	meters	**feet**	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐
Stream Order			
Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).			

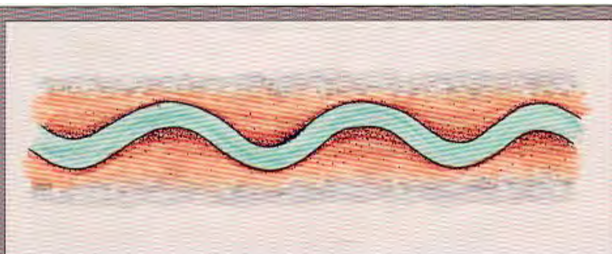
Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 4**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

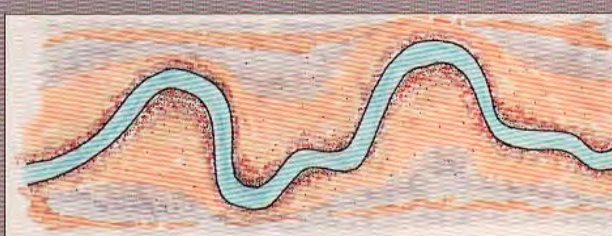
List ALL CATEGORIES that APPLY ☞	**M1**				

Various Meander Pattern variables modified from Galay et al. (1973)

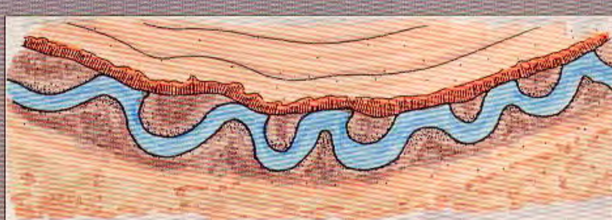


M1 REGULAR MEANDERS

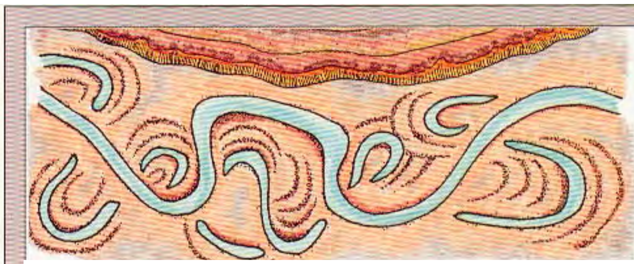
M2 TORTUOUS MEANDERS



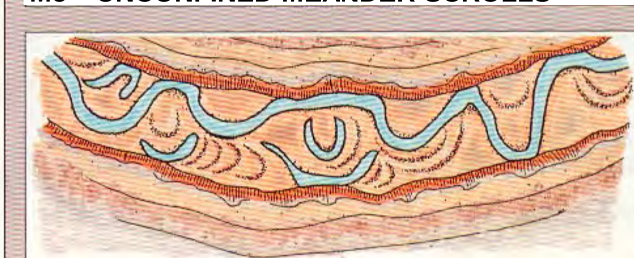
M3 IRREGULAR MEANDERS



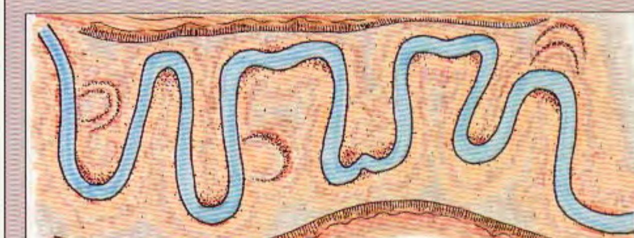
M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



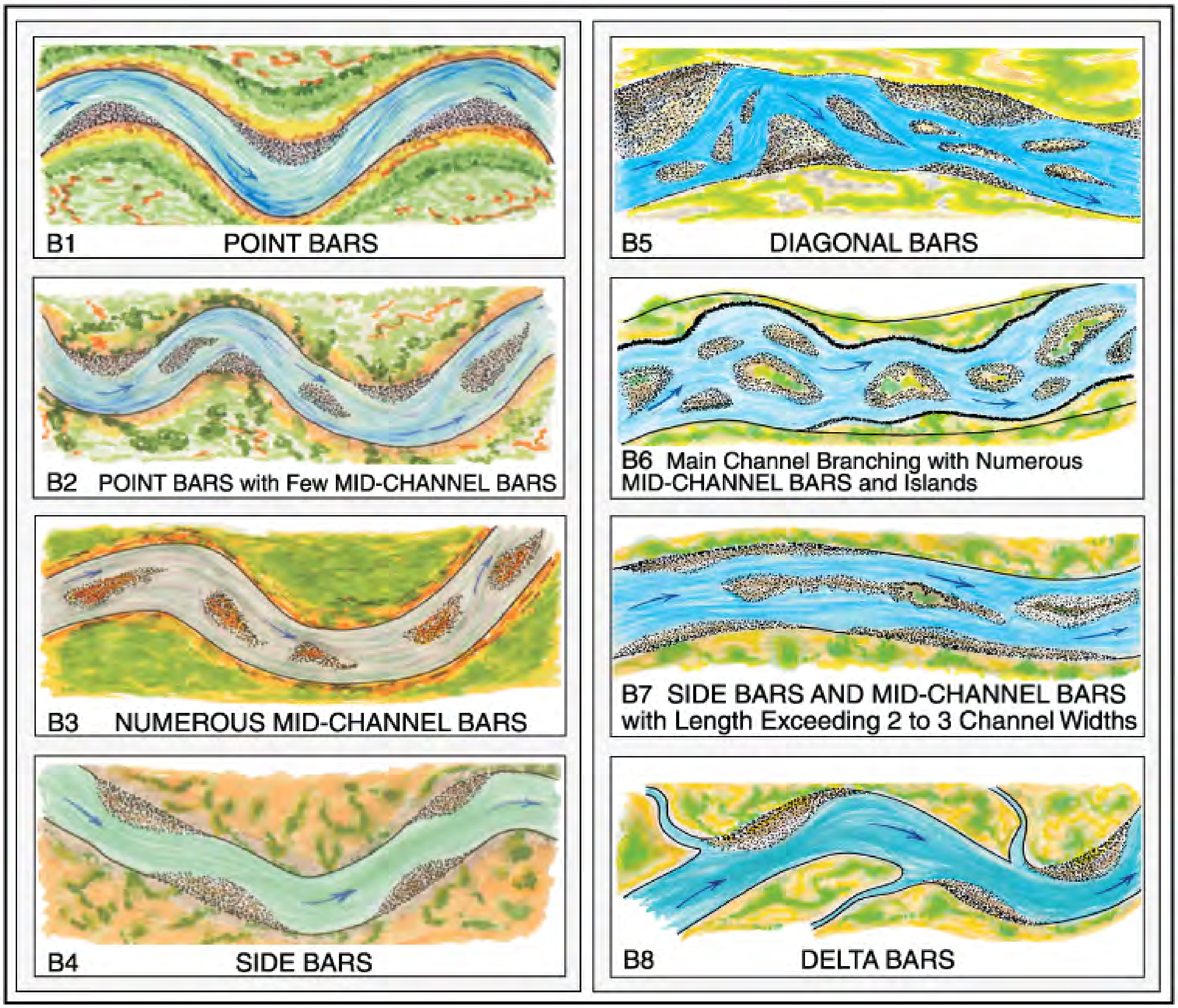
M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns					
Stream: **Fourmile Canyon Creek**		Reach: **Reach 4**			
Observers: **Lucas Babbitt**		Date: **8/20/2015**			
List ALL CATEGORIES that APPLY ☞	**B1**				

Various Depositional Features modified from Galay et al. (1973)

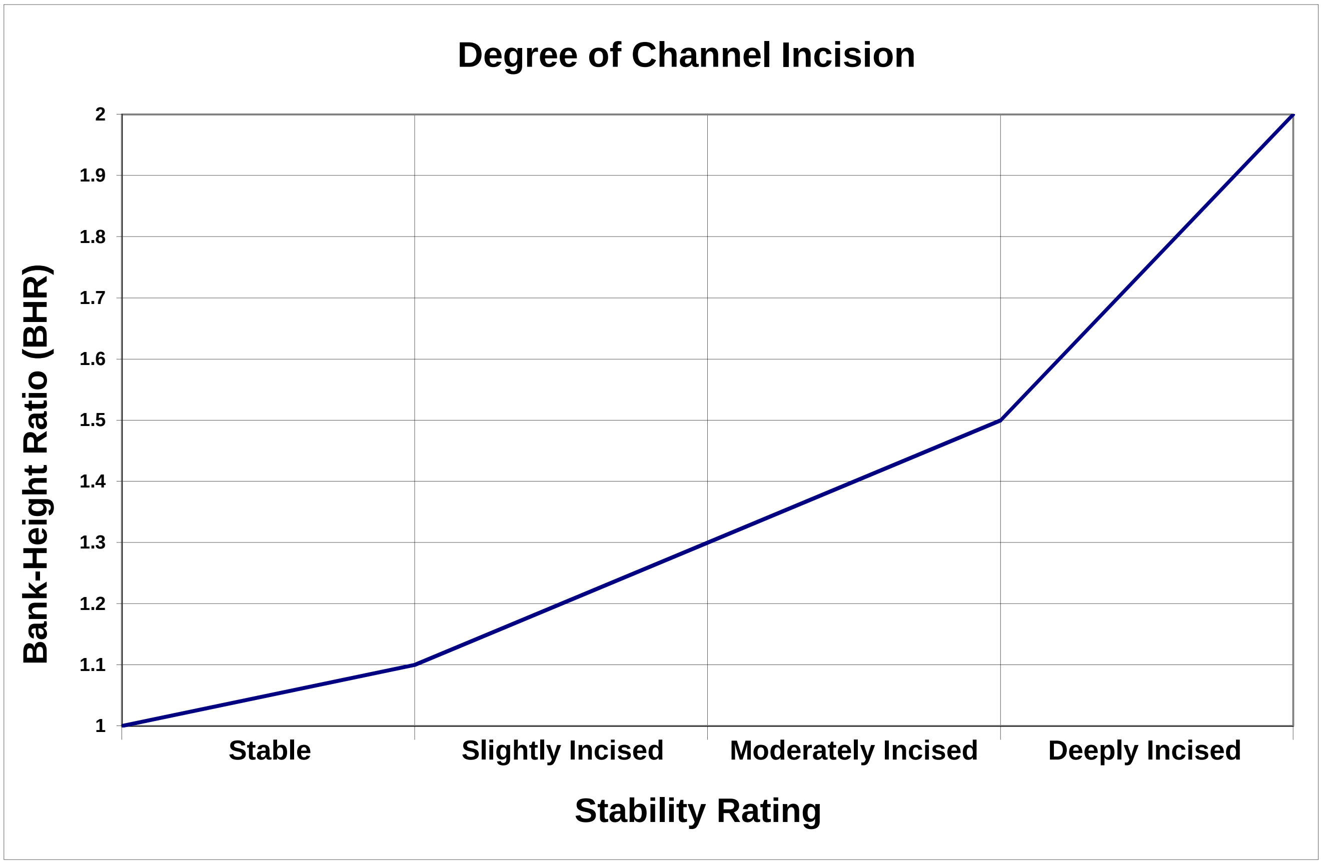


Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream: **Fourmile Canyon Creek**		Location: **Reach 4**	
Observers: **Lucas Babbitt**		Date: **8/20/2015**	
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☑
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☐
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

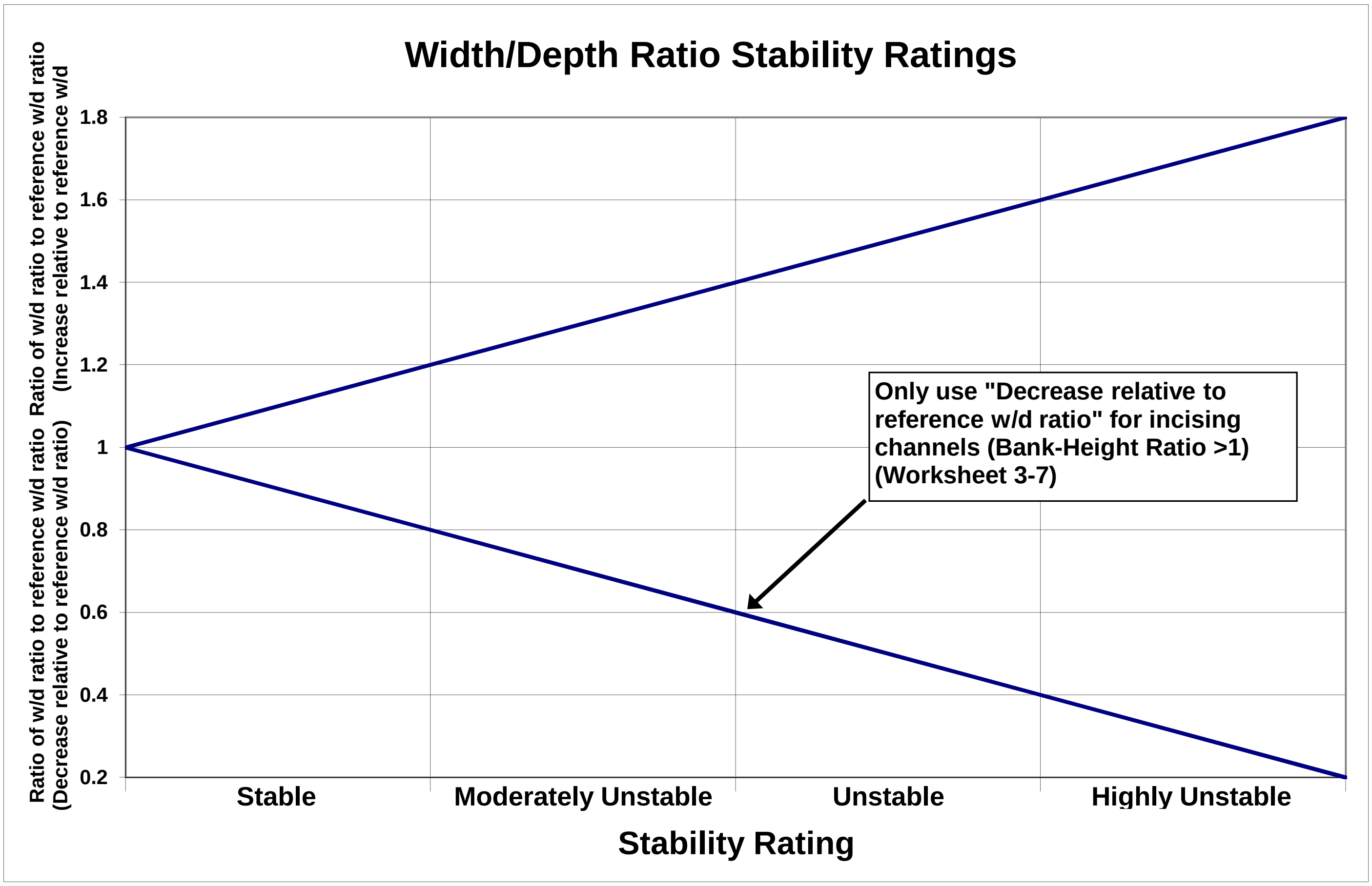
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision			
Low Bank Height:	0	Bank-Height Ratio:	0.0
Max Bankfull Depth:	0		
Degree of Channel Incision Stability Rating ☞		Slightly Incised	



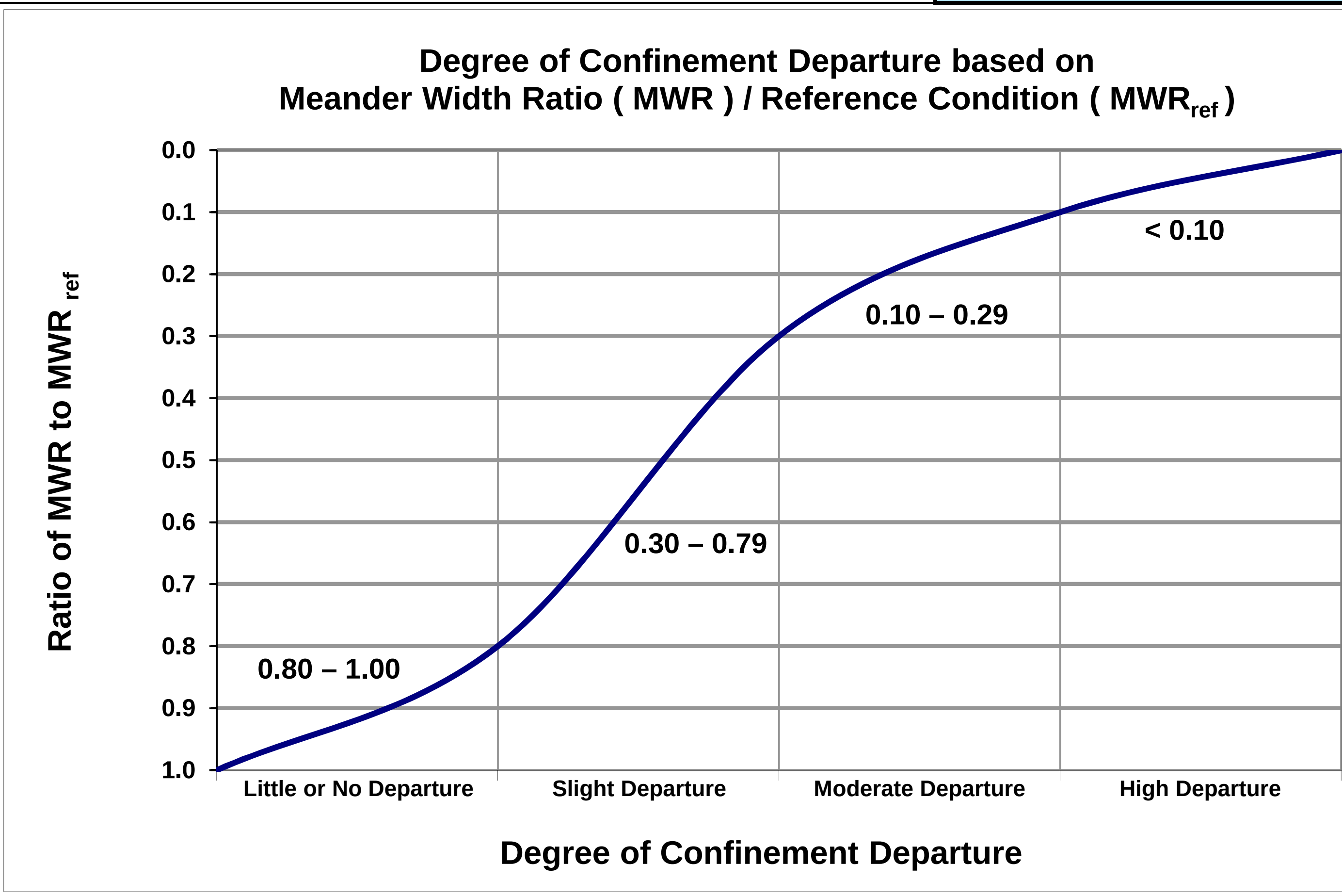
Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State			
Existing Width/Depth Ratio:	**21.87**	Ratio of existing W/d to reference W/d:	**0.95**
Reference Width/Depth Ratio:	**23**		
Width/Depth Ratio State Stability Rating ☞		**Moderately Unstable**	



Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement			
Existing Meander Width Ratio (MWR):	0.73	Ratio of MWR to MWR_{ref}:	0.18
Reference Meander Width Ratio (MWR_{ref}):	4		
Degree of Confinement Stability Rating ☞		Confined	



Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**		Stream Type: **B 4**		
Location:	**Reach 4**		Valley Type: **XIII**		
Observers:	**Lucas Babbitt**		Date: **08/20/2015**		
Enter Required Information for Existing Condition					
28.6	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.458	D_{max}	Largest particle from bar sample (ft)	**139.7**	**(mm)**	304.8 mm/ft
0.03521	S	Existing bankfull water surface slope (ft/ft)			
1.13	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress					
0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$	
4.89	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$	
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**	
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample					
	d	Required bankfull mean depth (ft)	$d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)	
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample					
	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)	
Check: ☑ Stable ☐ Aggrading ☐ Degrading					

Sediment Competence Using Dimensional Shear Stress		
2.483		Bankfull shear stress $\tau = \gamma d S$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **201.1**	CO **296.7**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **1.75**	CO **0.891**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **0.80**	CO **0.41**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0248**	CO **0.0126**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth
Check: ☑ Stable ☐ Aggrading ☐ Degrading		

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream: **Fourmile Canyon Creek, Reach - Reach 4**	
Basin:	Drainage Area: **3148.8** acres **4.92** mi^2
Location:	
Twp.&Rge: **;**	Sec.&Qtr.: **;**
Cross-Section Monuments (Lat./Long.): **40.06097 Lat / 105.31683 Long**	Date: **08/20/15**
Observers: **Lucas Babbitt**	Valley Type: VIII(b)

Parameter	Value	Units
Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**24.71**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.13**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**28.04**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**21.87**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.71**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**46.63**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.89**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**41.94**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.03521**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.07**	

Stream Type **B 4** (See **Figure 2-14**)

Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Fourmile Canyon Creek**	Stream Type: **B 4**
Location: **Reach 4**	Valley Type: **XIII**
Observers: **Lucas Babbitt**	Date: **08/20/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☑ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☐ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**B 4**
Location:	**Reach 4**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**4**
2 **Depositional Patterns (Worksheet 3-5)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**1**
3 **Meander Patterns (Worksheet 3-4)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)**	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**3**
				Total Points	**9**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **< 10** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**B 4**
Location:	**Reach 4**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points (from each row)**
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 **Sediment competence (Worksheet 3-14)**	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope-slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	
2 **Sediment Capacity (POWERSED)**	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	
3 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**4**
4 **Stream Succession States (Worksheet 3-16)**	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	
5 **Depositional Patterns (Worksheet 3-5)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 3-6)**	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**4**
				Total Points	**9**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **< 15** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**B 4**
Location:	**Reach 4**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points** (from each row)
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 **Sediment Competence (Worksheet 3-14)**	Does not indicate excess competence **(2)**	Trend to move larger sizes than *D* $_{100}$ of bar or > D_{84} of bed **(4)**	*D* $_{100}$ of bed moved **(6)**	Particles much larger than *D* $_{100}$ of bed moved **(8)**	
2 **Sediment Capacity (POWERSED)**	Does not indicate excess capacity **(2)**	Slight excess energy: up to 10% increase above reference **(4)**	Excess energy sufficient to increase load up to 50% of annual load **(6)**	Excess energy transporting more than 50% of annual load **(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 3-7)**	1.00 – 1.10 **(2)**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	4
4 **Stream Succession States (Worksheets 3-16 and 3-7)**	Does not indicate incision or degradation **(2)**	If BHR > 1.1 and stream type has W/d between 5–10 **(4)**	If BHR > 1.1 and stream type has W/d less than 5 **(6)**	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) **(8)**	
5 **Confinement** (MWR / MWR_{ref}) **(Worksheet 3-9)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	3
				Total Points	**7**

Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Channel Incision / Degradation**			
	Not Incised **< 12** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Fourmile Canyon Creek**				Stream Type: **B 4**	
Location: **Reach 4**				Valley Type: **XIII**	
Observers: **Lucas Babbitt**				Date: **08/20/2015**	
Channel Enlargement Prediction Criteria **(choose one stability category for each criterion 1–4)**	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 **Successional Stage Shift (Worksheet 3-16)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	
2 **Lateral Stability (Worksheet 3-17)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	2
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	
4 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	
				Total Points	**2**
	Category Point Range				
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐	

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: **Fourmile Canyon Creek**		Stream Type: **B 4**	
Location: **Reach 4**		Valley Type: **XIII**	
Observers:		Date: **08/20/2015**	

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 3-17)	***Stable***	**1**	**1**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	***No Deposition***	**1**	
	Mod. Deposition	**2**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	***Not Incised***	**1**	
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 Channel Enlargement Prediction (Worksheet 3-20)	***No Increase***	**1**	
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**4**	
5 Pfankuch Channel Stability (Worksheet 3-10)	***Good: Stable***	**1**	
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**4**	
		Total Points	**1**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **< 6** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☐	***Very High*** **> 15** ☐

Worksheet 3-22. Summary of stability condition categories.

1	Stream:	**Fourmile Canyon Creek** — Location: **Reach 4**
2	Observers:	**Lucas Babbitt** — Date: **8/20/2015** — Stream Type: **B 4** — Valley Type: **XIII**
3–4	**Channel Dimension**	Mean Bankfull Depth (ft): **1.13** — Bankfull Width (ft): **24.71** — Cross-Sectional Area (ft^2): **28.04** — Width/Depth Ratio: **21.87** — Entrenchment Ratio: **1.89**
5–6	**Channel Pattern**	Mean: / Range: — λ/W_{bkf}: **4.69** / **3.97 - 6.11** — L_m/W_{bkf}: **4.78** / **4.78 - 4.78** — R_c/W_{bkf}: **1.78** / **0.28 - 4.65** — MWR: **0.73** / **0.53 - 0.93** — Sinuosity: **1.07**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec): **4.798** — Bankfull Discharge (Q_{bkf}): **134.536** — Estimation Method: — Drainage Area (mi^2): **4.92**
9	**River Profile & Bed Features**	Check: ☐ Riffle/Pool ☐ Step/Pool ☐ Plane Bed ☐ Convergence/Divergence ☐ Dunes/Antidunes/Smooth Bed
10–12		Max Bankfull Depth (ft): Riffle **1.71**, Pool **1.56** — Depth Ratio (max to mean): Riffle **1.51**, Pool **1.53** — Pool-to-Pool Spacing: Ratio **0** — Slope: Valley: **0.033**, Water Surface: **0.03521**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation — Current Composition/Density: **See description** — Potential Composition/Density: **Same as existing native speci** — Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**
15–16		Flow Regime: **P 1 2 8** — Stream Size & Order: **S-4(2)** — Meander Patterns: **M1** — Depositional Patterns: **B1** — Debris/Channel Blockages: **D2 D10**
17–18		Degree of Incision (Bank-Height Ratio): **0** — Degree of Incision Stability Rating: **Slightly Incised** — Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **80 -**
19–20		Width/depth Ratio (W/d): **31.61** — Reference W/d Ratio (W/d_{ref}): **23** — Width/Depth Ratio State (W/d) / (W/d_{ref}): **1.37** — W/d Ratio State Stability Rating: **Moderately Unstable**
21–22		Meander Width Ratio (MWR): **0.73** — Reference MWR_{ref}: **4** — Degree of confinement (MWR / MWR_{ref}): **0.1825** — MWR / MWR_{ref} Stability Rating: **Moderately Unstable**
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft): **0** — Annual Streambank Erosion Rate: **0** (tons/yr) **0** (tons/yr/ft) — Curve Used: — Remarks:
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity ☐ Insufficient Capacity ☐ Excess Capacity — Remarks:
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm): **139.7** — $\tau =$ **0.891** — $\tau^* =$ **0** — Existing Depth: **0** — Required Depth: **0.41** — Existing Slope: **####** — Required Slope: **####**
28–29	**Successional Stage Shift**	→ → → → → — Existing Stream State (Type): **B 4** — Potential Stream State (Type):
30	**Lateral Stability**	☑ *Stable* ☐ *Mod. Unstable* ☐ *Unstable* ☐ *Highly Unstable* — Remarks/causes:
31	**Vertical Stability (Aggradation)**	☐ *No Deposition* ☐ *Mod. Deposition* ☐ *Ex. Deposition* ☐ *Aggradation* — Remarks/causes:
32	**Vertical Stability (Degradation)**	☐ *Not Incised* ☐ *Slightly Incised* ☐ *Mod. Incised* ☐ *Degradation* — Remarks/causes:
33	**Channel Enlargement**	☐ *No Increase* ☐ *Slight Increase* ☐ *Mod. Increase* ☐ *Extensive* — Remarks/causes:
34–35	**Sediment Supply (Channel Source)**	☐ *Low* ☐ *Moderate* ☐ *High* ☐ *Very High* — Remarks/causes:

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 5
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	4
Mass Wasting:	6
Debris Jam Potential:	4
Vegetative Protection:	9

Lower Bank

Channel Capacity:	3
Bank Rock Content:	4
Obstructions to Flow:	4
Cutting:	12
Deposition:	12

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	12
Scouring and Deposition:	12
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	High
Stream Bed Stability:	
W/D Condition:	
Stream Type:	

Rating - 96

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek**	Location: **Reach 5**							
Observers: **Lucas Babbitt**	Date: **8/20/2015**							
List ALL COMBINATIONS that APPLY..............☞	**P**	**1**	**2**	**8**				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order

Stream:	**Fourmile Canyon Creek**
Location:	**Reach 5**
Observers:	**Lucas Babbitt**
Date:	**8/20/2015**

Stream Size Category and Order ☞ **S-4(2)**

Category	STREAM SIZE: Bankfull width		Check (✓) appropriate category
	meters	feet	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐

Stream Order

Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).

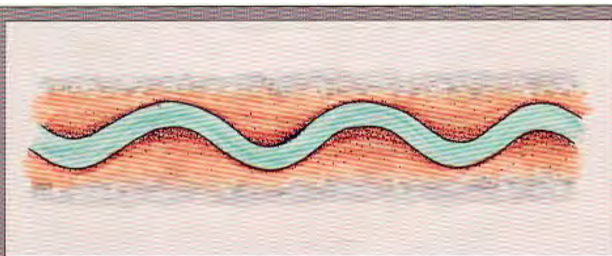
Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

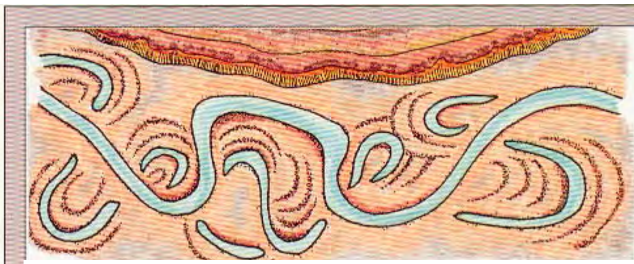
Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 5**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

List ALL CATEGORIES that APPLY ☞	**M1**	**M4**	**M6**		

Various Meander Pattern variables modified from Galay et al. (1973)

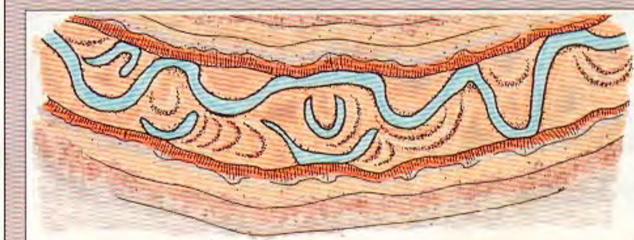


M1 REGULAR MEANDERS



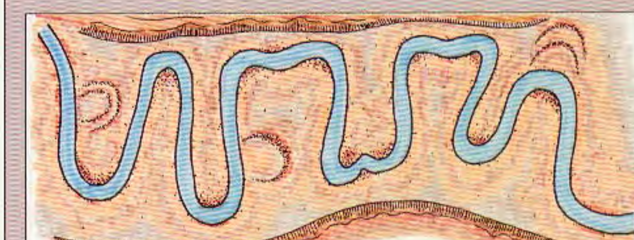
M5 UNCONFINED MEANDER SCROLLS

M2 TORTUOUS MEANDERS

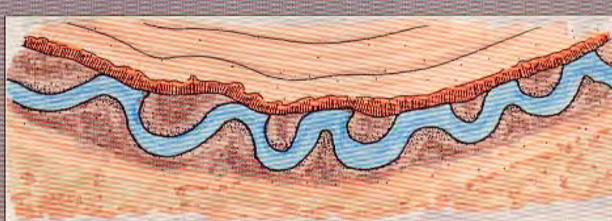


M6 CONFINED MEANDER SCROLLS

M3 IRREGULAR MEANDERS



M7 DISTORTED MEANDER LOOPS



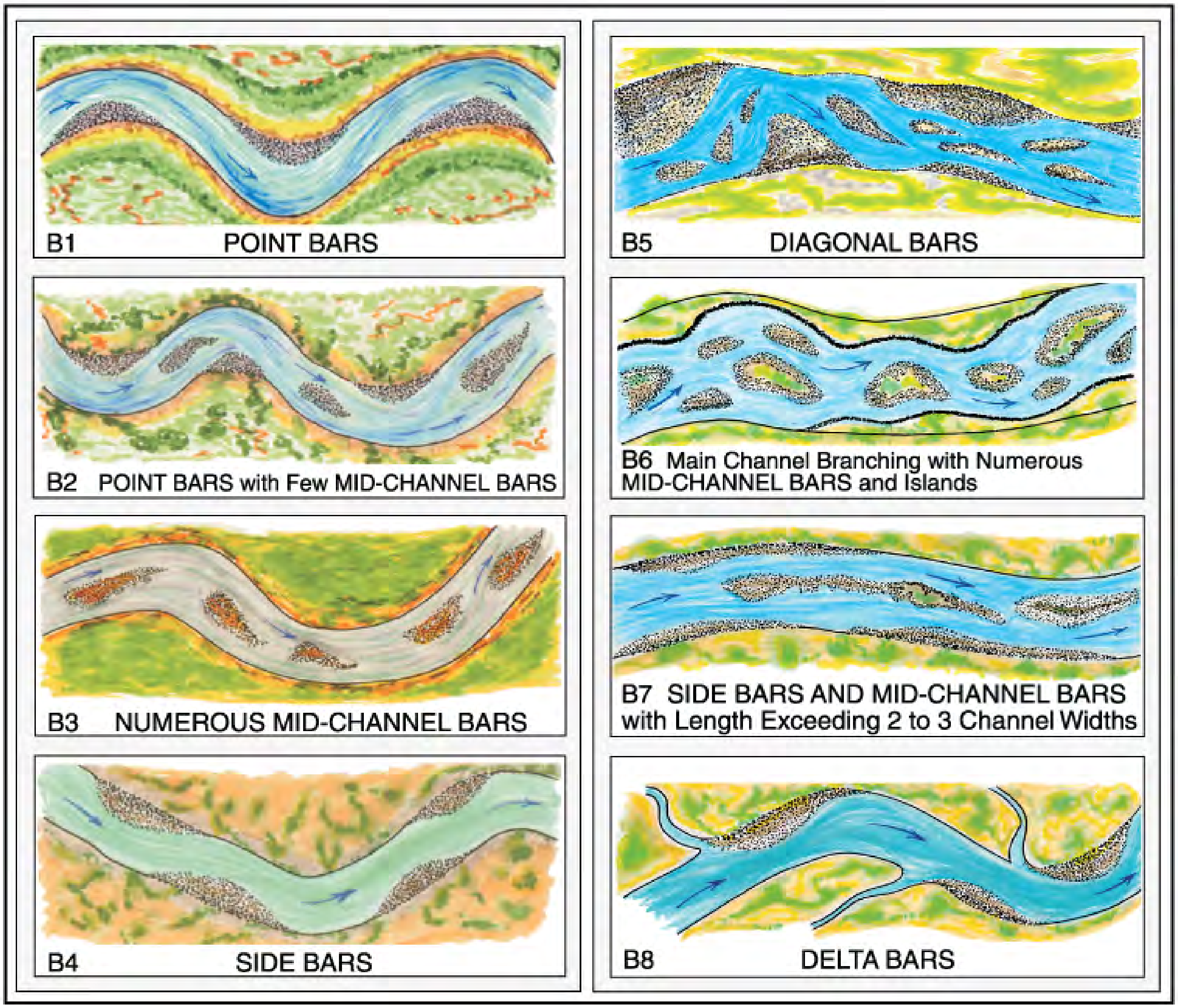
M4 TRUNCATED MEANDERS

M8 IRREGULAR MEANDERS with oxbows and

Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns					
Stream: **Fourmile Canyon Creek**		Reach: **Reach 5**			
Observers: **Lucas Babbitt**		Date: **8/20/2015**			
List ALL CATEGORIES that APPLY ☞	**B1**	**B3**	**B4**	**B5**	

Various Depositional Features modified from Galay et al. (1973)

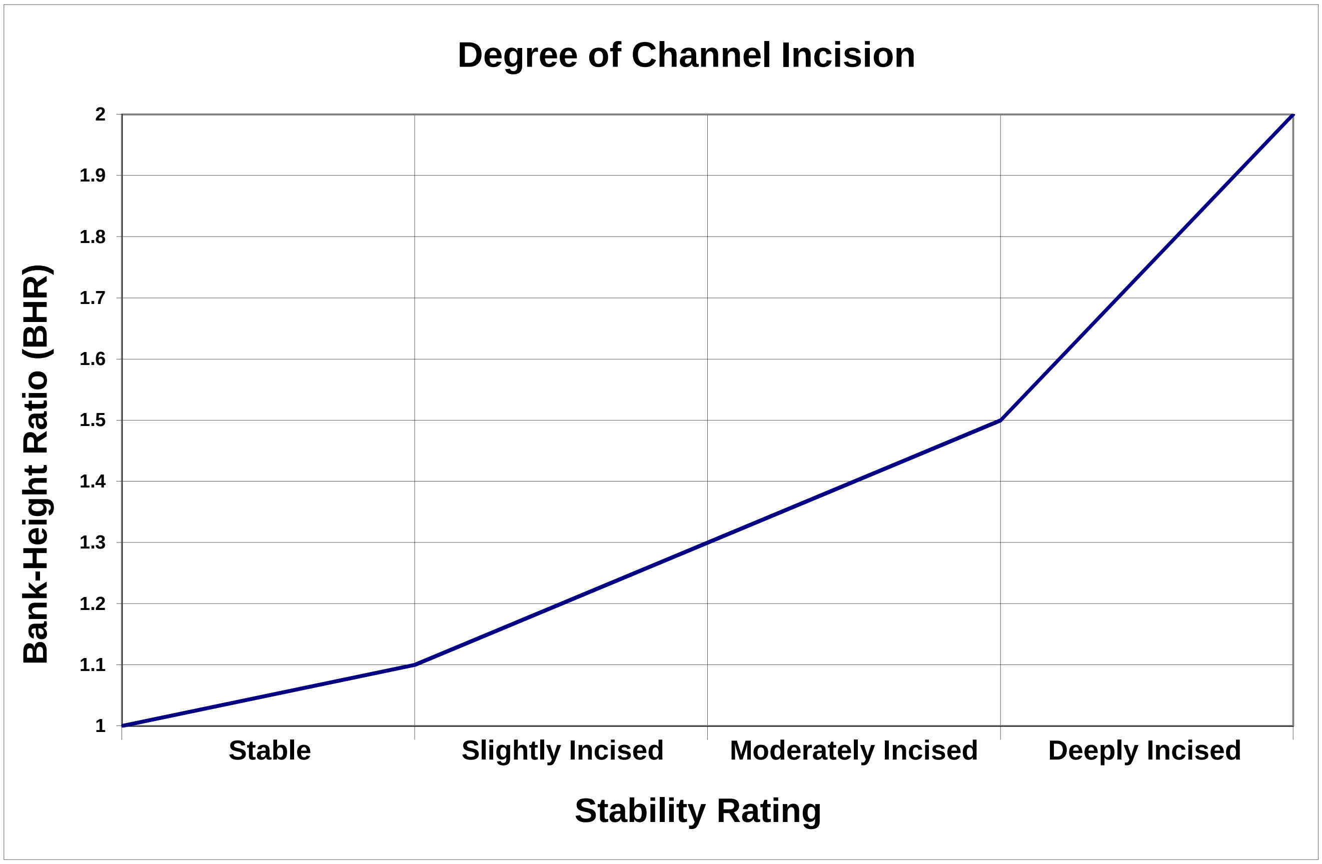


Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages				
Stream:	**Fourmile Canyon Creek**	Location: **Reach 5**		
Observers:	**Lucas Babbitt**	Date: **8/20/2015**		
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**	
D1	None	Minor amounts of small, floatable material.	☐	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☐	
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☑	
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑	

Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision			
Low Bank Height:	**2.39**	Bank-Height Ratio:	**0.0**
Max Bankfull Depth:	**0**		
Degree of Channel Incision Stability Rating ☞			

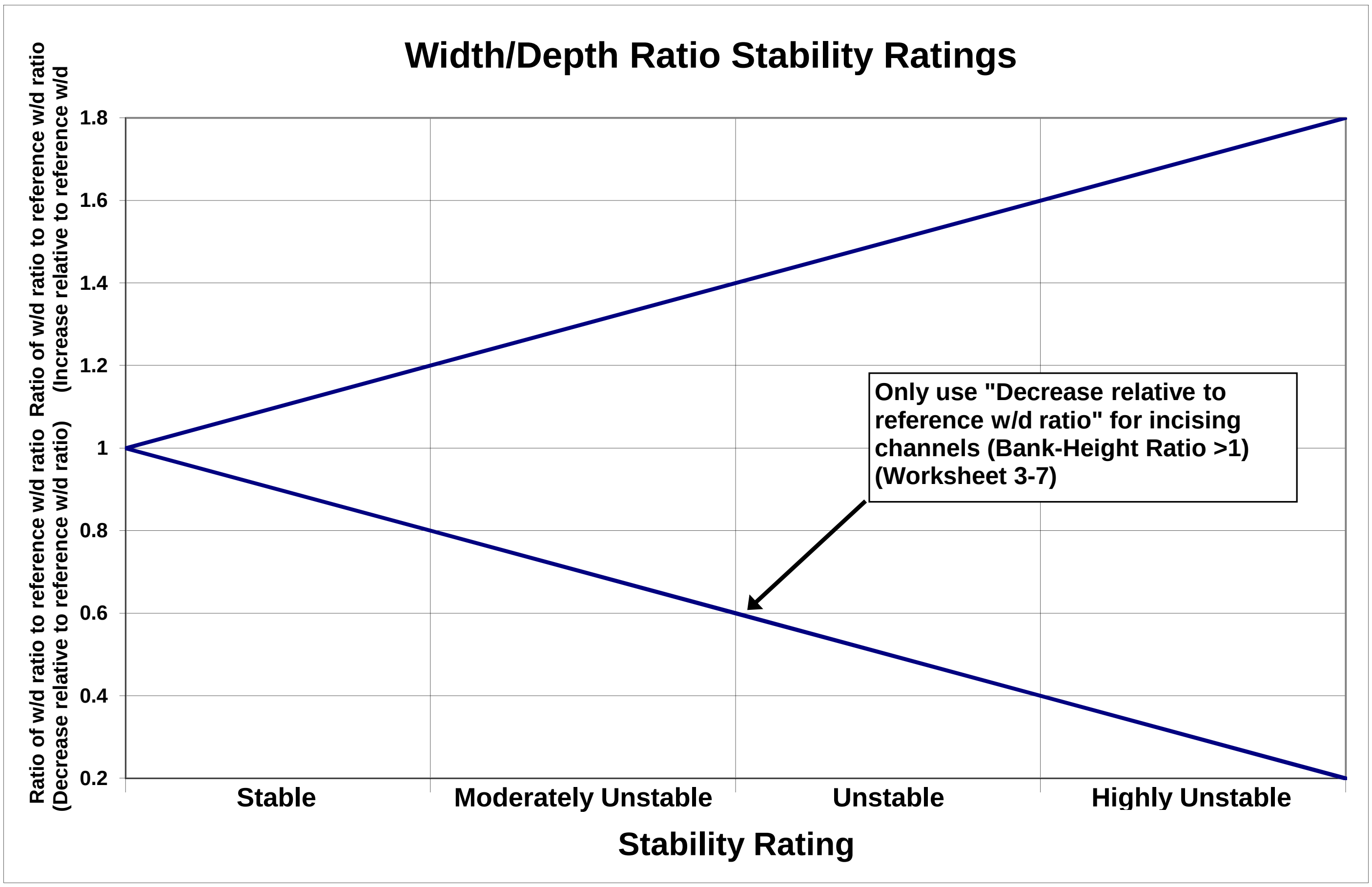


Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State

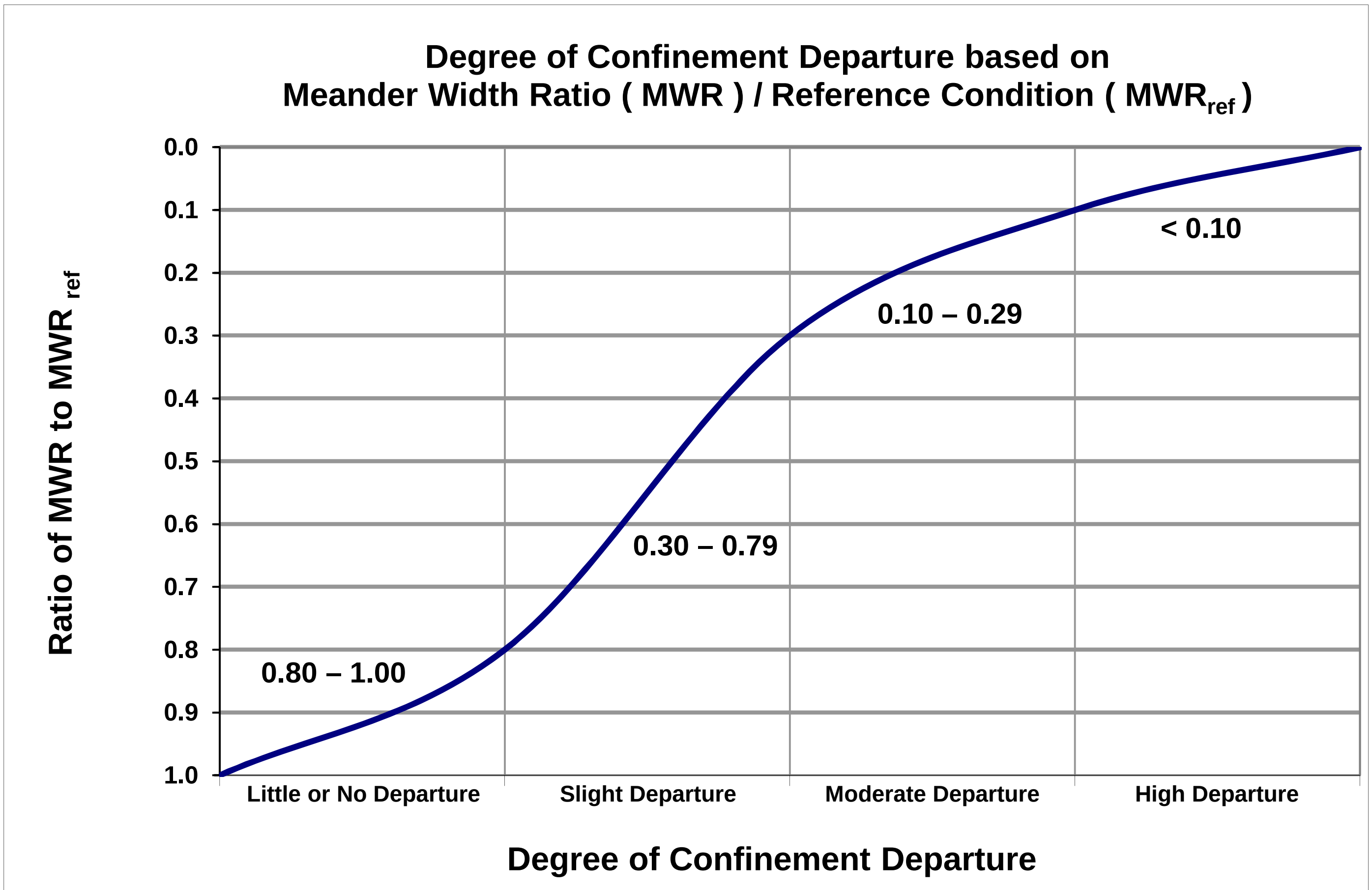
Existing Width/Depth Ratio:	0	Ratio of existing W/d to reference W/d:	0.00
Reference Width/Depth Ratio:	23		

Width/Depth Ratio State Stability Rating ☞	



Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement			
Existing Meander Width Ratio (MWR):	0	Ratio of MWR to MWR_{ref}:	0.00
Reference Meander Width Ratio (MWR_{ref}):	4		
Degree of Confinement Stability Rating ☞			



Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Fourmile Canyon Creek**	Stream Type:
Location: **Reach 5**	Valley Type: **VIII**
Observers: **Lucas Babbitt**	Date: **08/20/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☐ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☐ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Fourmile Canyon Creek**	Stream Type:	
Location:	**Reach 5**	Valley Type:	**VIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 W/d Ratio State (Worksheet 3-8)	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	
2 Depositional Patterns (Worksheet 3-5)	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**4**
3 Meander Patterns (Worksheet 3-4)	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**3**
4 Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5 Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	
				Total Points	**7**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **< 10** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	
Location:	**Reach 5**	Valley Type:	**VIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points** (from each row)
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 **Sediment competence (Worksheet 3-14)**	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope- slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	
2 **Sediment Capacity (POWERSED)**	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	
3 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	
4 **Stream Succession States (Worksheet 3-16)**	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	
5 **Depositional Patterns (Worksheet 3-5)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 3-6)**	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**4**
				Total Points	**5**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **< 15** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	
Location:	**Reach 5**	Valley Type:	**VIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points** (from each row)
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 **Sediment Competence** (Worksheet 3-14)	Does not indicate excess competence **(2)**	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed **(4)**	D_{100} of bed moved **(6)**	Particles much larger than D_{100} of bed moved **(8)**	
2 **Sediment Capacity (POWERSED)**	Does not indicate excess capacity **(2)**	Slight excess energy: up to 10% increase above reference **(4)**	Excess energy sufficient to increase load up to 50% of annual load **(6)**	Excess energy transporting more than 50% of annual load **(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 3-7)**	1.00 – 1.10 **(2)**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	
4 **Stream Succession States (Worksheets 3-16 and 3-7)**	Does not indicate incision or degradation **(2)**	If BHR > 1.1 and stream type has W/d between 5–10 **(4)**	If BHR > 1.1 and stream type has W/d less than 5 **(6)**	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) **(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	
				Total Points	**0**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **< 12** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream:	**Fourmile Canyon Creek**			Stream Type:	
Location:	**Reach 5**			Valley Type:	**VIII**
Observers:	**Lucas Babbitt**			Date:	**08/20/2015**

Channel Enlargement Prediction Criteria (choose one stability category for each criterion 1–4)	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 **Successional Stage Shift (Worksheet 3-16)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	
2 **Lateral Stability (Worksheet 3-17)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	2
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	
4 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	
				Total Points	**2**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: **Fourmile Canyon Creek**		Stream Type:	
Location: **Reach 5**		Valley Type:	**VIII**
Observers:		Date:	**08/20/2015**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	Stability Rating	Points	Selected Points
1 Lateral Stability (Worksheet 3-17)	*Stable*	1	1
	Mod. Unstable	2	
	Unstable	3	
	Highly Unstable	4	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	*No Deposition*	1	
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	*Not Incised*	1	
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 Channel Enlargement Prediction (Worksheet 3-20)	*No Increase*	1	
	Slight Increase	2	
	Mod. Increase	3	
	Extensive	4	
5 Pfankuch Channel Stability (Worksheet 3-10)	*Good: Stable*	1	
	Fair: Mod. Unstable	2	
	Poor: Unstable	4	
		Total Points	1

Overall Sediment Supply Rating (use total points and check stability rating)	Category Point Range			
	Low < 6 ☐	*Moderate* 6 – 10 ☐	*High* 11 – 15 ☐	*Very High* > 15 ☐

Worksheet 3-22. Summary of stability condition categories.

	A	B – AM
1	Stream:	**Fourmile Canyon Creek** ; Location: **Reach 5**
2	Observers:	**Lucas Babbitt** ; Date: **8/20/2015** ; Stream Type: ; Valley Type: **VIII**
3–4	**Channel Dimension**	Mean Bankfull Depth (ft): **0** ; Bankfull Width (ft): **0** ; Cross-Sectional Area (ft^2): **0** ; Width/Depth Ratio: **0** ; Entrenchment Ratio:
5–6	**Channel Pattern**	Mean: / Range: ; λ/W_{bkf}: ; L_m/W_{bkf}: ; R_c/W_{bkf}: ; MWR: ; Sinuosity: **1.07**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec): **0** ; Bankfull Discharge (Q_{bkf}): **0** ; Estimation Method: ; Drainage Area (mi^2): **4.92**
9	**River Profile & Bed Features**	Check: ☐ Riffle/Pool ☐ Step/Pool ☐ Plane Bed ☐ Convergence/Divergence ☐ Dunes/Antidunes/Smooth Bed
10–12		Max Bankfull Depth (ft): Riffle **0**, Pool **0** ; Depth Ratio (max to mean): Riffle , Pool ; Pool-to-Pool Spacing: Ratio **0** ; Slope: Valley: **0.058** ; Water Surface: **0**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation — Current Composition/Density: **See description** ; Potential Composition/Density: **Same as existing native speci** ; Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**
15–16		Flow Regime: **P 1 2 8** ; Stream Size & Order: **S-4(2)** ; Meander Patterns: **M1 M4 M6** ; Depositional Patterns: **B1 B3 B4 B5** ; Debris/Channel Blockages: **D3 D10**
17–18		Degree of Incision (Bank-Height Ratio): **0** ; Degree of Incision Stability Rating: ; Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **96 -**
19–20		Width/depth Ratio (W/d): **0** ; Reference W/d Ratio (W/d_{ref}): **23** ; Width/Depth Ratio State $(W/d) / (W/d_{ref})$: **0.00** ; W/d Ratio State Stability Rating:
21–22		Meander Width Ratio (MWR): **0** ; Reference MWR_{ref}: **4** ; Degree of confinement (MWR / MWR_{ref}): **0** ; MWR / MWR_{ref} Stability Rating:
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft): **0** ; Annual Streambank Erosion Rate: **0** (tons/yr) **0** (tons/yr/ft) ; Curve Used: ; Remarks:
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity ☐ Insufficient Capacity ☐ Excess Capacity ; Remarks:
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm): **127** ; $\tau =$ **0.783** ; $\tau^* =$ **0** ; Existing Depth: **0** ; Required Depth: **0** ; Existing Slope: **####** ; Required Slope: **####**
28–29	**Successional Stage Shift**	→ → → → → ; Existing Stream State (Type): ; Potential Stream State (Type):
30	**Lateral Stability**	☑ *Stable* ☐ *Mod. Unstable* ☐ *Unstable* ☐ *Highly Unstable* ; Remarks/causes:
31	**Vertical Stability (Aggradation)**	☐ *No Deposition* ☐ *Mod. Deposition* ☐ *Ex. Deposition* ☐ *Aggradation* ; Remarks/causes:
32	**Vertical Stability (Degradation)**	☐ *Not Incised* ☐ *Slightly Incised* ☐ *Mod. Incised* ☐ *Degradation* ; Remarks/causes:
33	**Channel Enlargement**	☐ *No Increase* ☐ *Slight Increase* ☐ *Mod. Increase* ☐ *Extensive* ; Remarks/causes:
34–35	**Sediment Supply (Channel Source)**	☐ *Low* ☐ *Moderate* ☐ *High* ☐ *Very High* ; Remarks/causes:

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 6
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	4
Mass Wasting:	6
Debris Jam Potential:	4
Vegetative Protection:	6

Lower Bank

Channel Capacity:	4
Bank Rock Content:	4
Obstructions to Flow:	6
Cutting:	12
Deposition:	12

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	12
Scouring and Deposition:	18
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	High
Stream Bed Stability:	
W/D Condition:	
Stream Type:	C4

Rating - 102
Condition - Fair

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream: **Fourmile Canyon Creek, Reach - Reach 6**			
Basin:	Drainage Area: **3148.8** acres	**4.92**	mi^2
Location:			
Twp.&Rge: **;**	Sec.&Qtr.: **;**		
Cross-Section Monuments (Lat./Long.): **40.06286 Lat / 105.31333 Long**		Date: **08/20/15**	
Observers: **Lucas Babbitt**		Valley Type: VIII(b)	

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**13.58**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.44**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**19.55**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**9.43**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**2.57**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**65.49**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**4.82**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**24.48**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.01969**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.03**	

Stream Type **C4** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek**		Location: **Reach - Reach 6**	
Observers: **Lucas Babbitt**	Date: **08/20/15**	Valley Type: **XIII**	Stream Type: **C4**

River Reach Dimension Summary Data.....1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	6.79	0	13.6	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	9.78	0.00	19.55
Mean Riffle Depth (d_{bkf})	0.72	0	1.44	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	4.72	0.00	9.43
Maximum Riffle Depth (d_{max})	1.29	0	2.57	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	0.893	0.000	1.785
Width of Flood-Prone Area (W_{fpa})	32.8	0	65.5	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	2.412	0.000	4.823
Riffle Inner Berm Width (W_{ib})	2.99	0	5.99	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.221	0.000	0.441
Riffle Inner Berm Depth (d_{ib})	0.23	0	0.46	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.161	0.000	0.322
Riffle Inner Berm Area (A_{ib})	1.39	0	2.78	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.071	0.000	0.142
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	6.45	0	12.9					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	13.3	13.3	13.3	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	1.956	1.956	1.956
Mean Pool Depth (d_{bkfp})	1.53	1.53	1.53	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	2.125	2.125	2.125
Pool Cross-Sectional Area (A_{bkfp})	20.4	20.4	20.4	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	2.082	2.082	2.082
Maximum Pool Depth (d_{maxp})	2.4	2.4	2.4	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	3.333	3.333	3.333
Pool Inner Berm Width (W_{ibp})	6.4	6.4	6.4	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.482	0.482	0.482
Pool Inner Berm Depth (d_{ibp})	0.28	0.28	0.28	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.183	0.183	0.183
Pool Inner Berm Area (A_{ibp})	1.79	1.79	1.79	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.088	0.088	0.088
Point Bar Slope (S_{pb})	0.000	0.000	0.000	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	####	####	####

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	12.9	12.9	12.9	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	1.900	1.900	1.900
Mean Run Depth (d_{bkfr})	1.42	1.42	1.42	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	1.972	1.972	1.972
Run Cross-Sectional Area (A_{bkfr})	18.3	18.3	18.3	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	1.869	1.869	1.869
Maximum Run Depth (d_{maxr})	2.97	2.97	2.97	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	4.125	4.125	4.125
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	9.09	9.09	9.09	ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	17.6	17.6	17.6	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	2.598	2.598	2.598
Mean Glide Depth (d_{bkfg})	1.14	1.14	1.14	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	1.583	1.583	1.583
Glide Cross-Sectional Area (A_{bkfg})	20	20	20	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	2.049	2.049	2.049
Maximum Glide Depth (d_{maxg})	1.55	1.55	1.55	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	2.153	2.153	2.153
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	15.5	15.5	15.5	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	0.000	0.000	0.000
Glide Inner Berm Width (W_{ibg})	0	0	0	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Depth (d_{ibg})	0	0	0	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Area (A_{ibg})	0	0	0	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.000	0.000	0.000

Step**

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	0	0	0	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	0.000	0.000	0.000
Mean Step Depth (d_{bkfs})	0	0	0	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	0.000	0.000	0.000
Step Cross-Sectional Area (A_{bkfs})	0	0	0	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	0.000	0.000	0.000
Maximum Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0.000	0.000	0.000
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	0	0	0					

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek**		Location: **Reach - Reach 6**	
Observers: **Lucas Babbitt**	Date: **08/20/15**	Valley Type: **XIII**	Stream Type: **C4**

River Reach Summary Data.....2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**5.656**	ft/sec	Estimation Method	**U/U***	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**110.575**	cfs	Drainage Area	**4.92**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**262**	**95**	**430**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**#####**	**#####**	**####**
Stream Meander Length (L_m)	**157**	**157**	**157**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**#####**	**#####**	**####**
Radius of Curvature (R_c)	**58**	**26**	**98**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**8.542**	**3.829**	**####**
Belt Width (W_{blt})	**41**	**30**	**52**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**6.038**	**4.418**	**7.658**
Arc Length (L_a)	**0**	**0**	**0**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**0.000**	**0.000**	**0.000**
Riffle Length (L_r)	**36.8**	**10.1**	**63.5**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**5.420**	**1.483**	**9.355**
Individual Pool Length (L_p)	**10.9**	**9.5**	**12.1**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**1.604**	**1.399**	**1.784**
Pool to Pool Spacing (P_s)	**53.9**	**18.7**	**89.2**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**7.943**	**2.756**	**####**

Channel Profile

Valley Slope (S_{val})	**0.021**	ft/ft	Average Water Surface Slope (S)	**0.01969**	ft/ft	Sinuosity (S_{val} / S)	**1.03**
Stream Length (SL)	**781**	ft	Valley Length (VL)	**741**	ft	Sinuosity (SL / VL)	**1.05**

Low Bank Height (LBH)	start **4.08** ft	end **5.13** ft	Max Depth (d_{max})	start **1.62** ft	end **2.52** ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start **2.52**	end **2.04**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.041**	**0.030**	**0.053**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**2.103**	**1.523**	**2.683**
Run Slope (S_{run})	**0.153**	**0.137**	**0.169**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**7.746**	**6.956**	**8.586**
Pool Slope (S_p)	**0.011**	**0.006**	**0.019**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.560**	**0.328**	**0.942**
Glide Slope (S_g)	**0.026**	**0.019**	**0.033**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**1.314**	**0.955**	**1.672**
Step Slope (S_s)	**0.000**	**0.000**	**0.000**	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	**0.000**	**0.000**	**0.000**

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	**0.78**	**0.71**	**0.85**	ft	Max Riffle Depth to Mean Riffle Depth (d_{maxrif} / d_{bkf})	**1.083**	**0.986**	**1.18**
Max Run Depth (d_{maxrun})	**1.19**	**1.02**	**1.29**	ft	Max Run Depth to Mean Riffle Depth (d_{maxrun} / d_{bkf})	**1.653**	**1.417**	**1.79**
Max Pool Depth (d_{maxp})	**1.62**	**1.23**	**2.12**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.25**	**1.708**	**2.94**
Max Glide Depth (d_{maxg})	**0.76**	**0.58**	**0.85**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**1.056**	**0.806**	**1.18**
Max Step Depth (d_{maxs})	**0**	**0**	**0**	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	**0**	**0**	**0**

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**	**0**		D_{16}	**1.89**	**6.08**			mm
% Sand	**17**	**8**		D_{35}	**10.64**	**20.4**			mm
% Gravel	**55**	**53**		D_{50}	**24.48**	**46.58**			mm
% Cobble	**27**	**37**		D_{84}	**86.29**	**128**			mm
% Boulder	**1**	**2**		D_{95}	**145.33**	**180**			mm
% Bedrock	**0**	**0**		D_{100}	**361.99**	**511.99**			mm

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.

[b] Composite sample of riffles and pools within the designated reach. [c] Active bed of a riffle. [d] Height of roughness feature above bed.

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek**	Location: **Reach 6**							
Observers: **Lucas Babbitt**	Date: **8/20/2015**							
List ALL COMBINATIONS that APPLY..............☞	**P**	**1**	**2**	**8**				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order			
Stream:	**Fourmile Canyon Creek**		
Location:	**Reach 6**		
Observers:	**Lucas Babbitt**		
Date:	**8/20/2015**		
Stream Size Category and Order ☞			**S-4(2)**
Category	**STREAM SIZE: Bankfull width**		**Check (✓) appropriate category**
	meters	**feet**	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐
Stream Order			
Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).			

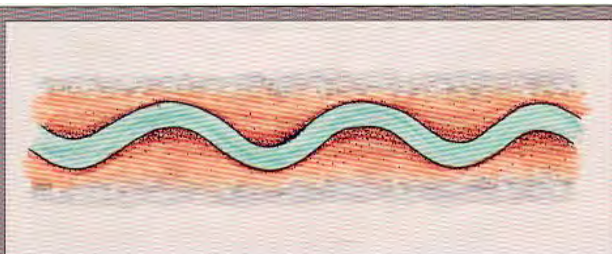
Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 6**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

List ALL CATEGORIES that APPLY ☞	**M2**				

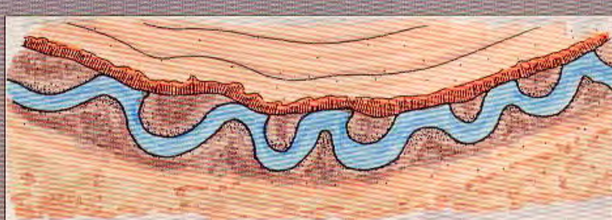
Various Meander Pattern variables modified from Galay et al. (1973)



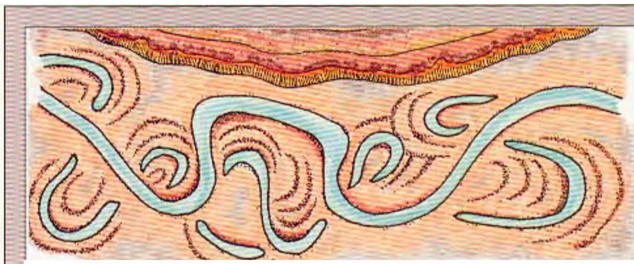
M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

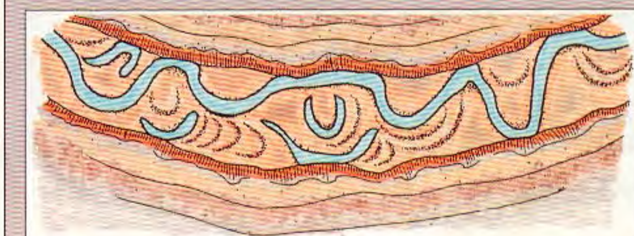
M3 IRREGULAR MEANDERS



M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS

M7 DISTORTED MEANDER LOOPS

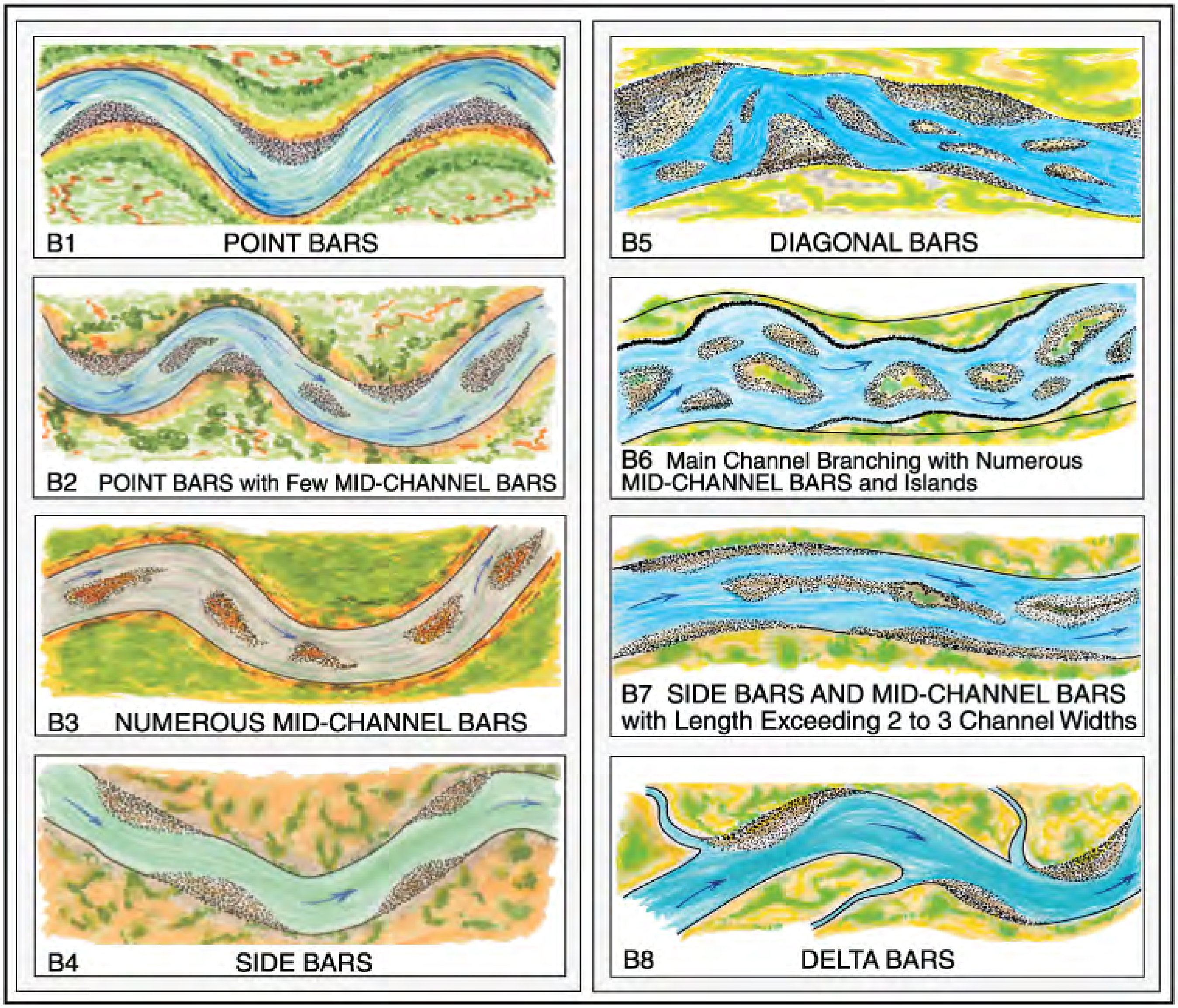
M8 IRREGULAR MEANDERS with oxbows and

Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 6**		
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**		
List ALL CATEGORIES that APPLY ☞	**B5**	**B7**			

Various Depositional Features modified from Galay et al. (1973)



Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages				
Stream:	**Fourmile Canyon Creek**	Location: **Reach 6**		
Observers:	**Lucas Babbitt**	Date: **8/20/2015**		
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**	
D1	None	Minor amounts of small, floatable material.	☐	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☐	
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☐	
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☑	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑	

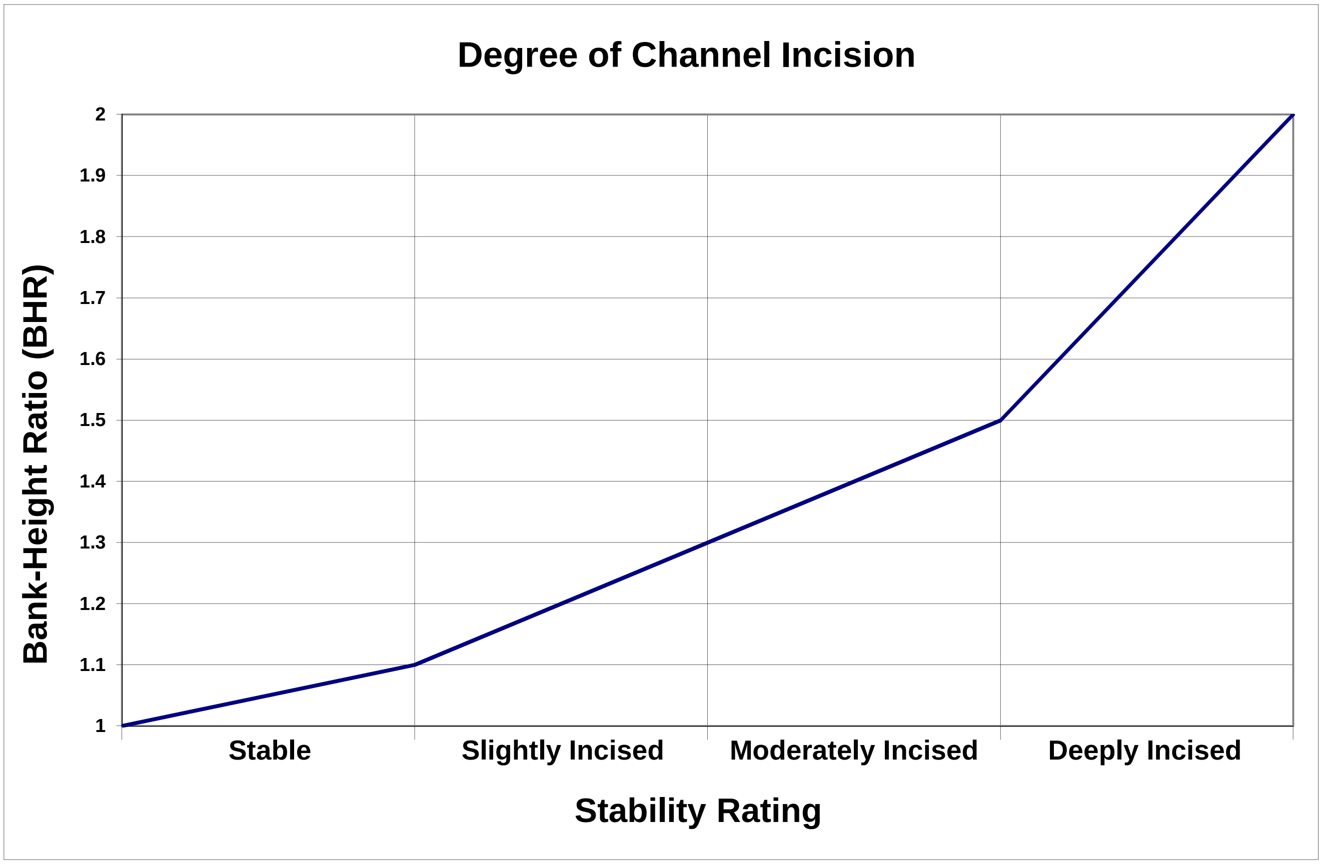
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision

Low Bank Height:	**4.08**
Max Bankfull Depth:	**1.62**

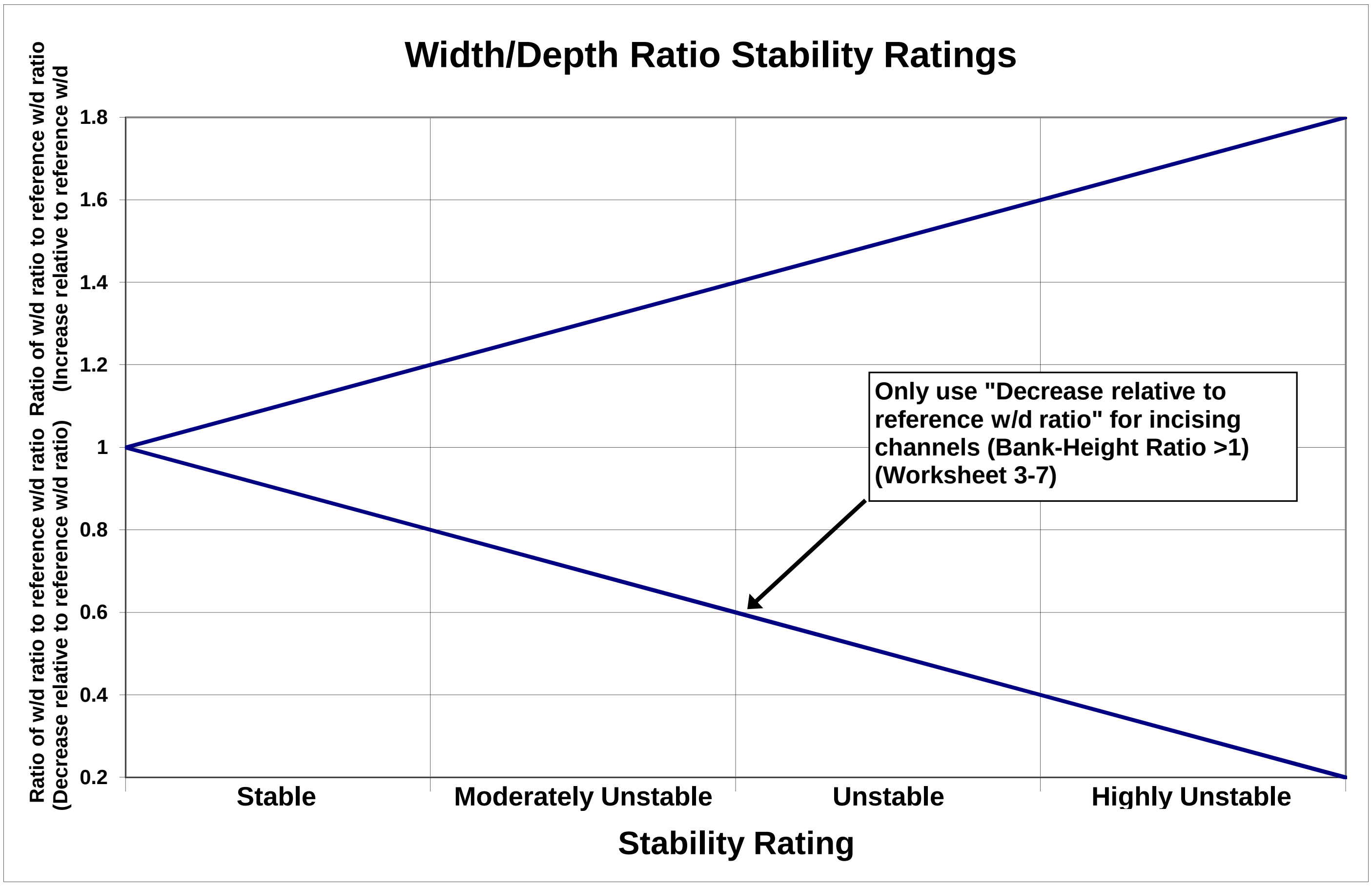
Bank-Height Ratio:	**2.5**

Degree of Channel Incision Stability Rating ☞	**Deeply Incised**



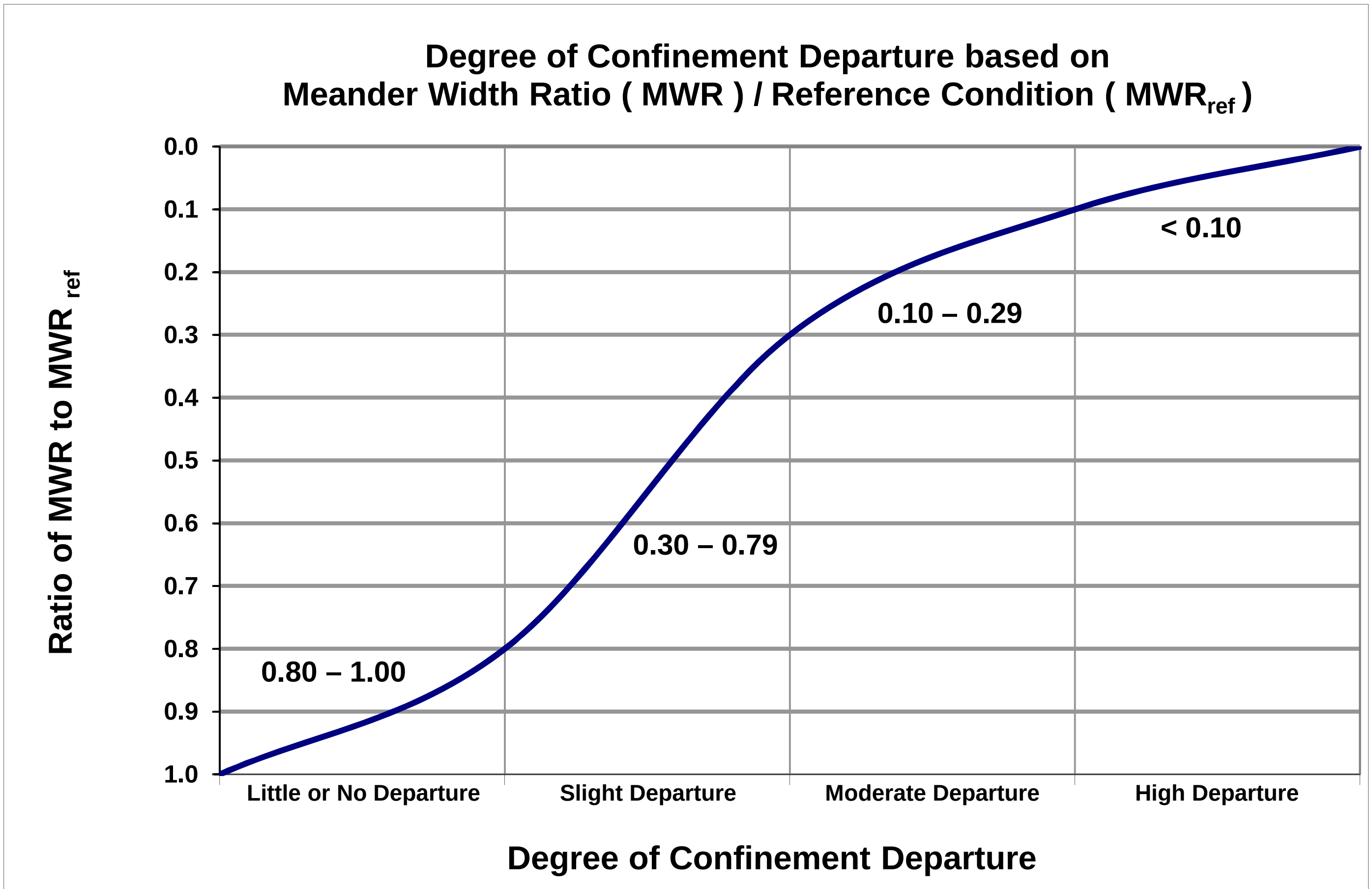
Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State			
Existing Width/Depth Ratio:	9.43	Ratio of existing W/d to reference W/d:	0.41
Reference Width/Depth Ratio:	23		
Width/Depth Ratio State Stability Rating ☞		Stable	



Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement			
Existing Meander Width Ratio (MWR):	3.02	Ratio of MWR to MWR_{ref}:	0.60
Reference Meander Width Ratio (MWR_{ref}):	5		
Degree of Confinement Stability Rating ☞		Moderately Confined	



Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**		Stream Type:	**C4**
Location:	**Reach 6**		Valley Type:	**XIII**
Observers:	**Lucas Babbitt**		Date:	**08/20/2015**

Enter Required Information for Existing Condition

46.6	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.802	D_{max}	Largest particle from bar sample (ft)	**244.475**	**(mm)**	304.8 mm/ft
0.01969	S	Existing bankfull water surface slope (ft/ft)			
1.44	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
5.25	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \dfrac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \dfrac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☑ Aggrading ☐ Degrading

Sediment Competence Using Dimensional Shear Stress

Shields	CO	
1.769		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
141.3	**231.3**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
2.995	**1.908**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
2.44	**1.55**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \dfrac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
0.0333	**0.0212**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \dfrac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☐ Stable ☑ Aggrading ☐ Degrading

Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Fourmile Canyon Creek**	Stream Type: **C4**
Location: **Reach 6**	Valley Type: **XIII**
Observers: **Lucas Babbitt**	Date: **08/20/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☑ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☐ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C4**
Location:	**Reach 6**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**2**
2 **Depositional Patterns (Worksheet 3-5)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**4**
3 **Meander Patterns (Worksheet 3-4)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**3**
4 **Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)**	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**2**
				Total Points	**11**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **< 10** ☐	***Moderately Unstable*** **10 – 12** ☑	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C4**
Location:	**Reach 6**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points** (from each row)
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 **Sediment competence (Worksheet 3-14)**	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope-slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	**6**
2 **Sediment Capacity (POWERSED)**	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	**6**
3 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**2**
4 **Stream Succession States (Worksheet 3-16)**	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	**2**
5 **Depositional Patterns (Worksheet 3-5)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 3-6)**	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**4**
				Total Points	**21**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **< 15** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C4**
Location:	**Reach 6**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points** (from each row)
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 **Sediment Competence** (Worksheet 3-14)	Does not indicate excess competence **(2)**	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed **(4)**	D_{100} of bed moved **(6)**	Particles much larger than D_{100} of bed moved **(8)**	**2**
2 **Sediment Capacity (POWERSED)**	Does not indicate excess capacity **(2)**	Slight excess energy: up to 10% increase above reference **(4)**	Excess energy sufficient to increase load up to 50% of annual load **(6)**	Excess energy transporting more than 50% of annual load **(8)**	**2**
3 **Degree of Channel Incision (BHR) (Worksheet 3-7)**	1.00 – 1.10 **(2)**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**8**
4 **Stream Succession States (Worksheets 3-16 and 3-7)**	Does not indicate incision or degradation **(2)**	If BHR > 1.1 and stream type has W/d between 5–10 **(4)**	If BHR > 1.1 and stream type has W/d less than 5 **(6)**	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) **(8)**	**4**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**2**
				Total Points	**18**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **< 12** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Fourmile Canyon Creek**			Stream Type:	**C4**	
Location: **Reach 6**			Valley Type:	**XIII**	
Observers: **Lucas Babbitt**			Date:	**08/20/2015**	
Channel Enlargement Prediction Criteria **(choose one stability category for each criterion 1–4)**	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 **Successional Stage Shift (Worksheet 3-16)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 3-17)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**4**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**6**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**4**
				Total Points	**16**
	Category Point Range				
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** [ ]	***Slight Increase*** **11 – 16** [x]	***Moderate Increase*** **17 – 24** [ ]	***Extensive*** **> 24** [ ]	

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: **Fourmile Canyon Creek**		Stream Type:	**C4**
Location: **Reach 6**		Valley Type:	**XIII**
Observers:		Date:	**08/20/2015**
Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 3-17)	***Stable***	**1**	**2**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	***No Deposition***	**1**	**3**
	Mod. Deposition	**2**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	***Not Incised***	**1**	**2**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 Channel Enlargement Prediction (Worksheet 3-20)	***No Increase***	**1**	**2**
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**4**	
5 Pfankuch Channel Stability (Worksheet 3-10)	***Good: Stable***	**1**	**2**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**4**	
		Total Points	**11**
	Category Point Range		
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **< 6** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☑
			Very High **> 15** ☐

Worksheet 3-22. Summary of stability condition categories.

	A								
1	Stream:	**Fourmile Canyon Creek**				Location:	**Reach 6**		
2	Observers:	**Lucas Babbitt**		Date:	**8/20/2015**	Stream Type:	**C4**	Valley Type:	**XIII**
3–4	**Channel Dimension**	Mean Bankfull Depth (ft):	**1.44**	Bankfull Width (ft):	**13.58**	Cross-Sectional Area (ft^2):	**19.55**	Width/Depth Ratio: **9.43**	Entrenchment Ratio: **4.82**
5–6	**Channel Pattern**	Mean: / Range:	λ/W_{bkf}: **19.29** / **7.00 - 31.66**	L_m/W_{bkf}:	**11.56** / **11.56 - 11.56**	R_c/W_{bkf}:	**4.27** / **1.91 - 7.22**	MWR: **3.02** / **2.21 - 3.83**	Sinuosity: **1.03**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec):	**5.656**	Bankfull Discharge (Q_{bkf}):	**110.575**	Estimation Method:	**U/U***		Drainage Area (mi^2): **4.92**
9	**River Profile & Bed Features**	Check: ☐ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed			
10–12		Max Bankfull Depth (ft):	Riffle **2.57**	Pool **2.4**	Depth Ratio (max to mean): Riffle **1.78**	Pool **1.57**	Pool-to-Pool Spacing: Ratio **53.93**	Slope — Valley: **0.021**	Water Surface: **0.01969**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation	Current Composition/Density: **See description**		Potential Composition/Density: **Same as existing native speci**		Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**		
15–16		Flow Regime:	**P 1 2** / **8**	Stream Size & Order:	**S-4(2)**	Meander Patterns:	**M2**	Depositional Patterns: **B5 B7**	Debris/Channel Blockages: **D4 D10**
17–18		Degree of Incision (Bank-Height Ratio):	**2.52**	Degree of Incision Stability Rating:	**Deeply Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**102 -**		
19–20		Width/depth Ratio (W/d):	**9.43**	Reference W/d Ratio (W/d_{ref}):	**23**	Width/Depth Ratio State $(W/d) / (W/d_{ref})$:	**0.41**	W/d Ratio State Stability Rating:	**Stable**
21–22		Meander Width Ratio (MWR):	**3.02**	Reference MWR_{ref}:	**5**	Degree of confinement (MWR / MWR_{ref}):	**0.604**	MWR / MWR_{ref} Stability Rating:	**Moderately Unstable**
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft):	**0**	Annual Streambank Erosion Rate: **0** (tons/yr)	**0** (tons/yr/ft)	Curve Used:	Remarks:		
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity		Remarks:			
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm):	**244.475**	$\tau =$ **1.908**	$\tau^* =$ **0**	Existing Depth: **1.44**	Required Depth: **1.55**	Existing Slope: **####**	Required Slope: **####**
28–29	**Successional Stage Shift**	→ → → → →				Existing Stream State (Type):	**C4**	Potential Stream State (Type):	
30	**Lateral Stability**	☐ *Stable*	☑ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:			
31	**Vertical Stability (Aggradation)**	☐ *No Deposition*	☐ *Mod. Deposition*	☑ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:			
32	**Vertical Stability (Degradation)**	☐ *Not Incised*	☑ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:			
33	**Channel Enlargement**	☐ *No Increase*	☑ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:			
34–35	**Sediment Supply (Channel Source)**	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:			

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 7
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	8
Mass Wasting:	9
Debris Jam Potential:	4
Vegetative Protection:	9

Lower Bank

Channel Capacity:	3
Bank Rock Content:	4
Obstructions to Flow:	1
Cutting:	12
Deposition:	12

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	12
Scouring and Deposition:	18
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	High
Stream Bed Stability:	
W/D Condition:	
Stream Type:	F4B

Rating - 106
Condition - Good

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream: **Fourmile Canyon Creek, Reach - Reach 7**	
Basin:	Drainage Area: **3148.8** acres **4.92** mi^2
Location:	
Twp.&Rge: **;**	Sec.&Qtr.: **;**
Cross-Section Monuments (Lat./Long.): **40.06375 Lat / 105.31125 Long**	Date: **08/20/15**
Observers: **Lucas Babbitt**	Valley Type: VIII(b)

Parameter	Value	Units
Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**16.58**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.33**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**22**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**12.47**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**2.34**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**22.84**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.38**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**29.65**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.04992**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.08**	

Stream Type **F 4b** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek**					Location: **Reach - Reach 7**			
Observers: **Lucas Babbitt**		Date: **08/20/15**			Valley Type: **XIII**		Stream Type: **F 4b**	

River Reach Dimension Summary Data…..1

Riffle Dimensions* ** ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	16.6	16.6	16.6	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	22.00	22.00	22.00
Mean Riffle Depth (d_{bkf})	1.33	1.33	1.33	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	12.47	12.47	12.47
Maximum Riffle Depth (d_{max})	2.34	2.34	2.34	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.759	1.759	1.759
Width of Flood-Prone Area (W_{fpa})	22.8	22.8	22.8	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	1.378	1.378	1.378
Riffle Inner Berm Width (W_{ib})	0	0	0	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.000	0.000	0.000
Riffle Inner Berm Depth (d_{ib})	0	0	0	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.000	0.000	0.000
Riffle Inner Berm Area (A_{ib})	0	0	0	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.000	0.000	0.000
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	0	0	0					

Pool Dimensions* ** ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	13.8	13.8	13.8	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	0.834	0.834	0.834
Mean Pool Depth (d_{bkfp})	1.27	1.27	1.27	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	0.955	0.955	0.955
Pool Cross-Sectional Area (A_{bkfp})	17.5	17.5	17.5	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	0.796	0.796	0.796
Maximum Pool Depth (d_{maxp})	2.19	2.19	2.19	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	1.647	1.647	1.647
Pool Inner Berm Width (W_{ibp})	9.62	9.62	9.62	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.696	0.696	0.696
Pool Inner Berm Depth (d_{ibp})	1.05	1.05	1.05	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.827	0.827	0.827
Pool Inner Berm Area (A_{ibp})	10.1	10.1	10.1	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.577	0.577	0.577
Point Bar Slope (S_{pb})	0.000	0.000	0.000	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	9.151	9.151	9.151

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	0	0	0	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	0.000	0.000	0.000
Mean Run Depth (d_{bkfr})	0	0	0	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	0.000	0.000	0.000
Run Cross-Sectional Area (A_{bkfr})	0	0	0	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	0.000	0.000	0.000
Maximum Run Depth (d_{maxr})	0	0	0	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	0.000	0.000	0.000
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	0	0	0	ft				

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	0	0	0	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	0.000	0.000	0.000
Mean Glide Depth (d_{bkfg})	0	0	0	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.000	0.000	0.000
Glide Cross-Sectional Area (A_{bkfg})	0	0	0	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	0.000	0.000	0.000
Maximum Glide Depth (d_{maxg})	0	0	0	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	0.000	0.000	0.000
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	0	0	0	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	0.000	0.000	0.000
Glide Inner Berm Width (W_{ibg})	0	0	0	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Depth (d_{ibg})	0	0	0	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Area (A_{ibg})	0	0	0	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.000	0.000	0.000

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	16.6	16.6	16.6	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	1.000	1.000	1.000
Mean Step Depth (d_{bkfs})	1.33	1.33	1.33	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	1.000	1.000	1.000
Step Cross-Sectional Area (A_{bkfs})	22	22	22	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	1.000	1.000	1.000
Maximum Step Depth (d_{maxs})	2.34	2.34	2.34	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	1.759	1.759	1.759
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	12.5	12.5	12.5					

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream:	**Fourmile Canyon Creek**		Location: **Reach - Reach 7**				
Observers:	**Lucas Babbitt**	Date: **08/20/15**		Valley Type: **XIII**		Stream Type: **F 4b**	

River Reach Summary Data.....2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**9.686**	ft/sec	Estimation Method	**U/U***	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**213.092**	cfs	Drainage Area	**4.92**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	135	135	135	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	8.142	8.142	8.142
Stream Meander Length (L_m)	157	157	157	ft	Stream Meander Length Ratio (L_m / W_{bkf})	9.469	9.469	9.469
Radius of Curvature (R_c)	69	39	98	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	4.162	2.352	5.911
Belt Width (W_{blt})	16	16	16	ft	Meander Width Ratio (W_{blt} / W_{bkf})	0.965	0.965	0.965
Arc Length (L_a)	0	0	0	ft	Arc Length to Riffle Width (L_a / W_{bkf})	0.000	0.000	0.000
Riffle Length (L_r)	42.7	42.7	42.7	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	2.572	2.572	2.572
Individual Pool Length (L_p)	8.72	8.4	9.03	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	0.526	0.507	0.545
Pool to Pool Spacing (P_s)	41.1	27	55.2	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	2.481	1.630	3.331

Channel Profile

Valley Slope (S_{val})	0.056	ft/ft	Average Water Surface Slope (S)	0.04992	ft/ft	Sinuosity (S_{val} / S)	1.08
Stream Length (SL)	480	ft	Valley Length (VL)	462	ft	Sinuosity (SL / VL)	1.04

Low Bank Height (LBH)	start	3.01 ft	Max Depth (d_{max})	start	2.49 ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	1.21
	end	4.43 ft		end	2.2 ft		end	2.01

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.059	0.059	0.059	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	1.186	1.186	1.186
Run Slope (S_{run})	0.213	0.120	0.309	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	4.274	2.406	6.188
Pool Slope (S_p)	0.001	0.001	0.002	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	0.025	0.018	0.033
Glide Slope (S_g)	0.027	0.027	0.027	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	0.531	0.531	0.531
Step Slope (S_s)	0.000	0.000	0.000	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	0.000	0.000	0.000

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	0.87	0.87	0.87	ft	Max Riffle Depth to Mean Riffle Depth (d_{maxrif} / d_{bkf})	0.654	0.654	0.65
Max Run Depth (d_{maxrun})	1.01	0.86	1.26	ft	Max Run Depth to Mean Riffle Depth (d_{maxrun} / d_{bkf})	0.759	0.647	0.95
Max Pool Depth (d_{maxp})	1.58	1.48	1.66	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	1.188	1.113	1.25
Max Glide Depth (d_{maxg})	0.92	0.74	1.18	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	0.692	0.556	0.89
Max Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0	0	0

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	0	0		D_{16}	1.71	12.48			mm
% Sand	18	6		D_{35}	16	33.53			mm
% Gravel	61	65		D_{50}	29.65	45			mm
% Cobble	18	29		D_{84}	104.25	90			mm
% Boulder	3	0		D_{95}	180	119.86			mm
% Bedrock	0	0		D_{100}	511.98	180			mm

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.

[b] Composite sample of riffles and pools within the designated reach. [c] Active bed of a riffle. [d] Height of roughness feature above bed.

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek**	Location: **Reach 7**							
Observers: **Lucas Babbitt**	Date: **8/20/2015**							
List ALL COMBINATIONS that APPLY..............☞	**P**	**1**	**2**	**3**				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order

Stream:	**Fourmile Canyon Creek**
Location:	**Reach 7**
Observers:	**Lucas Babbitt**
Date:	**8/20/2015**
Stream Size Category and Order ☞	**S-4(2)**

Category	STREAM SIZE: Bankfull width		Check (✓) appropriate category
	meters	feet	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐

Stream Order

Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).

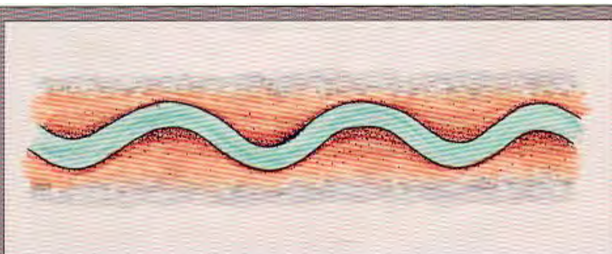
Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 7**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

List ALL CATEGORIES that APPLY ☞	**M1**	**M2**			

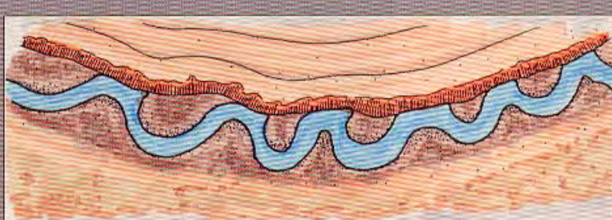
Various Meander Pattern variables modified from Galay et al. (1973)



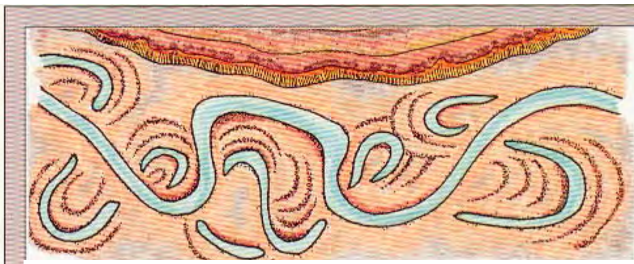
M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

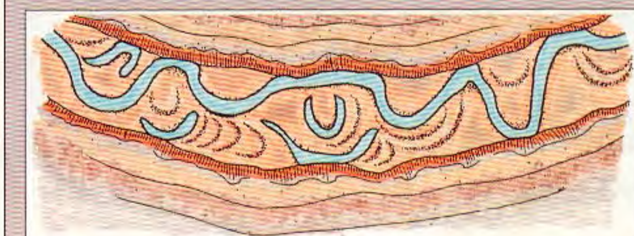
M3 IRREGULAR MEANDERS



M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS

M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

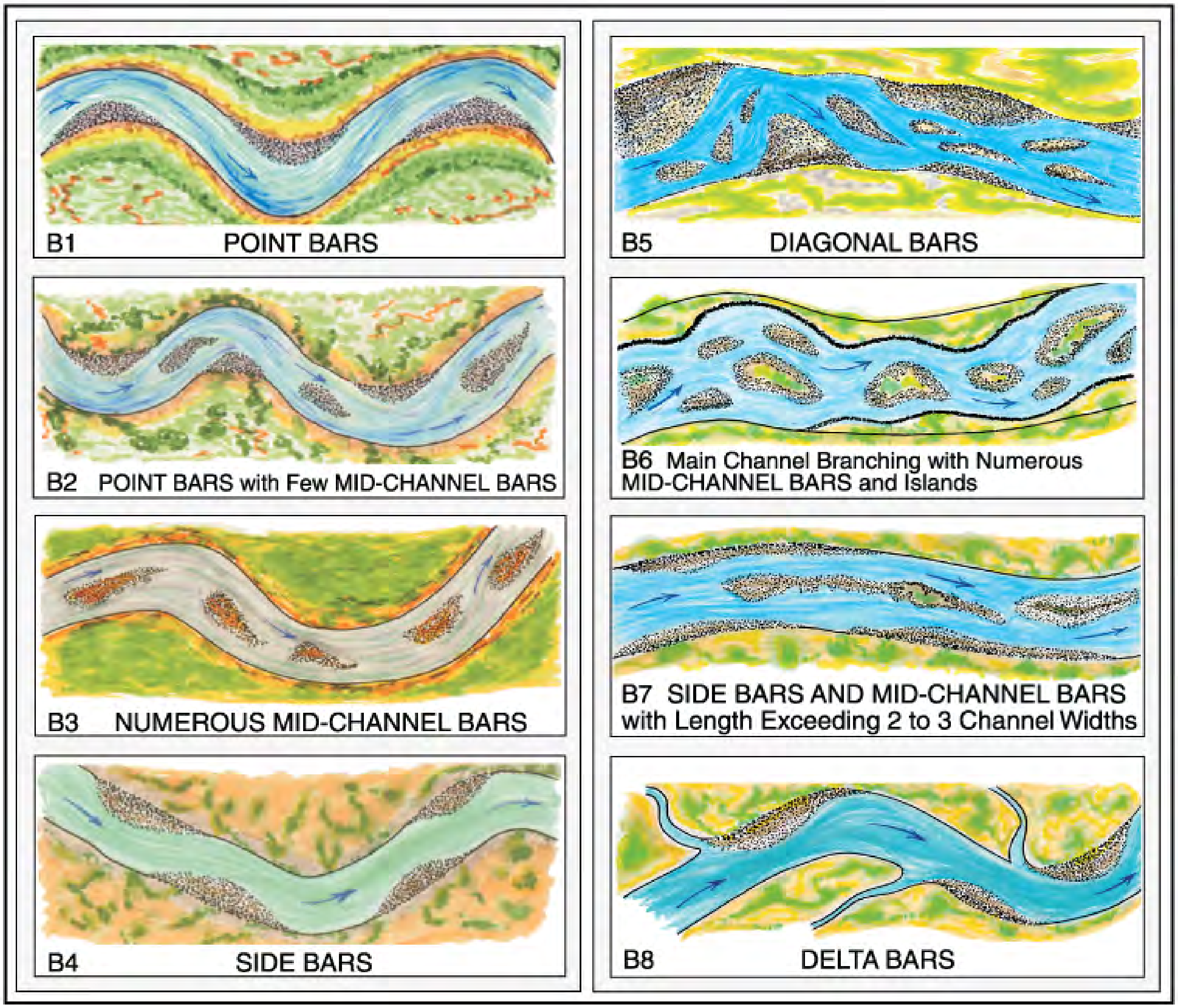
Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 7**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

List ALL CATEGORIES that APPLY ☞	**B2**	**B5**			

Various Depositional Features modified from Galay et al. (1973)

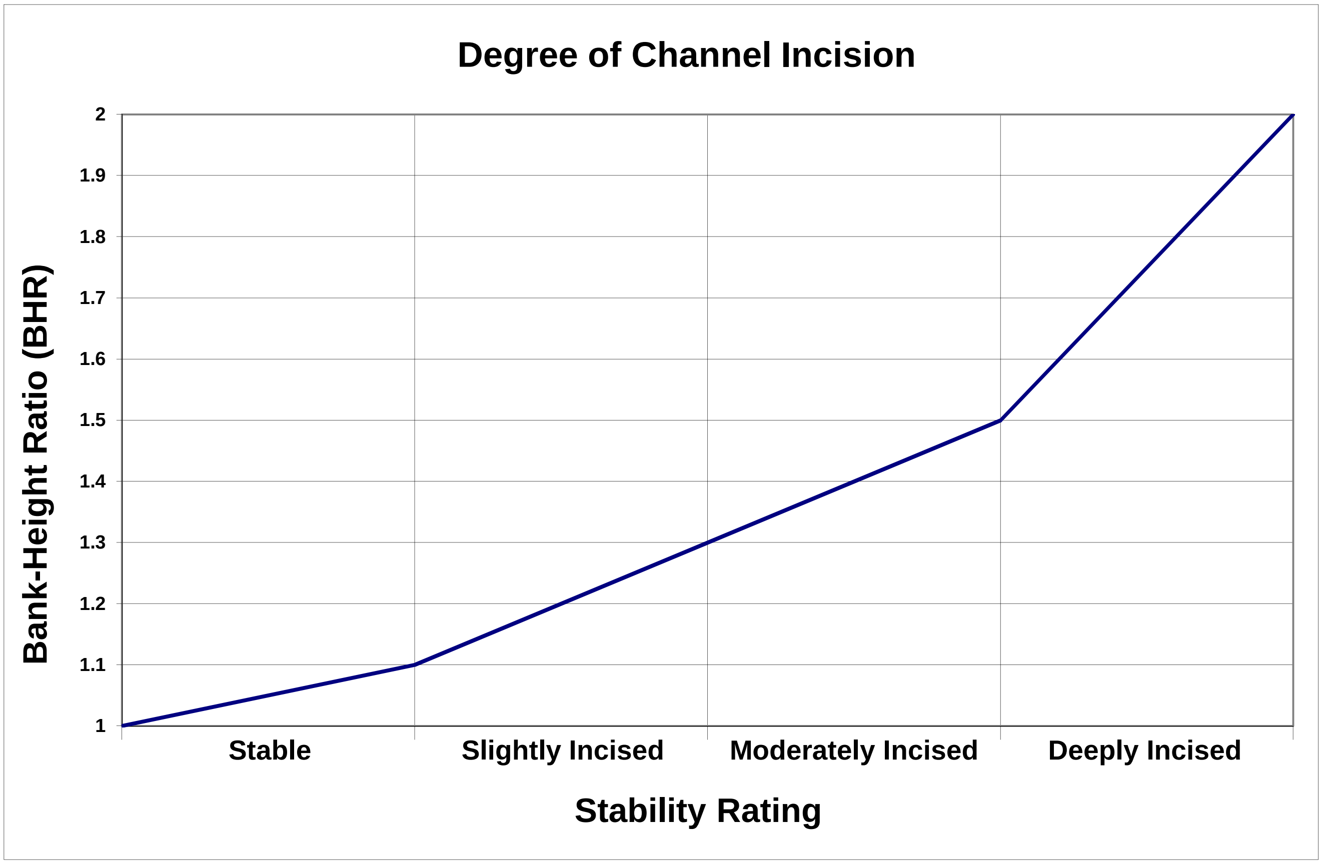


Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream: **Fourmile Canyon Creek**		Location: **Reach 7**	
Observers: **Lucas Babbitt**		Date: **8/20/2015**	
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☐
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☑
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision			
Low Bank Height:	3.01	Bank-Height Ratio:	1.2
Max Bankfull Depth:	2.49		
Degree of Channel Incision Stability Rating ☞		Slightly Incised	

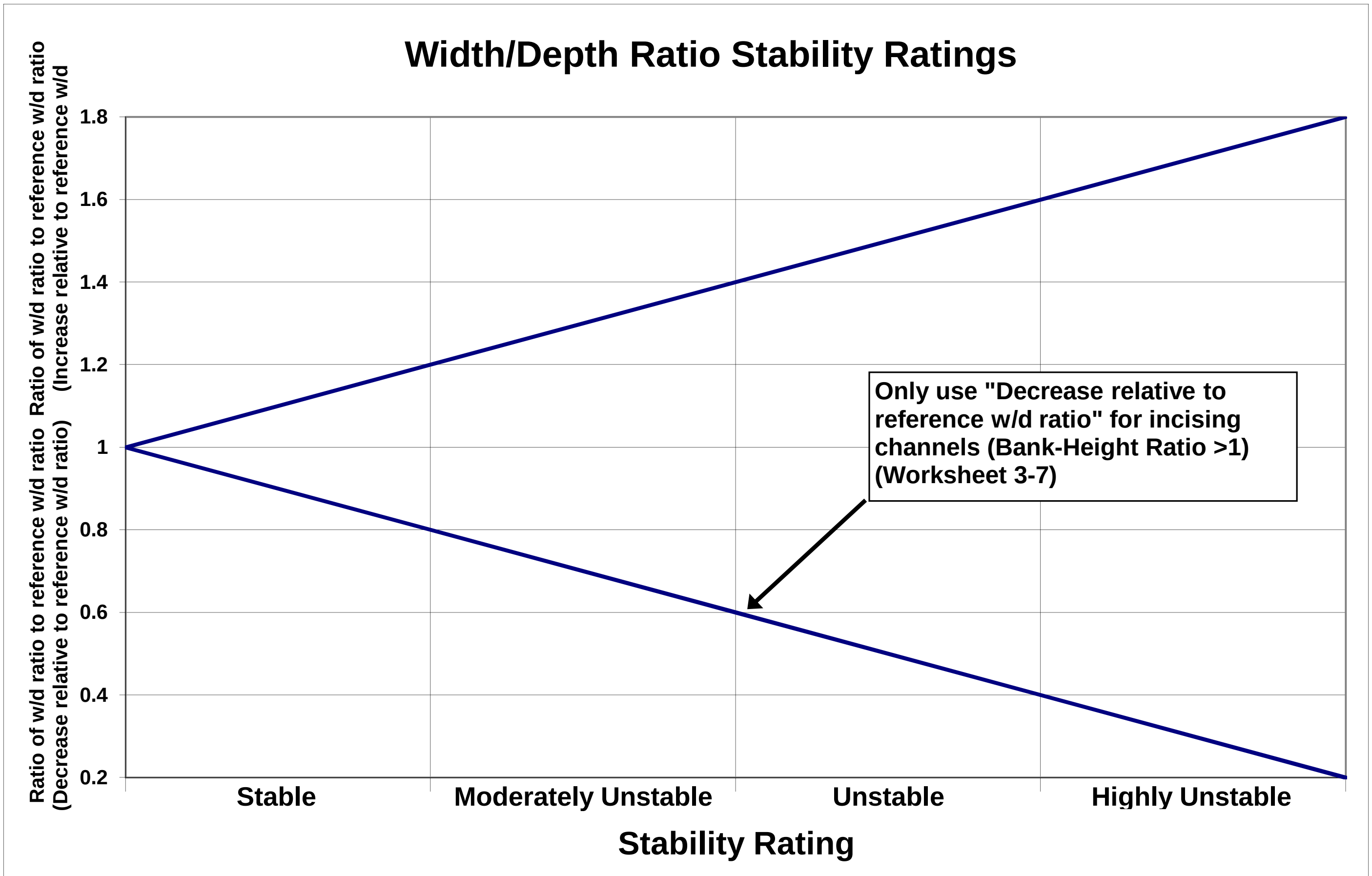


Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State

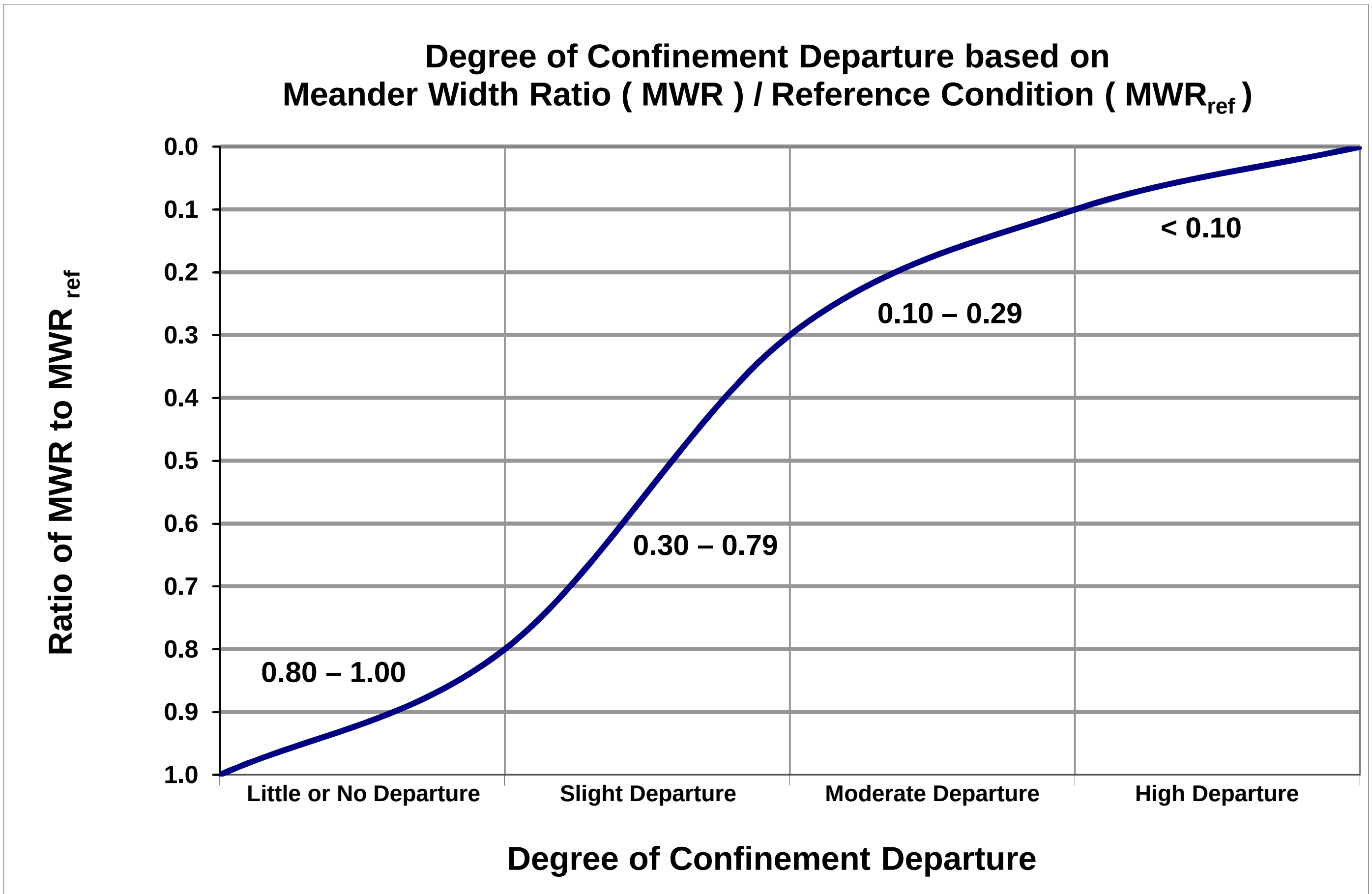
Existing Width/Depth Ratio:	**12.47**	Ratio of existing W/d to reference W/d:	**0.54**
Reference Width/Depth Ratio:	**23**		

Width/Depth Ratio State Stability Rating ☞	**Unstable**



Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement			
Existing Meander Width Ratio (MWR):	0.97	Ratio of MWR to MWR_{ref}:	0.24
Reference Meander Width Ratio (MWR_{ref}):	4		
Degree of Confinement Stability Rating ☞	Confined		



Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**		Stream Type:	**F 4b**	
Location:	**Reach 7**		Valley Type:	**XIII**	
Observers:	**Lucas Babbitt**		Date:	**08/20/2015**	
Enter Required Information for Existing Condition					
45.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.875	D_{max}	Largest particle from bar sample (ft)	**266.7**	**(mm)**	304.8 mm/ft
0.04992	S	Existing bankfull water surface slope (ft/ft)			
1.33	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress				
0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
5.93	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample				
	d	Required bankfull mean depth (ft)	$d = \frac{\tau^*(\gamma_s - 1) D_{max}}{S}$	(use D_{max} in ft)
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample				
	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^*(\gamma_s - 1) D_{max}}{d}$	(use D_{max} in ft)
Check: ☐ Stable ☐ Aggrading ☑ Degrading				

Sediment Competence Using Dimensional Shear Stress			
4.143		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope	
Shields **342.9**	CO **432.4**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**	
Shields **3.255**	CO **2.147**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**	
Shields **1.05**	CO **0.69**	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope	$d = \frac{\tau}{\gamma S}$
Shields **0.0392**	CO **0.0259**	Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, d = existing depth	$S = \frac{\tau}{\gamma d}$
Check: ☐ Stable ☐ Aggrading ☑ Degrading			

Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Fourmile Canyon Creek**	Stream Type: **F 4b**
Location: **Reach 7**	Valley Type: **XIII**
Observers: **Lucas Babbitt**	Date: **08/20/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☐ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☑ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: **Fourmile Canyon Creek**			Stream Type:	**F 4b**	
Location: **Reach 7**			Valley Type:	**XIII**	
Observers: **Lucas Babbitt**			Date:	**08/20/2015**	
Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**6**
2 **Depositional Patterns (Worksheet 3-5)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**4**
3 **Meander Patterns (Worksheet 3-4)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**3**
4 **Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)**	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**3**
				Total Points	**16**
	Lateral Stability Category Point Range				
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **< 10** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐	

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**F 4b**
Location:	**Reach 7**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points** (from each row)
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 **Sediment competence (Worksheet 3-14)**	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope-slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	**2**
2 **Sediment Capacity (POWERSED)**	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	**2**
3 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**6**
4 **Stream Succession States (Worksheet 3-16)**	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	**6**
5 **Depositional Patterns (Worksheet 3-5)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 3-6)**	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**4**
				Total Points	**21**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **< 15** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**F 4b**
Location:	**Reach 7**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points (from each row)**
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 **Sediment Competence (Worksheet 3-14)**	Does not indicate excess competence **(2)**	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed **(4)**	D_{100} of bed moved **(6)**	Particles much larger than D_{100} of bed moved **(8)**	**8**
2 **Sediment Capacity (POWERSED)**	Does not indicate excess capacity **(2)**	Slight excess energy: up to 10% increase above reference **(4)**	Excess energy sufficient to increase load up to 50% of annual load **(6)**	Excess energy transporting more than 50% of annual load **(8)**	**8**
3 **Degree of Channel Incision (BHR) (Worksheet 3-7)**	1.00 – 1.10 **(2)**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**4**
4 **Stream Succession States (Worksheets 3-16 and 3-7)**	Does not indicate incision or degradation **(2)**	If BHR > 1.1 and stream type has W/d between 5–10 **(4)**	If BHR > 1.1 and stream type has W/d less than 5 **(6)**	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) **(8)**	**8**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**3**
				Total Points	**31**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **< 12** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☑

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Fourmile Canyon Creek**				Stream Type: **F 4b**	
Location: **Reach 7**				Valley Type: **XIII**	
Observers: **Lucas Babbitt**				Date: **08/20/2015**	
Channel Enlargement Prediction Criteria (choose one stability category for each criterion 1–4)	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 **Successional Stage Shift (Worksheet 3-16)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	8
2 **Lateral Stability (Worksheet 3-17)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	6
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	6
4 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	8
				Total Points	**28**
	Category Point Range				
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** < 11 ☐	***Slight Increase*** 11 – 16 ☐	***Moderate Increase*** 17 – 24 ☐	***Extensive*** > 24 ☑	

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

<table>
<tr><td colspan="2">Stream: Fourmile Canyon Creek</td><td colspan="3">Stream Type: F 4b</td></tr>
<tr><td colspan="2">Location: Reach 7</td><td colspan="3">Valley Type: XIII</td></tr>
<tr><td colspan="2">Observers:</td><td colspan="3">Date: 08/20/2015</td></tr>
<tr><th colspan="2">Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)</th><th>Stability Rating</th><th>Points</th><th>Selected Points</th></tr>
<tr><td rowspan="4">1</td><td rowspan="4">Lateral Stability (Worksheet 3-17)</td><td>Stable</td><td>1</td><td rowspan="4">3</td></tr>
<tr><td>Mod. Unstable</td><td>2</td></tr>
<tr><td>Unstable</td><td>3</td></tr>
<tr><td>Highly Unstable</td><td>4</td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)</td><td>No Deposition</td><td>1</td><td rowspan="4">3</td></tr>
<tr><td>Mod. Deposition</td><td>2</td></tr>
<tr><td>Excess Deposition</td><td>3</td></tr>
<tr><td>Aggradation</td><td>4</td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">Vertical Stability Channel Incision or Degradation (Worksheet 3-19)</td><td>Not Incised</td><td>1</td><td rowspan="4">4</td></tr>
<tr><td>Slightly Incised</td><td>2</td></tr>
<tr><td>Mod. Incised</td><td>3</td></tr>
<tr><td>Degradation</td><td>4</td></tr>
<tr><td rowspan="4">4</td><td rowspan="4">Channel Enlargement Prediction (Worksheet 3-20)</td><td>No Increase</td><td>1</td><td rowspan="4">4</td></tr>
<tr><td>Slight Increase</td><td>2</td></tr>
<tr><td>Mod. Increase</td><td>3</td></tr>
<tr><td>Extensive</td><td>4</td></tr>
<tr><td rowspan="4">5</td><td rowspan="4">Pfankuch Channel Stability (Worksheet 3-10)</td><td>Good: Stable</td><td>1</td><td rowspan="4">4</td></tr>
<tr><td>Fair: Mod. Unstable</td><td>2</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Poor: Unstable</td><td>4</td></tr>
<tr><td colspan="4">Total Points</td><td>18</td></tr>
<tr><td colspan="2"></td><th colspan="3">Category Point Range</th></tr>
<tr><td colspan="2">Overall Sediment Supply Rating (use total points and check stability rating)</td><td>Low
< 6
☐</td><td>Moderate
6 – 10
☐</td><td>High
11 – 15
☐</td></tr>
<tr><td colspan="4"></td><td>Very High
> 15
☑</td></tr>
</table>

Worksheet 3-22. Summary of stability condition categories.

	A	B–AM								
1	Stream:	**Fourmile Canyon Creek**					Location:	**Reach 7**		
2	Observers:	**Lucas Babbitt**		Date:	**8/20/2015**		Stream Type:	**F 4B**	Valley Type:	**XIII**
3–4	**Channel Dimension**	Mean Bankfull Depth (ft):	**1.33**	Bankfull Width (ft):	**16.58**	Cross-Sectional Area (ft^2):	**22**	Width/Depth Ratio: **12.47**	Entrenchment Ratio:	**1.38**
5–6	**Channel Pattern**	Mean: / Range:	λ/W_{bkf}: **8.14** / **8.14 - 8.14**	L_m/W_{bkf}:	**9.47** / **9.47 - 9.47**	R_c/W_{bkf}:	**4.16** / **2.35 - 5.91**	MWR: **0.97** / **0.97 - 0.97**	Sinuosity:	**1.08**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec):	**9.686**	Bankfull Discharge (Q_{bkf}):	**213.092**	Estimation Method:	**U/U***		Drainage Area (mi^2):	**4.92**
9	**River Profile & Bed Features**	Check: ☐ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed				
10–12		Max Bankfull Depth (ft):	Riffle **2.34** / Pool **2.19**	Depth Ratio (max to mean):	Riffle **1.76** / Pool **1.72**	Pool-to-Pool Spacing:	Ratio **41.13**	Slope — Valley: **0.056**	Water Surface:	**0.04992**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation	Current Composition/Density: **See description**		Potential Composition/Density: **Same as existing native speci**		Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**			
15–16		Flow Regime:	**P 1 2** / **3**	Stream Size & Order:	**S-4(2)**	Meander Patterns:	**M1 M2**	Depositional Patterns: **B2 B5**	Debris/Channel Blockages:	**D3 D10**
17–18		Degree of Incision (Bank-Height Ratio):	**1.21**	Degree of Incision Stability Rating:	**Slightly Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**106 -**			
19–20		Width/depth Ratio (W/d):	**12.47**	Reference W/d Ratio (W/d_{ref}):	**23**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**0.54**	W/d Ratio State Stability Rating:	**Unstable**	
21–22		Meander Width Ratio (MWR):	**0.97**	Reference MWR_{ref}:	**4**	Degree of confinement (MWR / MWR_{ref}):	**0.2425**	MWR / MWR_{ref} Stability Rating:	**Unstable**	
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft):	**0**	Annual Streambank Erosion Rate: **0** (tons/yr)	**0** (tons/yr/ft)	Curve Used:	Remarks:			
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity		Remarks:				
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm):	**266.7**	$\tau =$ **2.147**	$\tau^* =$ **0**	Existing Depth: **0**	Required Depth: **0**	Existing Slope: **####**	Required Slope:	**####**
28–29	**Successional Stage Shift**	→ → → → →				Existing Stream State (Type):	**F 4b**	Potential Stream State (Type):		
30	**Lateral Stability**	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes:				
31	**Vertical Stability (Aggradation)**	☐ *No Deposition*	☐ *Mod. Deposition*	☑ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:				
32	**Vertical Stability (Degradation)**	☐ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☑ *Degradation*	Remarks/causes:				
33	**Channel Enlargement**	☐ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☑ *Extensive*	Remarks/causes:				
34–35	**Sediment Supply (Channel Source)**	☐ *Low*	☐ *Moderate*	☐ *High*	☑ *Very High*	Remarks/causes:				

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 8
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	8
Mass Wasting:	9
Debris Jam Potential:	4
Vegetative Protection:	9

Lower Bank

Channel Capacity:	4
Bank Rock Content:	4
Obstructions to Flow:	4
Cutting:	12
Deposition:	8

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	8
Scouring and Deposition:	12
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	High
Stream Bed Stability:	
W/D Condition:	
Stream Type:	C4B

Rating - 96
Condition - Fair

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Fourmile Canyon Creek**	Location:	**Reach - Reach 8**
Date:	Stream Type: **B4**	Valley Type:	**??**
Observers:		HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**24.20**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**1.00**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**24.27**	W_{bkf} (ft)	Wetted PERIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	**25.33**	W_p (ft)
D_{84} at Riffle	**90.00**	Dia. (mm)	D_{84} (mm) / 304.8	**0.30**	D_{84} (ft)
Bankfull SLOPE	**0.0459**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.96**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**3.25**	R / D_{84}
Drainage Area	**4.9**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	**1.191**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * \text{Log}\{R / D_{84}\}] u^*$	**6.79**	ft / sec	**164.42**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49 * R^{2/3} * S^{1/2} / n$; $n =$ **0.062**	**4.98**	ft / sec	**120.61**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49 * R^{2/3} * S^{1/2} / n$; $n =$ **0.062**	**4.98**	ft / sec	**120.61**	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49 * R^{2/3} * S^{1/2} / n$; $n = 0.39 * S^{0.38} * R^{-0.16}$; $n =$ **0.122** **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3	**2.54**	ft / sec	**61.40**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	**7.14**	ft / sec	**172.77**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Chezy C**	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge** Q = **0.0** year	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A	**0.00**	ft / sec	**0.00**	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrusion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Fourmile Canyon Creek, Reach - Reach 8**			
Basin:		Drainage Area: **3148.8** acres	**4.92**	mi^2
Location:				
Twp.&Rge: **;**		Sec.&Qtr.: **;**		
Cross-Section Monuments (Lat./Long.):	**40.06406 Lat / 105.30939 Long**		Date:	**08/20/15**
Observers:	**Lucas Babbitt**		Valley Type:	VIII(b)

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**20.91**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section (d_{bkf} = A / W_{bkf}).	**1.41**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**29.4**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**14.83**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**2.49**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or (2 x d_{mbkf}) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**46.75**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**2.24**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**29.65**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.04592**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.04**	

Stream Type **C 4b** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek**		Location: **Reach - Reach 8**	
Observers: **Lucas Babbitt**	Date: **08/20/15**	Valley Type: **XIII**	Stream Type: **C 4b**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	21.9	19.5	24.3	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	25.80	24.20	27.40
Mean Riffle Depth (d_{bkf})	1.21	1	1.41	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	19.05	13.83	24.27
Maximum Riffle Depth (d_{max})	2.16	1.93	2.39	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.813	1.695	1.930
Width of Flood-Prone Area (W_{fpa})	40.2	34.1	46.3	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	1.890	1.406	2.373
Riffle Inner Berm Width (W_{ib})	5.62	0	11.2	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.288	0.000	0.576
Riffle Inner Berm Depth (d_{ib})	0.2	0	0.41	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.145	0.000	0.290
Riffle Inner Berm Area (A_{ib})	2.29	0	4.59	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.084	0.000	0.167
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	13.8	0	27.5					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	16.8	16.8	16.8	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	0.767	0.767	0.767
Mean Pool Depth (d_{bkfp})	1.14	1.14	1.14	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	0.942	0.942	0.942
Pool Cross-Sectional Area (A_{bkfp})	19.2	19.2	19.2	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	0.744	0.744	0.744
Maximum Pool Depth (d_{maxp})	1.85	1.85	1.85	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	1.529	1.529	1.529
Pool Inner Berm Width (W_{ibp})	13.3	13.3	13.3	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.793	0.793	0.793
Pool Inner Berm Depth (d_{ibp})	0.45	0.45	0.45	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.395	0.395	0.395
Pool Inner Berm Area (A_{ibp})	5.99	5.99	5.99	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.312	0.312	0.312
Point Bar Slope (S_{pb})	0.000	0.000	0.000	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	####	####	####

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	24.3	24.3	24.3	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	1.109	1.109	1.109
Mean Run Depth (d_{bkfr})	1	1	1	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	0.826	0.826	0.826
Run Cross-Sectional Area (A_{bkfr})	24.2	24.2	24.2	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	0.938	0.938	0.938
Maximum Run Depth (d_{maxr})	1.93	1.93	1.93	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	1.595	1.595	1.595
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	24.3	24.3	24.3	ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	22.9	22.9	22.9	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	1.044	1.044	1.044
Mean Glide Depth (d_{bkfg})	1.08	1.08	1.08	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.893	0.893	0.893
Glide Cross-Sectional Area (A_{bkfg})	24.7	24.7	24.7	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	0.956	0.956	0.956
Maximum Glide Depth (d_{maxg})	1.81	1.81	1.81	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.496	1.496	1.496
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	21.2	21.2	21.2	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	0.000	0.000	0.000
Glide Inner Berm Width (W_{ibg})	0	0	0	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Depth (d_{ibg})	0	0	0	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Area (A_{ibg})	0	0	0	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.000	0.000	0.000

Step**

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	0	0	0	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	0.000	0.000	0.000
Mean Step Depth (d_{bkfs})	0	0	0	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	0.000	0.000	0.000
Step Cross-Sectional Area (A_{bkfs})	0	0	0	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	0.000	0.000	0.000
Maximum Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0.000	0.000	0.000
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	0	0	0					

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek**		Location: **Reach - Reach 8**	
Observers: **Lucas Babbitt**	Date: **08/20/15**	Valley Type: **XIII**	Stream Type: **C 4b**

River Reach Summary Data.....2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**4.984**	ft/sec	Estimation Method	**U/U***	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**120.613**	cfs	Drainage Area	**4.92**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**351**	**351**	**351**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**#####**	**#####**	**####**
Stream Meander Length (L_m)	**256**	**256**	**256**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**#####**	**#####**	**####**
Radius of Curvature (R_c)	**87**	**75**	**98**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**3.974**	**3.426**	**4.477**
Belt Width (W_{blt})	**13**	**13**	**13**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**0.594**	**0.594**	**0.594**
Arc Length (L_a)	**0**	**0**	**0**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**0.000**	**0.000**	**0.000**
Riffle Length (L_r)	**28.5**	**21**	**35.9**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**1.300**	**0.958**	**1.641**
Individual Pool Length (L_p)	**11.9**	**2.66**	**30.2**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**0.543**	**0.122**	**1.381**
Pool to Pool Spacing (P_s)	**36.3**	**13.4**	**70.9**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**1.656**	**0.613**	**3.238**

Channel Profile

Valley Slope (S_{val})	**0.043**	ft/ft	Average Water Surface Slope (S)	**0.04592**	ft/ft	Sinuosity (S_{val} / S)	**1.04**
Stream Length (SL)	**520**	ft	Valley Length (VL)	**505**	ft	Sinuosity (SL / VL)	**1.03**
Low Bank Height (LBH)	start **7** ft; end **4.76** ft		Max Depth (d_{max})	start **3.3** ft; end **1.46** ft		Bank-Height Ratio (BHR) (LBH / d_{max})	start **2.12**; end **3.26**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.029**	**0.025**	**0.034**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**0.642**	**0.537**	**0.746**
Run Slope (S_{run})	**0.161**	**0.161**	**0.161**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**3.510**	**3.510**	**3.510**
Pool Slope (S_p)	**0.008**	**0.002**	**0.015**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.182**	**0.050**	**0.337**
Glide Slope (S_g)	**0.033**	**0.033**	**0.033**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**0.728**	**0.728**	**0.728**
Step Slope (S_s)	**0.270**	**0.162**	**0.485**	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	**5.881**	**3.523**	**####**

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	**0.8**	**0.7**	**0.9**	ft	Max Riffle Depth to Mean Riffle Depth (d_{maxrif} / d_{bkf})	**0.661**	**0.579**	**0.74**
Max Run Depth (d_{maxrun})	**1.2**	**1.2**	**1.2**	ft	Max Run Depth to Mean Riffle Depth (d_{maxrun} / d_{bkf})	**0.992**	**0.992**	**0.99**
Max Pool Depth (d_{maxp})	**1.32**	**0.99**	**1.49**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**1.091**	**0.818**	**1.23**
Max Glide Depth (d_{maxg})	**0.47**	**0.47**	**0.47**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**0.388**	**0.388**	**0.39**
Max Step Depth (d_{maxs})	**0.88**	**0.41**	**1.33**	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	**0.727**	**0.339**	**1.1**

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**	**0**		D_{16}	**1.71**	**12.48**			mm
% Sand	**18**	**6**		D_{35}	**16**	**33.53**			mm
% Gravel	**61**	**65**		D_{50}	**29.65**	**45**			mm
% Cobble	**18**	**29**		D_{84}	**104.25**	**90**			mm
% Boulder	**3**	**0**		D_{95}	**180**	**119.86**			mm
% Bedrock	**0**	**0**		D_{100}	**511.98**	**180**			mm

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.

[b] Composite sample of riffles and pools within the designated reach. [c] Active bed of a riffle. [d] Height of roughness feature above bed.

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek**			Location: **Reach 8**					
Observers: **Lucas Babbitt**						Date: **8/20/2015**		
List ALL COMBINATIONS that APPLY..............☞	**P**	**1**	**2**	**8**				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order			
Stream:	**Fourmile Canyon Creek**		
Location:	**Reach 8**		
Observers:	**Lucas Babbitt**		
Date:	**8/20/2015**		
Stream Size Category and Order ☞			**S-4(2)**
Category	**STREAM SIZE: Bankfull width**		**Check (✓) appropriate category**
	meters	**feet**	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐
Stream Order			
Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).			

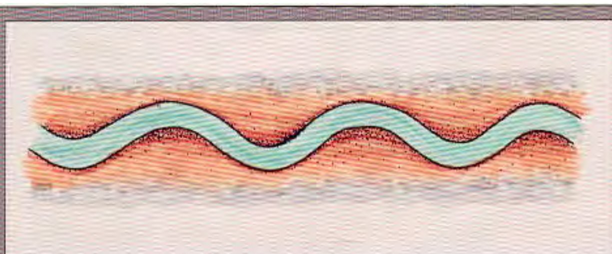
Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 8**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

List ALL CATEGORIES that APPLY ☞	**M1**				

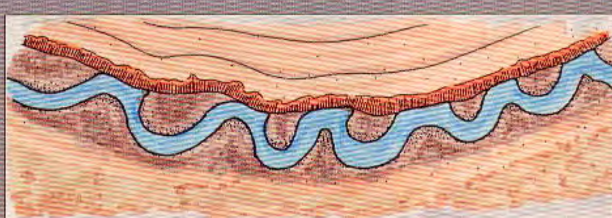
Various Meander Pattern variables modified from Galay et al. (1973)



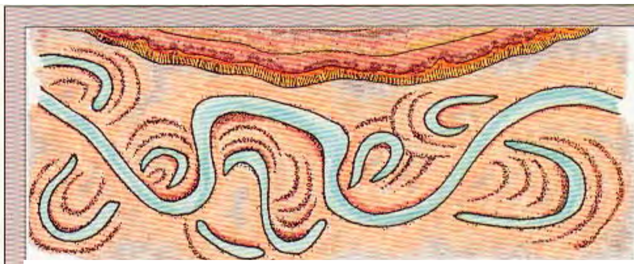
M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

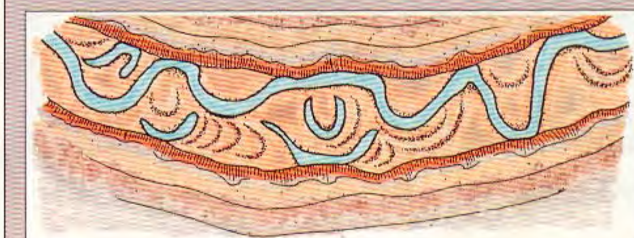
M3 IRREGULAR MEANDERS



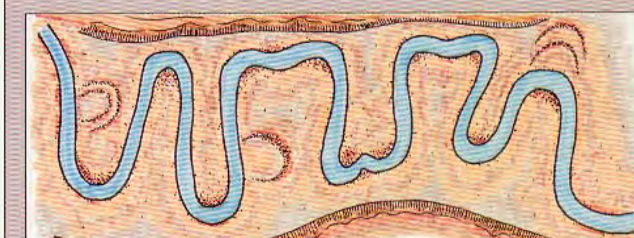
M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



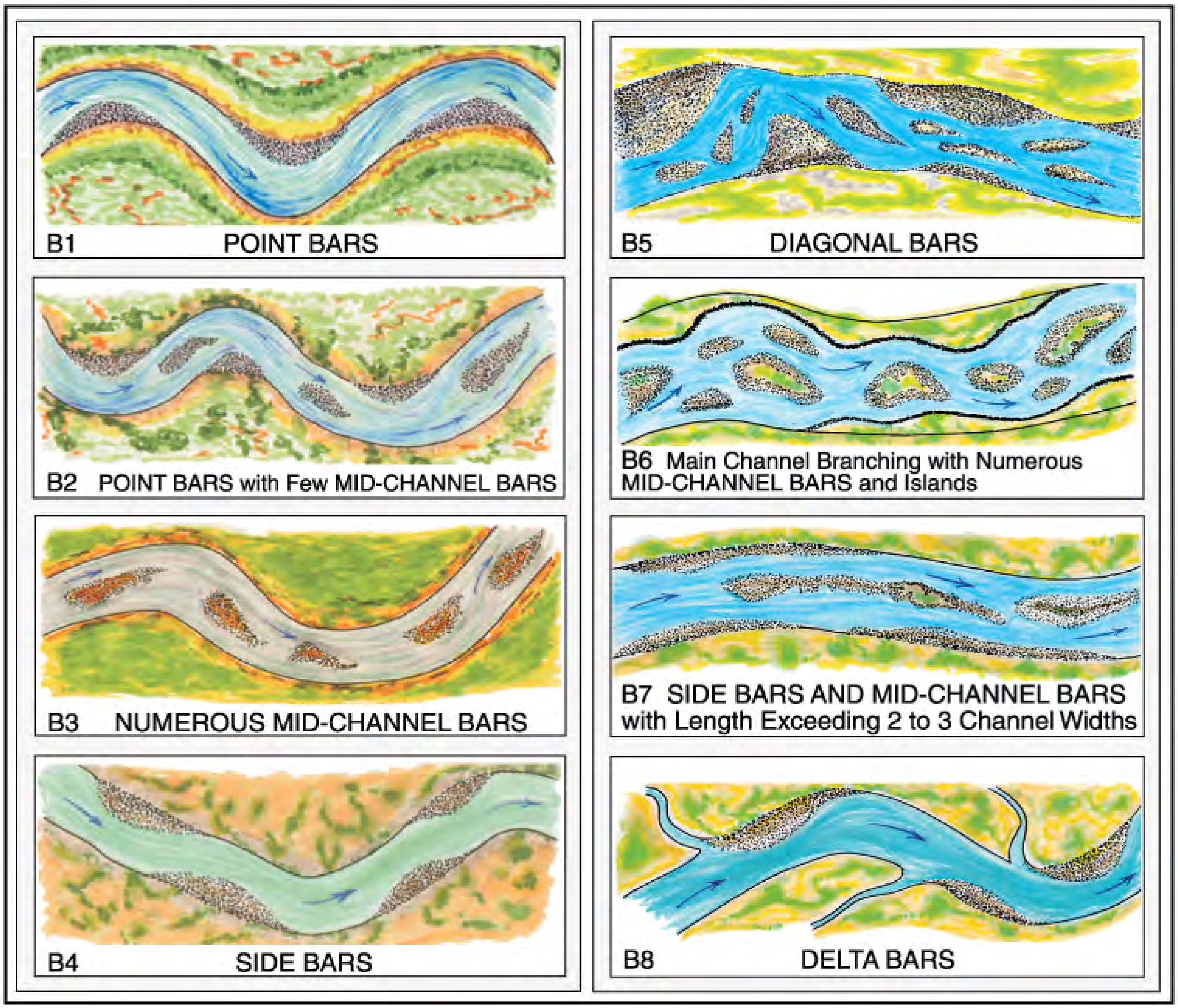
M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns						
Stream:	**Fourmile Canyon Creek**		Reach: **Reach 8**			
Observers:	**Lucas Babbitt**		Date: **8/20/2015**			
List ALL CATEGORIES that APPLY ☞		**B2**				

Various Depositional Features modified from Galay et al. (1973)



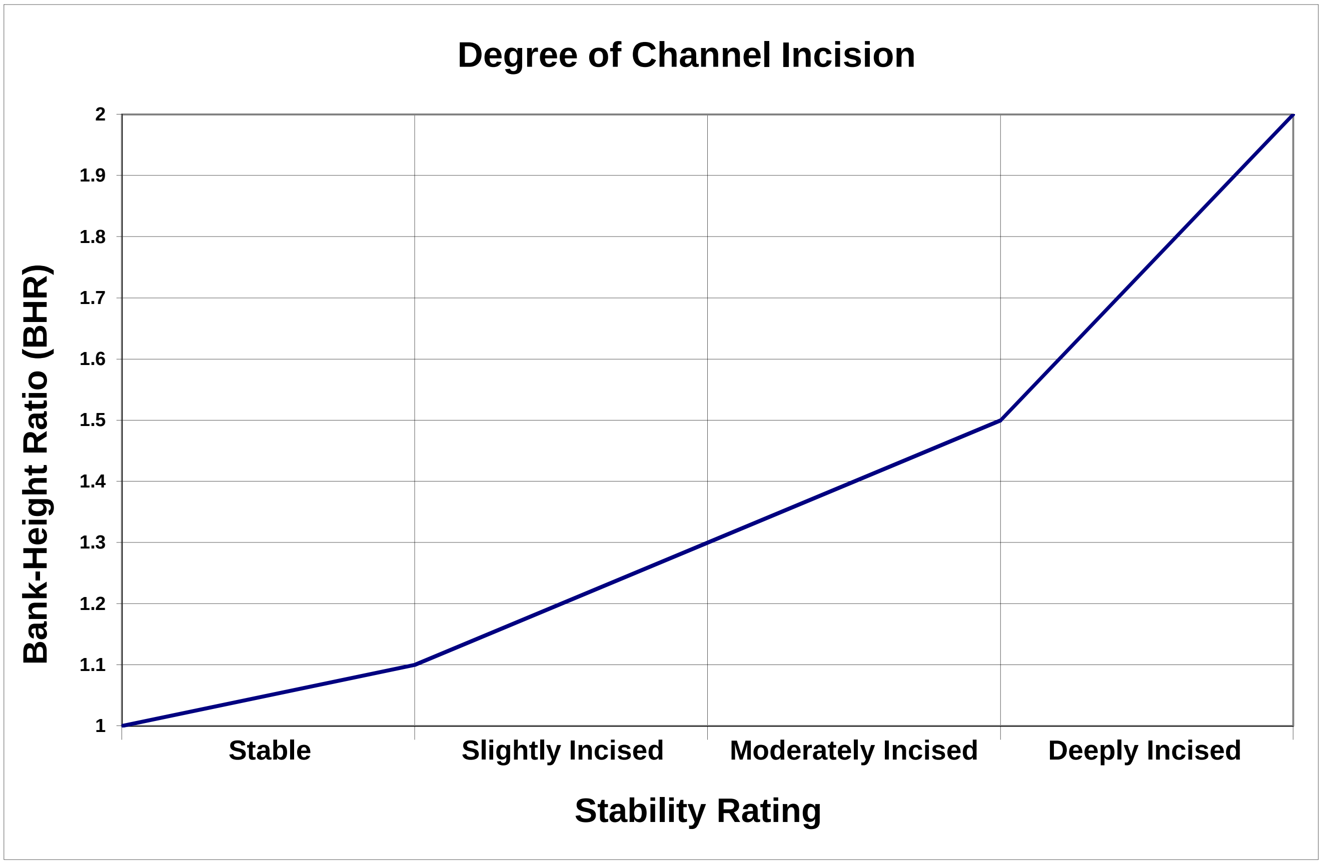
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream: **Fourmile Canyon Creek**		Location: **Reach 8**	
Observers: **Lucas Babbitt**		Date: **8/20/2015**	
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☐
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☑
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

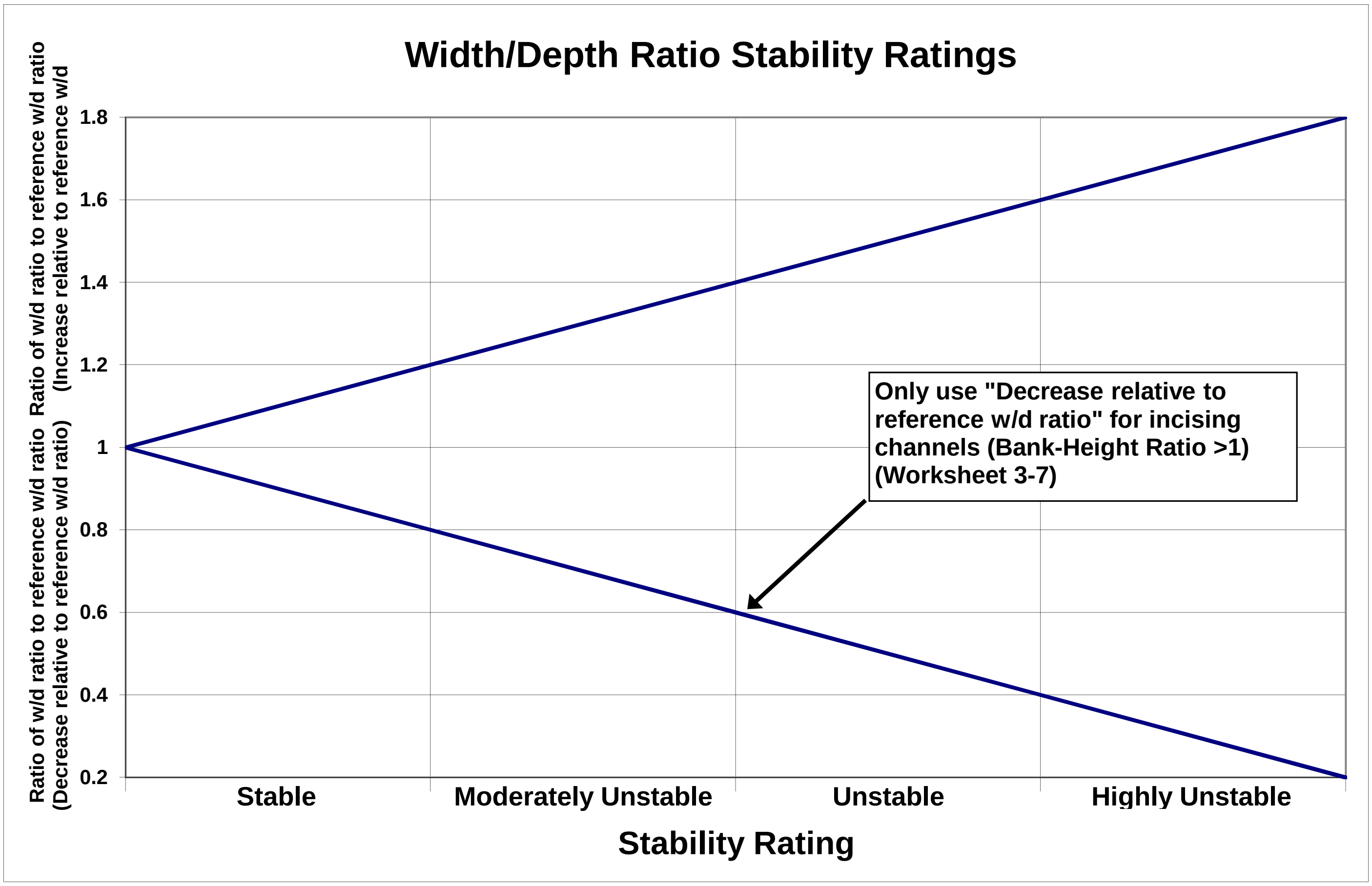
Degree of Channel Incision			
Low Bank Height:	7	Bank-Height Ratio:	2.1
Max Bankfull Depth:	3.3		

Degree of Channel Incision Stability Rating ☞	Deeply Incised



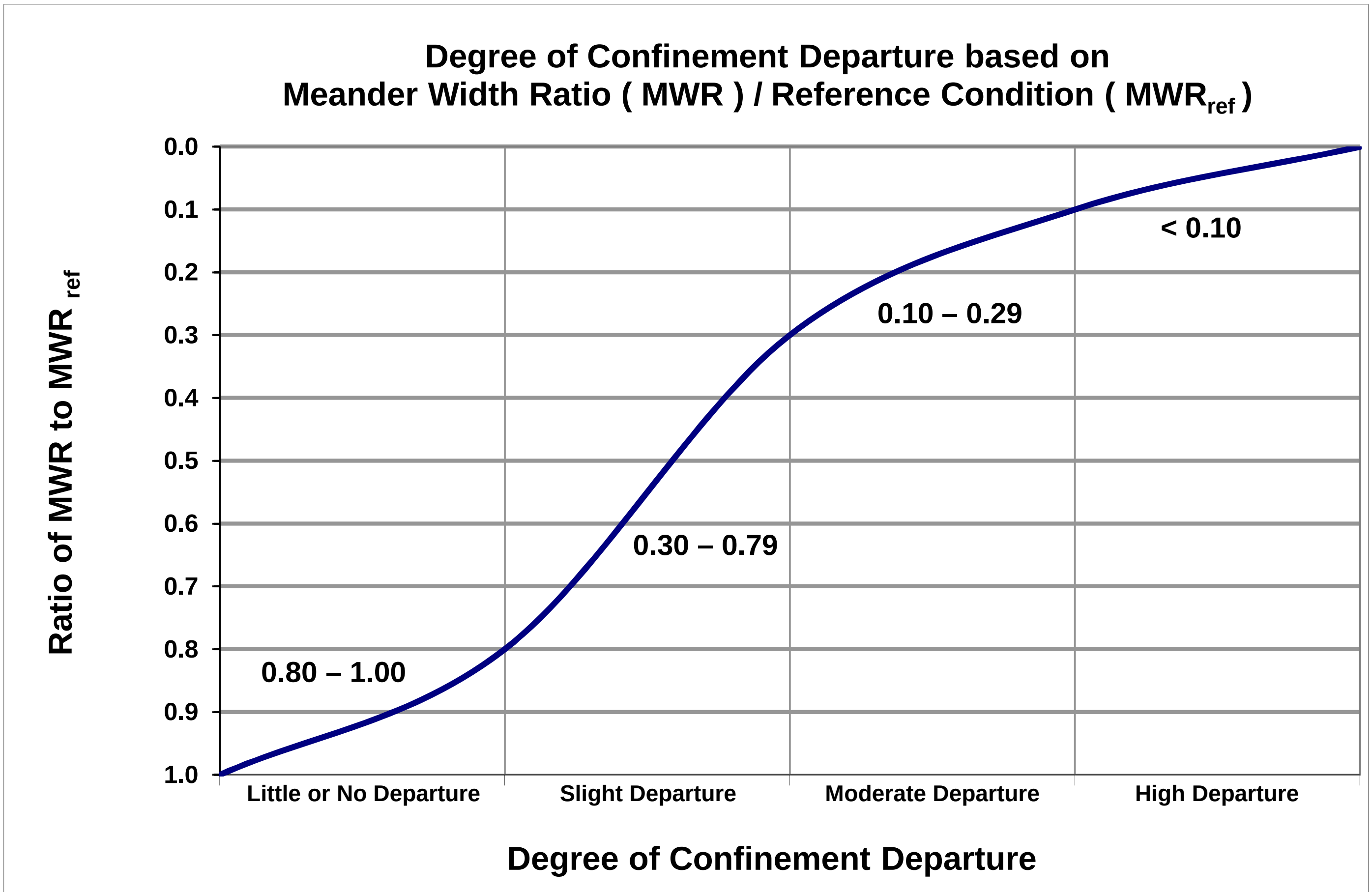
Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State			
Existing Width/Depth Ratio:	14.83	Ratio of existing W/d to reference W/d:	0.64
Reference Width/Depth Ratio:	23		
Width/Depth Ratio State Stability Rating ☞		Unstable	



Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement			
Existing Meander Width Ratio (MWR):	0.82	Ratio of MWR to MWR_{ref}:	0.16
Reference Meander Width Ratio (MWR_{ref}):	5		
Degree of Confinement Stability Rating ☞		Confined	



Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C 4b**
Location:	**Reach 8**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Enter Required Information for Existing Condition

45.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.750	D_{max}	Largest particle from bar sample (ft)	**228.6**	**(mm)**	304.8 mm/ft
0.04592	S	Existing bankfull water surface slope (ft/ft)			
1.18	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
5.08	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Sediment Competence Using Dimensional Shear Stress

3.381		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **277.5**	CO **372.4**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.808**	CO **1.741**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **0.98**	CO **0.61**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0381**	CO **0.0236**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Fourmile Canyon Creek**	Stream Type: **C 4b**
Location: **Reach 8**	Valley Type: **XIII**
Observers: **Lucas Babbitt**	Date: **08/20/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☐ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☑ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Fourmile Canyon Creek**			Stream Type:	**C 4b**	
Location:	**Reach 8**			Valley Type:	**XIII**	
Observers:	**Lucas Babbitt**			Date:	**08/20/2015**	
Lateral stability criteria (choose one stability category for each criterion 1–5)		**Lateral Stability Categories**				**Selected Points (from each row)**
		Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1	**W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**8**
2	**Depositional Patterns (Worksheet 3-5)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**1**
3	**Meander Patterns (Worksheet 3-4)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**1**
4	**Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)**	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5	**Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**3**
					Total Points	**13**
		Lateral Stability Category Point Range				
Overall Lateral Stability Category (use total points and check stability rating)		***Stable*** **< 10** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐	

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C 4b**
Location:	**Reach 8**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points (from each row)**
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 **Sediment competence (Worksheet 3-14)**	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope-slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	**2**
2 **Sediment Capacity (POWERSED)**	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	**2**
3 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**6**
4 **Stream Succession States (Worksheet 3-16)**	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	**2**
5 **Depositional Patterns (Worksheet 3-5)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 3-6)**	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**4**
				Total Points	**17**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **< 15** ☐	***Moderate Deposition*** **15 – 20** ☑	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C 4b**
Location:	**Reach 8**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points** (from each row)
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 Sediment Competence (Worksheet 3-14)	Does not indicate excess competence **(2)**	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed **(4)**	D_{100} of bed moved **(6)**	Particles much larger than D_{100} of bed moved **(8)**	**6**
2 Sediment Capacity (POWERSED)	Does not indicate excess capacity **(2)**	Slight excess energy: up to 10% increase above reference **(4)**	Excess energy sufficient to increase load up to 50% of annual load **(6)**	Excess energy transporting more than 50% of annual load **(8)**	**6**
3 Degree of Channel Incision (BHR) (Worksheet 3-7)	1.00 – 1.10 **(2)**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**8**
4 Stream Succession States (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation **(2)**	If BHR > 1.1 and stream type has W/d between 5–10 **(4)**	If BHR > 1.1 and stream type has W/d less than 5 **(6)**	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) **(8)**	**8**
5 Confinement (MWR / MWR_{ref}) (Worksheet 3-9)	0.80 – 1.00 **(1)**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**3**
				Total Points	**31**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **< 12** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☑

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Fourmile Canyon Creek**				Stream Type: **C 4b**	
Location: **Reach 8**				Valley Type: **XIII**	
Observers: **Lucas Babbitt**				Date: **08/20/2015**	
Channel Enlargement Prediction Criteria **(choose one stability category for each criterion 1–4)**	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 Successional Stage Shift (Worksheet 3-16)	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	**2**
2 Lateral Stability (Worksheet 3-17)	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**6**
3 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**4**
4 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**8**
				Total Points	**20**
	Category Point Range				
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐	

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: **Fourmile Canyon Creek**		Stream Type:	**C 4b**
Location: **Reach 8**		Valley Type:	**XIII**
Observers:		Date:	**08/20/2015**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 3-17)**	***Stable***	**1**	**3**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	***No Deposition***	**1**	**2**
	Mod. Deposition	**2**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	***Not Incised***	**1**	**4**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 **Channel Enlargement Prediction (Worksheet 3-20)**	***No Increase***	**1**	**3**
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**4**	
5 **Pfankuch Channel Stability (Worksheet 3-10)**	***Good: Stable***	**1**	**2**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**4**	
		Total Points	**14**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **< 6** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☑	***Very High*** **> 15** ☐

Worksheet 3-22. Summary of stability condition categories.

	A	B – AM
1	Stream:	**Fourmile Canyon Creek** — Location: **Reach 8**
2	Observers:	**Lucas Babbitt** — Date: **8/20/2015** — Stream Type: **C 4B** — Valley Type: **XIII**
3–4	**Channel Dimension**	Mean Bankfull Depth (ft): **1.41** — Bankfull Width (ft): **20.91** — Cross-Sectional Area (ft^2): **29.4** — Width/Depth Ratio: **14.83** — Entrenchment Ratio: **2.24**
5–6	**Channel Pattern**	Mean: / Range: — λ/W_{bkf}: **16.79** / **16.79 - 16.79** — L_m/W_{bkf}: **12.24** / **12.24 - 12.24** — R_c/W_{bkf}: **4.16** / **3.59 - 4.69** — MWR: **0.62** / **0.62 - 0.62** — Sinuosity: **1.04**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec): **4.984** — Bankfull Discharge (Q_{bkf}): **120.613** — Estimation Method: **U/U*** — Drainage Area (mi^2): **4.92**
9	**River Profile & Bed Features**	Check: ☐ Riffle/Pool ☐ Step/Pool ☐ Plane Bed ☐ Convergence/Divergence ☐ Dunes/Antidunes/Smooth Bed
10–12		Max Bankfull Depth (ft): Riffle **2.49**, Pool **1.85** — Depth Ratio (max to mean): Riffle **1.77**, Pool **1.62** — Pool-to-Pool Spacing: Ratio **36.26** — Slope: Valley: **0.043**, Water Surface: **0.04592**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation — Current Composition/Density: **See description** — Potential Composition/Density: **Same as existing native speci** — Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**
15–16		Flow Regime: **P 1 2 8** — Stream Size & Order: **S-4(2)** — Meander Patterns: **M1** — Depositional Patterns: **B2** — Debris/Channel Blockages: **D3 D10**
17–18		Degree of Incision (Bank-Height Ratio): **2.12** — Degree of Incision Stability Rating: **Deeply Incised** — Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **96 -**
19–20		Width/depth Ratio (W/d): **13.37** — Reference W/d Ratio (W/d_{ref}): **23** — Width/Depth Ratio State $(W/d)/(W/d_{ref})$: **0.58** — W/d Ratio State Stability Rating: **Unstable**
21–22		Meander Width Ratio (MWR): **0.82** — Reference MWR_{ref}: **5** — Degree of confinement (MWR/MWR_{ref}): **0.164** — MWR/MWR_{ref} Stability Rating: **Unstable**
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft): **0** — Annual Streambank Erosion Rate: **0** (tons/yr) **0** (tons/yr/ft) — Curve Used: — Remarks:
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity ☐ Insufficient Capacity ☐ Excess Capacity — Remarks:
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm): **228.6** — $\tau =$ **1.741** — $\tau^* =$ **0** — Existing Depth: **1.18** — Required Depth: **0.61** — Existing Slope: **####** — Required Slope: **####**
28–29	**Successional Stage Shift**	→ → → → → — Existing Stream State (Type): **C 4b** — Potential Stream State (Type):
30	**Lateral Stability**	☐ *Stable* ☐ *Mod. Unstable* [x] *Unstable* ☐ *Highly Unstable* — Remarks/causes:
31	**Vertical Stability (Aggradation)**	☐ *No Deposition* [x] *Mod. Deposition* ☐ *Ex. Deposition* ☐ *Aggradation* — Remarks/causes:
32	**Vertical Stability (Degradation)**	☐ *Not Incised* ☐ *Slightly Incised* ☐ *Mod. Incised* [x] *Degradation* — Remarks/causes:
33	**Channel Enlargement**	☐ *No Increase* ☐ *Slight Increase* [x] *Mod. Increase* ☐ *Extensive* — Remarks/causes:
34–35	**Sediment Supply (Channel Source)**	☐ *Low* ☐ *Moderate* [x] *High* ☐ *Very High* — Remarks/causes:

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 9
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	8
Mass Wasting:	9
Debris Jam Potential:	4
Vegetative Protection:	9

Lower Bank

Channel Capacity:	3
Bank Rock Content:	4
Obstructions to Flow:	2
Cutting:	4
Deposition:	4

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	8
Scouring and Deposition:	6
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	High
Stream Bed Stability:	
W/D Condition:	
Stream Type:	E4B

Rating - 75
Condition - Good

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Fourmile Canyon Creek, Reach - Reach 9**				
Basin:		Drainage Area:	**4748.8** acres	**7.42**	mi^2
Location:					
Twp.&Rge:	**;**	Sec.&Qtr.:	**;**		
Cross-Section Monuments (Lat./Long.):	**40.06497 Lat / 105.30794 Long**			Date:	**08/20/15**
Observers:	**Lucas Babbitt**			Valley Type:	VIII(b)

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**12.15**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**1.48**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**17.98**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**8.21**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**2.3**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**47.82**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**3.94**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**39.22**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.03451**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.11**	

Stream Type **E 4b** (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek**				Location: **Reach - Reach 9**			
Observers: **Lucas Babbitt**		Date: **08/20/15**		Valley Type: **XIII**		Stream Type: **E 4b**	

River Reach Dimension Summary Data.....1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	12.2	12.2	12.2	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	17.98	17.98	17.98
Mean Riffle Depth (d_{bkf})	1.48	1.48	1.48	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	8.21	8.21	8.21
Maximum Riffle Depth (d_{max})	2.3	2.3	2.3	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.554	1.554	1.554
Width of Flood-Prone Area (W_{fpa})	47.8	47.8	47.8	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	3.936	3.936	3.936
Riffle Inner Berm Width (W_{ib})	0	0	0	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.000	0.000	0.000
Riffle Inner Berm Depth (d_{ib})	0	0	0	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.000	0.000	0.000
Riffle Inner Berm Area (A_{ib})	0	0	0	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.000	0.000	0.000
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	0	0	0					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	13.2	13	13.3	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	1.082	1.072	1.093
Mean Pool Depth (d_{bkfp})	1.45	1.26	1.63	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	0.980	0.851	1.101
Pool Cross-Sectional Area (A_{bkfp})	19	16.4	21.7	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.058	0.911	1.206
Maximum Pool Depth (d_{maxp})	2.52	2.22	2.82	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	1.703	1.500	1.905
Pool Inner Berm Width (W_{ibp})	2.32	0	4.64	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.175	0.000	0.350
Pool Inner Berm Depth (d_{ibp})	0.27	0	0.54	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.166	0.000	0.332
Pool Inner Berm Area (A_{ibp})	1.25	0	2.51	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.058	0.000	0.116
Point Bar Slope (S_{pb})	0.000	0.000	0.000	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	4.295	0.000	8.590

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	11.3	11.3	11.3	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	0.928	0.928	0.928
Mean Run Depth (d_{bkfr})	1.78	1.78	1.78	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	1.203	1.203	1.203
Run Cross-Sectional Area (A_{bkfr})	20.1	20.1	20.1	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	1.116	1.116	1.116
Maximum Run Depth (d_{maxr})	2.85	2.85	2.85	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	1.926	1.926	1.926
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	6.34	6.34	6.34	ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	15.6	15.6	15.6	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	1.284	1.284	1.284
Mean Glide Depth (d_{bkfg})	1.36	1.36	1.36	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.919	0.919	0.919
Glide Cross-Sectional Area (A_{bkfg})	21.1	21.1	21.1	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	1.176	1.176	1.176
Maximum Glide Depth (d_{maxg})	2.58	2.58	2.58	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.743	1.743	1.743
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	11.5	11.5	11.5	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	0.000	0.000	0.000
Glide Inner Berm Width (W_{ibg})	0	0	0	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Depth (d_{ibg})	0	0	0	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Area (A_{ibg})	0	0	0	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.000	0.000	0.000

Step**

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	11.9	11.9	11.9	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	0.982	0.982	0.982
Mean Step Depth (d_{bkfs})	1.63	1.63	1.63	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	1.101	1.101	1.101
Step Cross-Sectional Area (A_{bkfs})	19.4	19.4	19.4	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	1.081	1.081	1.081
Maximum Step Depth (d_{maxs})	2.54	2.54	2.54	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	1.716	1.716	1.716
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	7.32	7.32	7.32					

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream:	**Fourmile Canyon Creek**		Location: **Reach - Reach 9**		
Observers:	**Lucas Babbitt**	Date: **08/20/15**	Valley Type: **XIII**	Stream Type: **E 4b**	

River Reach Summary Data.....2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**9.532**	ft/sec	Estimation Method	**U/U***	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**171.385**	cfs	Drainage Area	**7.42**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**638**	**505**	**771**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**#####**	**#####**	**####**
Stream Meander Length (L_m)	**676**	**676**	**676**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**#####**	**#####**	**####**
Radius of Curvature (R_c)	**198**	**89**	**308**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**#####**	**7.325**	**####**
Belt Width (W_{blt})	**40**	**40**	**40**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**3.292**	**3.292**	**3.292**
Arc Length (L_a)	**0**	**0**	**0**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**0.000**	**0.000**	**0.000**
Riffle Length (L_r)	**38.7**	**7.62**	**72.2**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**3.185**	**0.627**	**5.939**
Individual Pool Length (L_p)	**11.8**	**4.23**	**28.4**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**0.974**	**0.348**	**2.333**
Pool to Pool Spacing (P_s)	**36.4**	**13.7**	**75.8**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**2.992**	**1.125**	**6.235**

Channel Profile

Valley Slope (S_{val})	**0.047**	ft/ft	Average Water Surface Slope (S)	**0.03451**	ft/ft	Sinuosity (S_{val} / S)		**1.11**
Stream Length (SL)	**808**	ft	Valley Length (VL)	**689**	ft	Sinuosity (SL / VL)		**1.17**
Low Bank Height (LBH)	start **4.3**	ft	Max Depth (d_{max}) start	**2.2**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**1.95**
	end **2.2**	ft	end	**2.2**	ft		end	**1**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.029**	**0.017**	**0.040**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**0.847**	**0.492**	**1.146**
Run Slope (S_{run})	**0.148**	**0.048**	**0.230**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**4.283**	**1.383**	**6.661**
Pool Slope (S_p)	**0.015**	**0.002**	**0.039**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.427**	**0.053**	**1.123**
Glide Slope (S_g)	**0.050**	**0.002**	**0.202**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**1.458**	**0.045**	**5.864**
Step Slope (S_s)	**0.000**	**0.000**	**0.000**	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	**0.000**	**0.000**	**0.000**

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	**1.01**	**0.83**	**1.25**	ft	Max Riffle Depth to Mean Riffle Depth (d_{maxrif} / d_{bkf})	**0.682**	**0.561**	**0.84**
Max Run Depth (d_{maxrun})	**1.07**	**0.66**	**1.42**	ft	Max Run Depth to Mean Riffle Depth (d_{maxrun} / d_{bkf})	**0.723**	**0.446**	**0.96**
Max Pool Depth (d_{maxp})	**1.45**	**1.06**	**2**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**0.98**	**0.716**	**1.35**
Max Glide Depth (d_{maxg})	**0.8**	**0.54**	**1.07**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**0.541**	**0.365**	**0.72**
Max Step Depth (d_{maxs})	**0**	**0**	**0**	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	**0**	**0**	**0**

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**	**0**		D_{16}	**3**	**8**			mm
% Sand	**14**	**9**		D_{35}	**24.17**	**25.29**			mm
% Gravel	**52**	**74**		D_{50}	**39.22**	**35.61**			mm
% Cobble	**34**	**17**		D_{84}	**107.73**	**66.36**			mm
% Boulder	**0**	**0**		D_{95}	**150.29**	**99.5**			mm
% Bedrock	**0**	**0**		D_{100}	**255.99**	**180**			mm

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.

[b] Composite sample of riffles and pools within the designated reach. [c] Active bed of a riffle. [d] Height of roughness feature above bed.

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek**	Location: **Reach 9**							
Observers: **Lucas Babbitt**					Date: **8/20/2015**			
List ALL COMBINATIONS that APPLY...............☞	**P**	**1**	**2**	**8**				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order

Stream:	**Fourmile Canyon Creek**
Location:	**Reach 9**
Observers:	**Lucas Babbitt**
Date:	**8/20/2015**
Stream Size Category and Order ☞	**S-4(3)**

Category	STREAM SIZE: Bankfull width		Check (✓) appropriate category
	meters	feet	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐

Stream Order

Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).

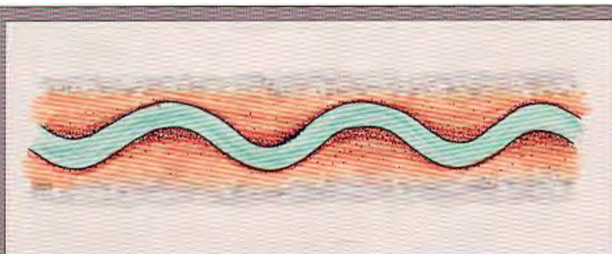
Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 9**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

List ALL CATEGORIES that APPLY ☞	**M1**	**M4**			

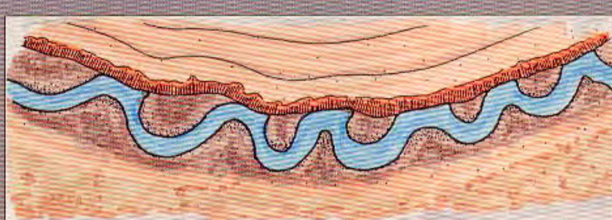
Various Meander Pattern variables modified from Galay et al. (1973)



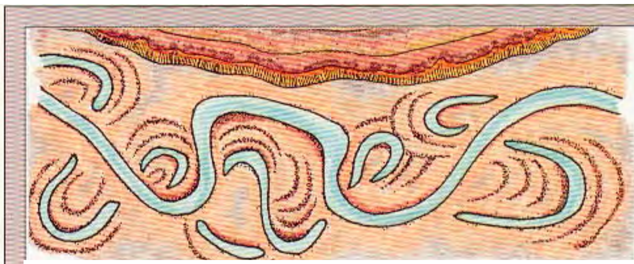
M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

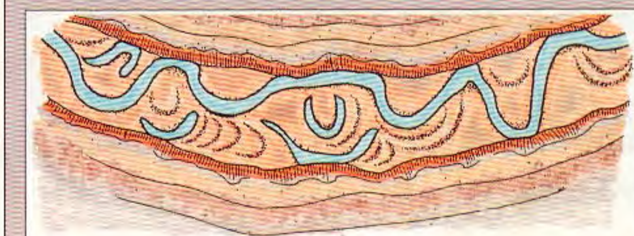
M3 IRREGULAR MEANDERS



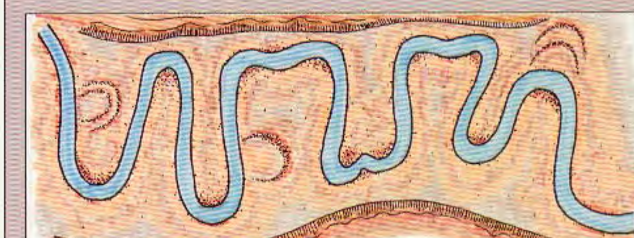
M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

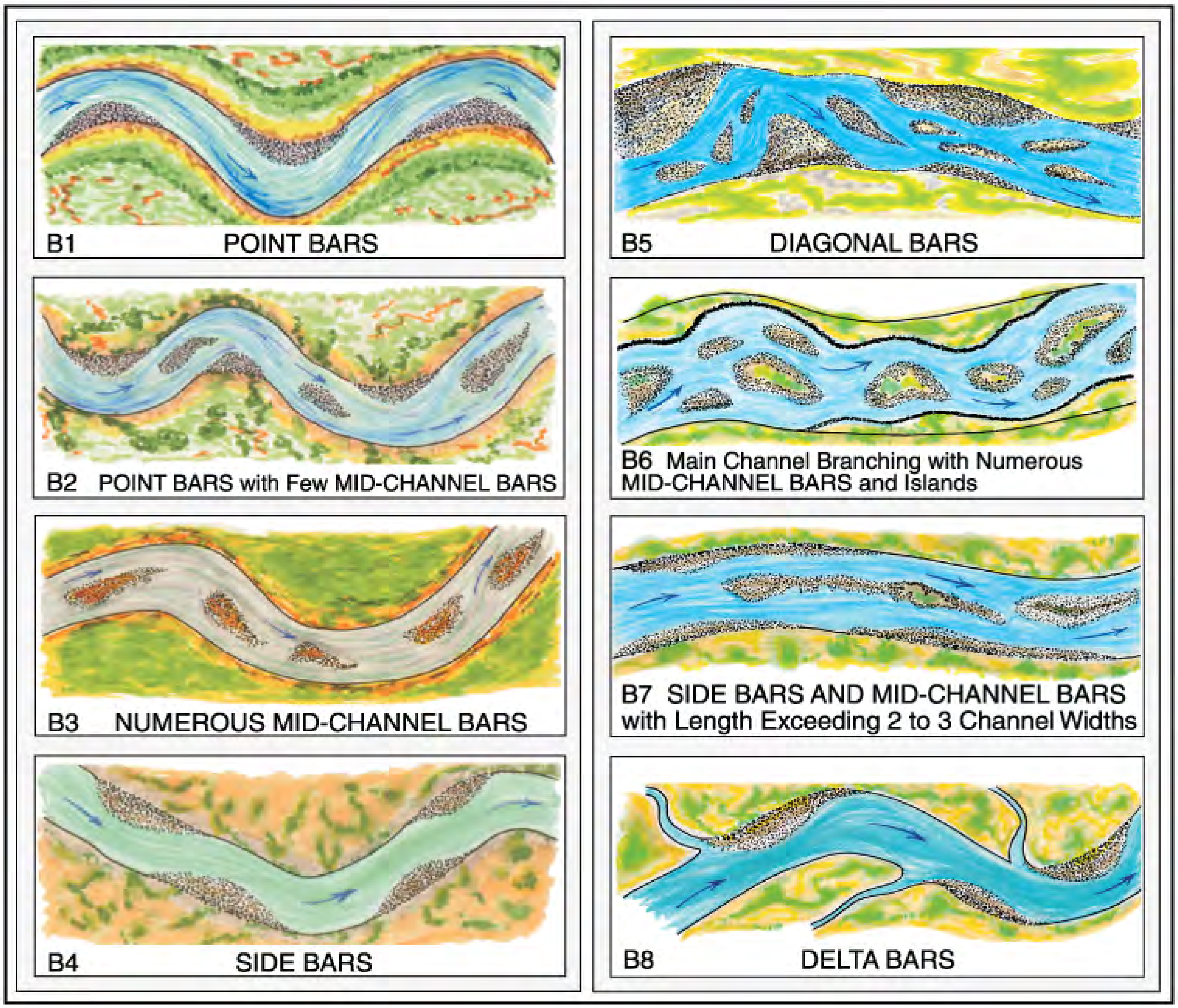
Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 9**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

List ALL CATEGORIES that APPLY ☞	**B1**				

Various Depositional Features modified from Galay et al. (1973)

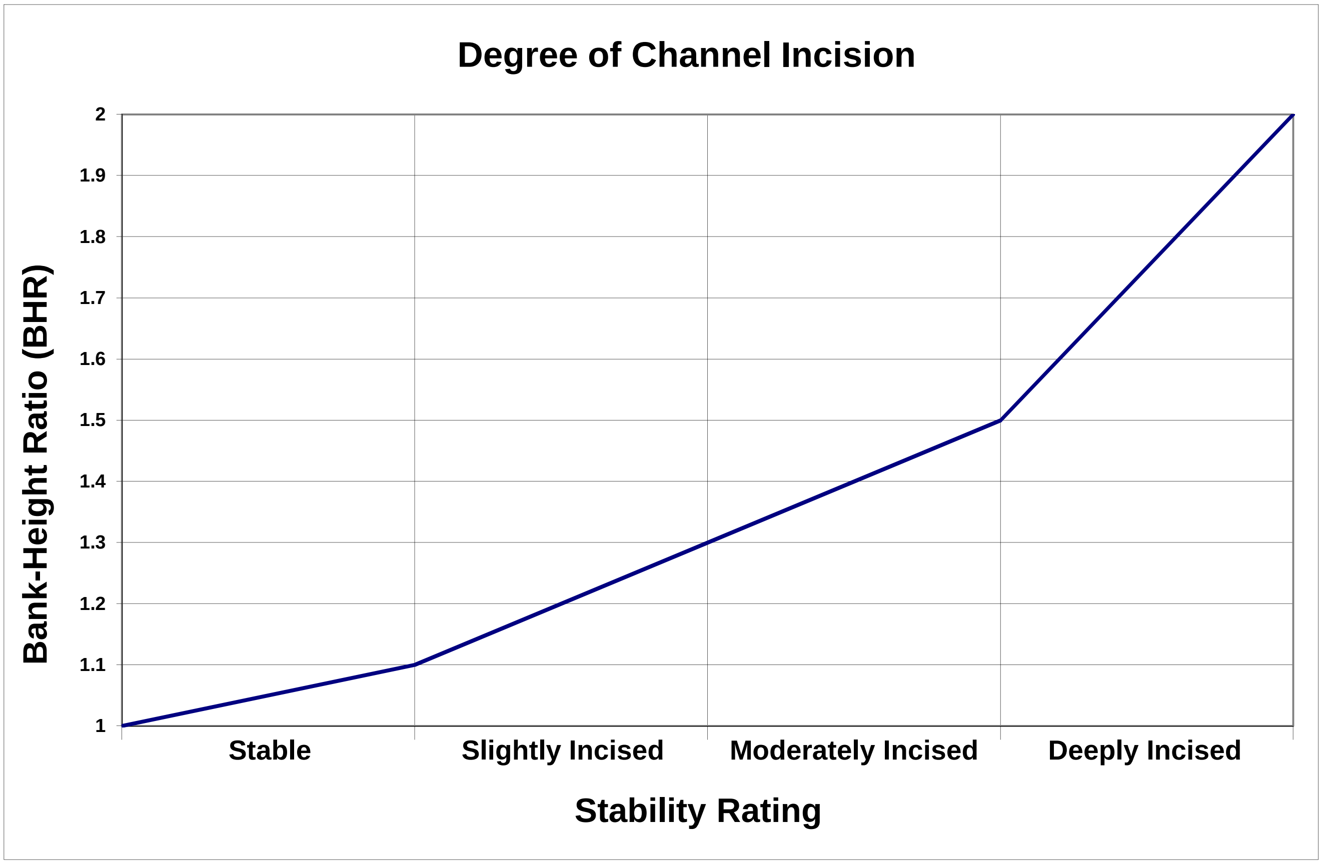


Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream:	**Fourmile Canyon Creek**	Location: **Reach 9**	
Observers:	**Lucas Babbitt**	Date: **8/20/2015**	
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☑
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☐
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☐
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

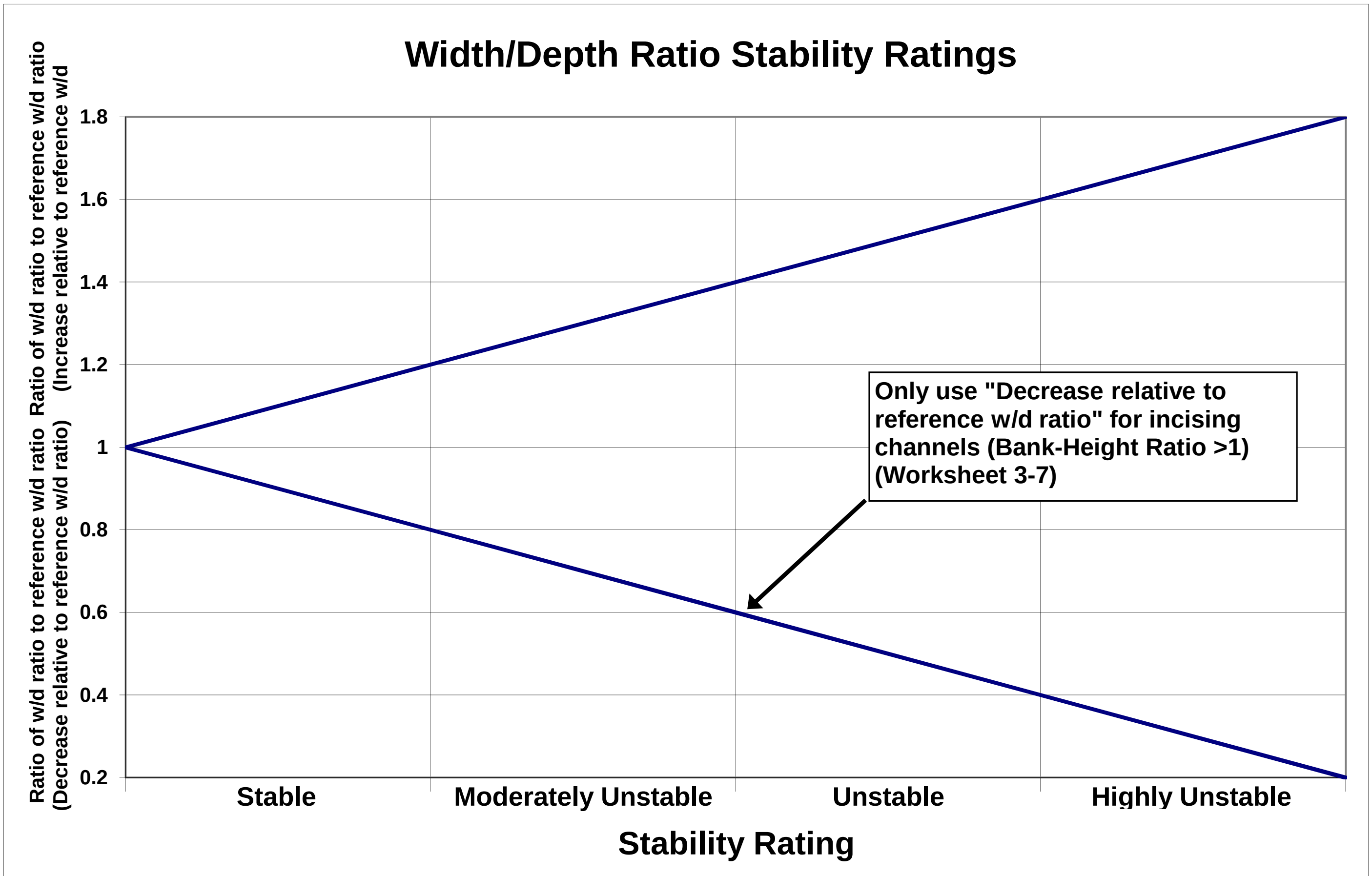
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision			
Low Bank Height:	4.3	Bank-Height Ratio:	2.0
Max Bankfull Depth:	2.2		
Degree of Channel Incision Stability Rating ☞		Deeply Incised	



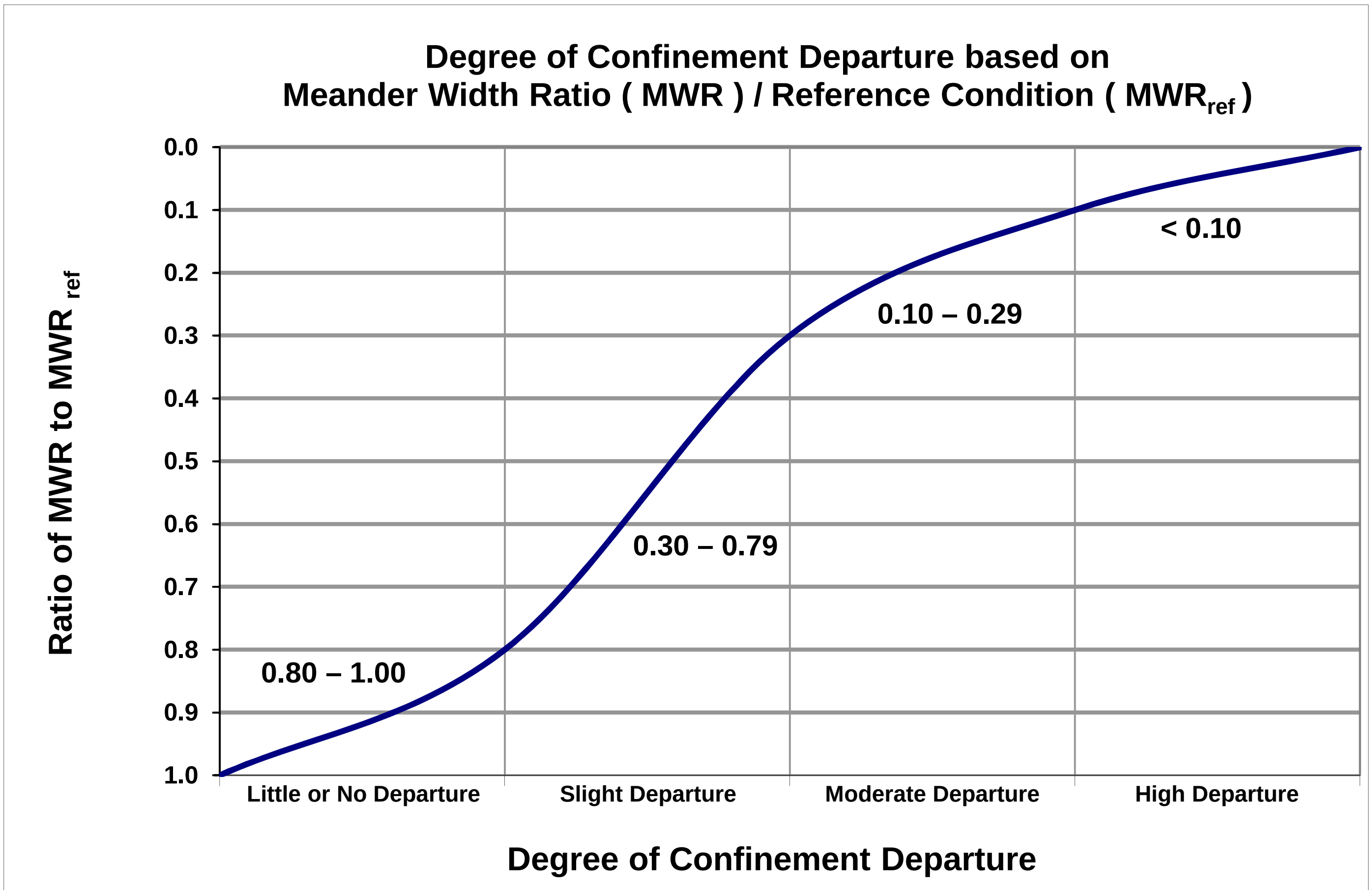
Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State			
Existing Width/Depth Ratio:	**8.21**	Ratio of existing W/d to reference W/d:	**1.37**
Reference Width/Depth Ratio:	**6**		
Width/Depth Ratio State Stability Rating ☞		**Moderately Unstable**	



Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement			
Existing Meander Width Ratio (MWR):	3.29	Ratio of MWR to MWR_{ref}:	0.82
Reference Meander Width Ratio (MWR_{ref}):	4		
Degree of Confinement Stability Rating ☞		Unconfined	



Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**E 4b**
Location:	**Reach 9**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Enter Required Information for Existing Condition

35.6	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.833	D_{max}	Largest particle from bar sample (ft)	**254**	**(mm)**	304.8 mm/ft
0.03451	S	Existing bankfull water surface slope (ft/ft)			
1.48	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
7.13	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \dfrac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \dfrac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Sediment Competence Using Dimensional Shear Stress

3.187		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **260.9**	CO **356.6**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **3.106**	CO **2.01**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **1.44**	CO **0.93**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \dfrac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0336**	CO **0.0218**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \dfrac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Fourmile Canyon Creek**	Stream Type: **E 4b**
Location: **Reach 9**	Valley Type: **XIII**
Observers: **Lucas Babbitt**	Date: **08/20/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☑ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☐ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Fourmile Canyon Creek**			Stream Type:	**E 4b**
Location:	**Reach 9**			Valley Type:	**XIII**
Observers:	**Lucas Babbitt**			Date:	**08/20/2015**

Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**4**
2 **Depositional Patterns (Worksheet 3-5)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**1**
3 **Meander Patterns (Worksheet 3-4)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)**	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**1**
				Total Points	**7**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **< 10** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**E 4b**
Location:	**Reach 9**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points (from each row)**
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 **Sediment competence (Worksheet 3-14)**	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope-slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	**2**
2 **Sediment Capacity (POWERSED)**	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	**2**
3 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**4**
4 **Stream Succession States (Worksheet 3-16)**	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	**2**
5 **Depositional Patterns (Worksheet 3-5)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 3-6)**	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**4**
				Total Points	**15**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **< 15** ☐	***Moderate Deposition*** **15 – 20** ☑	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**E 4b**
Location:	**Reach 9**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points** (from each row)
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 **Sediment Competence (Worksheet 3-14)**	Does not indicate excess competence **(2)**	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed **(4)**	D_{100} of bed moved **(6)**	Particles much larger than D_{100} of bed moved **(8)**	**6**
2 **Sediment Capacity (POWERSED)**	Does not indicate excess capacity **(2)**	Slight excess energy: up to 10% increase above reference **(4)**	Excess energy sufficient to increase load up to 50% of annual load **(6)**	Excess energy transporting more than 50% of annual load **(8)**	**6**
3 **Degree of Channel Incision (BHR) (Worksheet 3-7)**	1.00 – 1.10 **(2)**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**8**
4 **Stream Succession States (Worksheets 3-16 and 3-7)**	Does not indicate incision or degradation **(2)**	If BHR > 1.1 and stream type has W/d between 5–10 **(4)**	If BHR > 1.1 and stream type has W/d less than 5 **(6)**	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) **(8)**	**4**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**1**
				Total Points	**25**

Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Channel Incision / Degradation**			
	Not Incised < 12 ☐	***Slightly Incised*** 12 – 18 ☐	***Moderately Incised*** 19 – 27 ☑	***Degradation*** > 27 ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Fourmile Canyon Creek**				Stream Type: **E 4b**	
Location: **Reach 9**				Valley Type: **XIII**	
Observers: **Lucas Babbitt**				Date: **08/20/2015**	
Channel Enlargement Prediction Criteria (choose one stability category for each criterion 1–4)	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 **Successional Stage Shift (Worksheet 3-16)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 3-17)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**2**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**4**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**6**
				Total Points	**14**
	Category Point Range				
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☐	***Slight Increase*** **11 – 16** ☑	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐	

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: **Fourmile Canyon Creek**		Stream Type:	**E 4b**
Location: **Reach 9**		Valley Type:	**XIII**
Observers:		Date:	**08/20/2015**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 3-17)	***Stable***	**1**	**1**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	***No Deposition***	**1**	**2**
	Mod. Deposition	**2**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	***Not Incised***	**1**	**3**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 Channel Enlargement Prediction (Worksheet 3-20)	***No Increase***	**1**	**2**
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**4**	
5 Pfankuch Channel Stability (Worksheet 3-10)	***Good: Stable***	**1**	**2**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**4**	
		Total Points	**10**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **< 6** ☐	***Moderate*** **6 – 10** ☑	***High*** **11 – 15** ☐	***Very High*** **> 15** ☐

Worksheet 3-22. Summary of stability condition categories.

	A										
1	Stream:	**Fourmile Canyon Creek**				Location:	**Reach 9**				
2	Observers:	**Lucas Babbitt**		Date:	**8/20/2015**	Stream Type:	**E 4B**	Valley Type:	**XIII**		
3–4	**Channel Dimension**	Mean Bankfull Depth (ft):	**1.48**	Bankfull Width (ft):	**12.15**	Cross-Sectional Area (ft^2):	**17.98**	Width/Depth Ratio:	**8.21**	Entrenchment Ratio:	**3.94**
5–6	**Channel Pattern**	Mean: Range:	λ/W_{bkf}: **52.51** **41.56 - 63.46**	L_m/W_{bkf}:	**55.64** **55.64 - 55.64**	R_c/W_{bkf}:	**16.3** **7.33 - 25.35**	MWR:	**3.29** **3.29 - 3.29**	Sinuosity:	**1.11**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec):	**9.532**	Bankfull Discharge (Q_{bkf}):	**171.385**	Estimation Method:	**U/U***	Drainage Area (mi^2):	**7.42**		
9	**River Profile & Bed Features**	Check: ☐ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed					
10–12		Max Bankfull Depth (ft):	Riffle **2.3**	Pool **2.52**	Depth Ratio (max to mean):	Riffle **1.55**	Pool **1.74**	Pool-to-Pool Spacing:	Ratio **36.35**	Slope: Valley: **0.047**	Water Surface: **0.03451**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation	Current Composition/Density: **See descritpion**	Potential Composition/Density: **Same as existing native speci**	Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**						
15–16		Flow Regime:	**P 1 2 8**	Stream Size & Order:	**S-4(3)**	Meander Patterns:	**M1 M4**	Depositional Patterns:	**B1**	Debris/Channel Blockages:	**D1 D10**
17–18		Degree of Incision (Bank-Height Ratio):	**1.95**	Degree of Incision Stability Rating:	**Deeply Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**75 -**				
19–20		Width/depth Ratio (W/d):	**8.21**	Reference W/d Ratio (W/d_{ref}):	**6**	Width/Depth Ratio State $(W/d) / (W/d_{ref})$:	**1.37**	W/d Ratio State Stability Rating:	**Moderately Unstable**		
21–22		Meander Width Ratio (MWR):	**3.29**	Reference MWR_{ref}:	**4**	Degree of confinement (MWR / MWR_{ref}):	**0.8225**	MWR / MWR_{ref} Stability Rating:	**Moderately Unstable**		
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft):	**0**	Annual Streambank Erosion Rate: **0** (tons/yr)	**0** (tons/yr/ft)	Curve Used:	Remarks:				
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity	Remarks:						
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm):	**254**	$\tau =$ **2.01**	$\tau^* =$ **0**	Existing Depth:	**1.48**	Required Depth: **0.93**	Existing Slope: **####**	Required Slope:	**####**
28–29	**Successional Stage Shift**	→ → → → →				Existing Stream State (Type):	**E 4b**	Potential Stream State (Type):			
30	**Lateral Stability**	☑ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:					
31	**Vertical Stability (Aggradation)**	☐ *No Deposition*	☑ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:					
32	**Vertical Stability (Degradation)**	☐ *Not Incised*	☐ *Slightly Incised*	☑ *Mod. Incised*	☐ *Degradation*	Remarks/causes:					
33	**Channel Enlargement**	☐ *No Increase*	☑ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:					
34–35	**Sediment Supply (Channel Source)**	☐ *Low*	☑ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes:					

RIVERMORPH PFANKUCH SUMMARY

River Name: Reach 10
Reach Name: Assesments
Survey Date: 05/13/2015

Upper Bank

Landform Slope:	6
Mass Wasting:	9
Debris Jam Potential:	4
Vegetative Protection:	9

Lower Bank

Channel Capacity:	3
Bank Rock Content:	4
Obstructions to Flow:	4
Cutting:	12
Deposition:	12

Channel Bottom

Rock Angularity:	2
Brightness:	4
Consolidation of Particles:	4
Bottom Size Distribution:	8
Scouring and Deposition:	24
Aquatic Vegetation:	4

Channel Stability Evaluation

Sediment Supply:	High
Stream Bed Stability:	
W/D Condition:	
Stream Type:	B4

Rating - 109
Condition - Poor

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Fourmile Canyon Creek**	Location:	**Reach - Reach 10**
Date:	Stream Type: **C4**	Valley Type:	**??**
Observers:		HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**23.06**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**1.23**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**18.69**	W_{bkf} (ft)	Wetted PERIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**20.10**	W_p (ft)
D_{84} at Riffle	**90.00**	Dia. (mm)	D_{84} (mm) / 304.8	**0.30**	D_{84} (ft)
Bankfull SLOPE	**0.0351**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**1.15**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**3.90**	R / D_{84}
Drainage Area	**7.4**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	**1.140**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log \{ R / D_{84} \}] u^*$	**7.02**	ft / sec	**161.96**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.055**	**5.55**	ft / sec	**128.01**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.04**	**7.63**	ft / sec	**175.99**	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2} / n$ $n = 0.39*S^{0.38}*R^{-0.16}$ $n =$ **0.107** Note: This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3	**2.86**	ft / sec	**65.86**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	**7.53**	ft / sec	**173.71**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Chezy C**	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge** Q = **0.0** year	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A	**0.00**	ft / sec	**0.00**	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrusion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 5-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream: **Fourmile Canyon Creek, Reach - Reach 10**	
Basin:	Drainage Area: **4748.8** acres **7.42** mi^2
Location:	
Twp.&Rge: **;**	Sec.&Qtr.: **;**
Cross-Section Monuments (Lat./Long.): **40.0645 Lat / 105.30531 Long**	Date: **08/20/15**
Observers: **Lucas Babbitt**	Valley Type: VIII(b)

Parameter	Value	Unit
Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**24.93**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.73**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**18.11**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**34.15**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.7**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**37.05**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.49**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**29.65**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.03512**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.11**	

Stream Type → **B 4** ← (See **Figure 2-14**)

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek** Location: **Reach - Reach 10**

Observers: **Lucas Babbitt** Date: **08/20/15** Valley Type: **XIII** Stream Type: **B 4**

River Reach Dimension Summary Data.....1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	21.8	18.7	24.9	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	20.59	18.11	23.06
Mean Riffle Depth (d_{bkf})	0.98	0.73	1.23	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	24.67	15.20	34.15
Maximum Riffle Depth (d_{max})	1.8	1.7	1.9	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.937	1.545	2.329
Width of Flood-Prone Area (W_{fpa})	36.3	35.6	37.1	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	1.694	1.486	1.902
Riffle Inner Berm Width (W_{ib})	6.22	0	12.4	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.250	0.000	0.499
Riffle Inner Berm Depth (d_{ib})	0.22	0	0.45	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.306	0.000	0.612
Riffle Inner Berm Area (A_{ib})	2.78	0	5.55	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.154	0.000	0.307
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	13.9	0	27.9					

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	21	21	21	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	0.961	0.961	0.961
Mean Pool Depth (d_{bkfp})	1.11	1.11	1.11	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	1.133	1.133	1.133
Pool Cross-Sectional Area (A_{bkfp})	23.2	23.2	23.2	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.126	1.126	1.126
Maximum Pool Depth (d_{maxp})	1.9	1.9	1.9	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	1.939	1.939	1.939
Pool Inner Berm Width (W_{ibp})	12.7	12.7	12.7	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.608	0.608	0.608
Pool Inner Berm Depth (d_{ibp})	0.75	0.75	0.75	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.680	0.680	0.680
Pool Inner Berm Area (A_{ibp})	9.62	9.62	9.62	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.415	0.415	0.415
Point Bar Slope (S_{pb})	0.000	0.000	0.000	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	####	####	####

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	18.7	18.7	18.7	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	0.857	0.857	0.857
Mean Run Depth (d_{bkfr})	1.23	1.23	1.23	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	1.255	1.255	1.255
Run Cross-Sectional Area (A_{bkfr})	23.1	23.1	23.1	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	1.120	1.120	1.120
Maximum Run Depth (d_{maxr})	1.9	1.9	1.9	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	1.939	1.939	1.939
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	15.2	15.2	15.2	ft				

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	0	0	0	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	0.000	0.000	0.000
Mean Glide Depth (d_{bkfg})	0	0	0	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.000	0.000	0.000
Glide Cross-Sectional Area (A_{bkfg})	0	0	0	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	0.000	0.000	0.000
Maximum Glide Depth (d_{maxg})	0	0	0	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	0.000	0.000	0.000
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	0	0	0	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	0.000	0.000	0.000
Glide Inner Berm Width (W_{ibg})	0	0	0	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Depth (d_{ibg})	0	0	0	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.000	0.000	0.000
Glide Inner Berm Area (A_{ibg})	0	0	0	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.000	0.000	0.000

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	0	0	0	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	0.000	0.000	0.000
Mean Step Depth (d_{bkfs})	0	0	0	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	0.000	0.000	0.000
Step Cross-Sectional Area (A_{bkfs})	0	0	0	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	0.000	0.000	0.000
Maximum Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0.000	0.000	0.000
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	0	0	0					

*Riffle–Pool system (i.e., C, E, F stream types) bed features include riffles, runs, pools and glides.

**Step–Pool system (i.e., A, B, G stream types) bed features include riffles, rapids, chutes, pools and steps (note: include rapids and chutes in riffle category).

***Convergence-Divergence system (i.e., D stream types) bed features include riffles and pools; cross-sections taken at riffles for classification purposes.

****Mean values are used as the normalization parameter for all dimensionless ratios; e.g., minimum pool width to riffle width ratio uses the *mean* riffle width value.

Worksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 2007; Rosgen, 2008).

Stream: **Fourmile Canyon Creek**		Location: **Reach - Reach 10**	
Observers: **Lucas Babbitt**	Date: **08/20/15**	Valley Type: **XIII**	Stream Type: **B 4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**4.926**	ft/sec	Estimation Method		
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**89.21**	cfs	Drainage Area	**7.42**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	174	105	272	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	7.978	4.814	####
Stream Meander Length (L_m)	218	164	302	ft	Stream Meander Length Ratio (L_m / W_{bkf})	9.995	7.519	####
Radius of Curvature (R_c)	68	23	115	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	3.118	1.055	5.273
Belt Width (W_{blt})	25	13	39	ft	Meander Width Ratio (W_{blt} / W_{bkf})	1.146	0.596	1.788
Arc Length (L_a)	0	0	0	ft	Arc Length to Riffle Width (L_a / W_{bkf})	0.000	0.000	0.000
Riffle Length (L_r)	45.1	30.5	54.5	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	2.066	1.399	2.500
Individual Pool Length (L_p)	0	0	0	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	0.000	0.000	0.000
Pool to Pool Spacing (P_s)	0	0	0	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	0.000	0.000	0.000

Channel Profile

Valley Slope (S_{val})	0.041	ft/ft	Average Water Surface Slope (S)	0.03512	ft/ft	Sinuosity (S_{val} / S)	1.11
Stream Length (SL)	2377	ft	Valley Length (VL)	2158	ft	Sinuosity (SL / VL)	1.1
Low Bank Height (LBH)	start 6.46 ft; end 6.1 ft		Max Depth (d_{max})	start 6.11 ft; end 2.03 ft		Bank-Height Ratio (BHR) (LBH / d_{max})	start 1.06; end 3

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.029	0.010	0.048	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	0.838	0.293	1.369
Run Slope (S_{run})	0.000	0.000	0.000	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	0.000	0.000	0.000
Pool Slope (S_p)	0.000	0.000	0.000	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	0.000	0.000	0.000
Glide Slope (S_g)	0.000	0.000	0.000	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	0.000	0.000	0.000
Step Slope (S_s)	0.000	0.000	0.000	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	0.000	0.000	0.000

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{maxrif})	0	0	0	ft	Max Riffle Depth to Mean Riffle Depth (d_{maxrif} / d_{bkf})	0	0	0
Max Run Depth (d_{maxrun})	0	0	0	ft	Max Run Depth to Mean Riffle Depth (d_{maxrun} / d_{bkf})	0	0	0
Max Pool Depth (d_{maxp})	0	0	0	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	0	0	0
Max Glide Depth (d_{maxg})	0	0	0	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	0	0	0
Max Step Depth (d_{maxs})	0	0	0	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	0	0	0

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	0	0		D_{16}	1.71	12.48			mm
% Sand	18	6		D_{35}	16	33.53			mm
% Gravel	61	65		D_{50}	29.65	45			mm
% Cobble	18	29		D_{84}	104.25	90			mm
% Boulder	3	0		D_{95}	180	119.86			mm
% Bedrock	0	0		D_{100}	511.98	180			mm

[a] Min, max & mean depths are measured from Thalweg to bankfull at mid-point of feature for riffles and runs, the deepest part of pools, & at the tail-out of glides.

[b] Composite sample of riffles and pools within the designated reach. [c] Active bed of a riffle. [d] Height of roughness feature above bed.

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Fourmile Canyon Creek**	Location: **Reach 10**							
Observers: **Lucas Babbitt**	Date: **8/20/2015**							
List ALL COMBINATIONS that APPLY..............☞	**P**	**1**	**2**	**8**				

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order

Stream:	**Fourmile Canyon Creek**
Location:	**Reach 10**
Observers:	**Lucas Babbitt**
Date:	**8/20/2015**
Stream Size Category and Order ☞	**S-4(3)**

Category	STREAM SIZE: Bankfull width		Check (✓) appropriate category
	meters	feet	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☑
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☐
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐

Stream Order

Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).

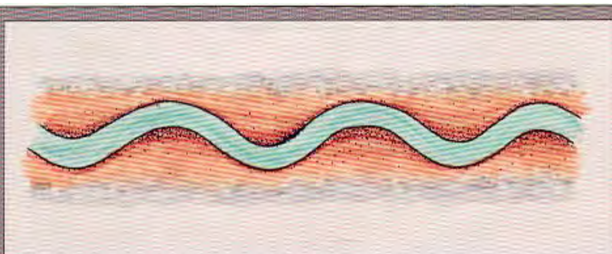
Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

Meander Patterns

Stream:	**Fourmile Canyon Creek**	Reach:	**Reach 10**
Observers:	**Lucas Babbitt**	Date:	**8/20/2015**

List ALL CATEGORIES that APPLY ☞	**M1**	**M3**	**M4**		

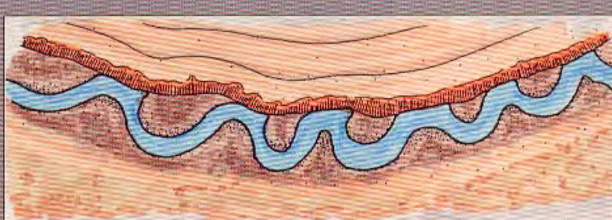
Various Meander Pattern variables modified from Galay et al. (1973)



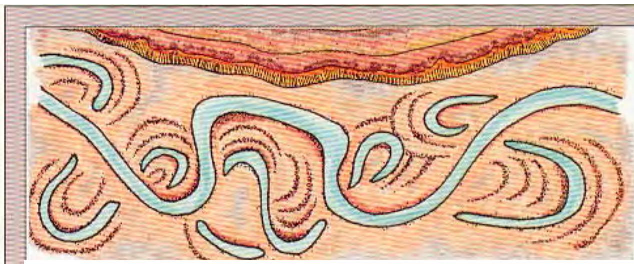
M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

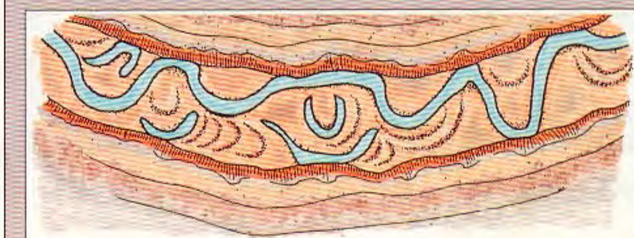
M3 IRREGULAR MEANDERS



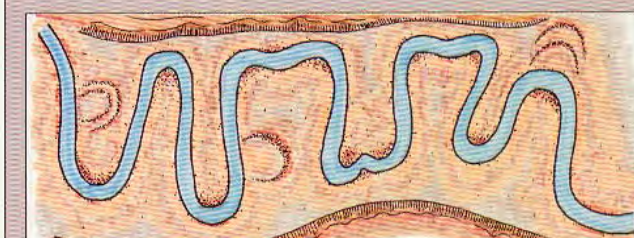
M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



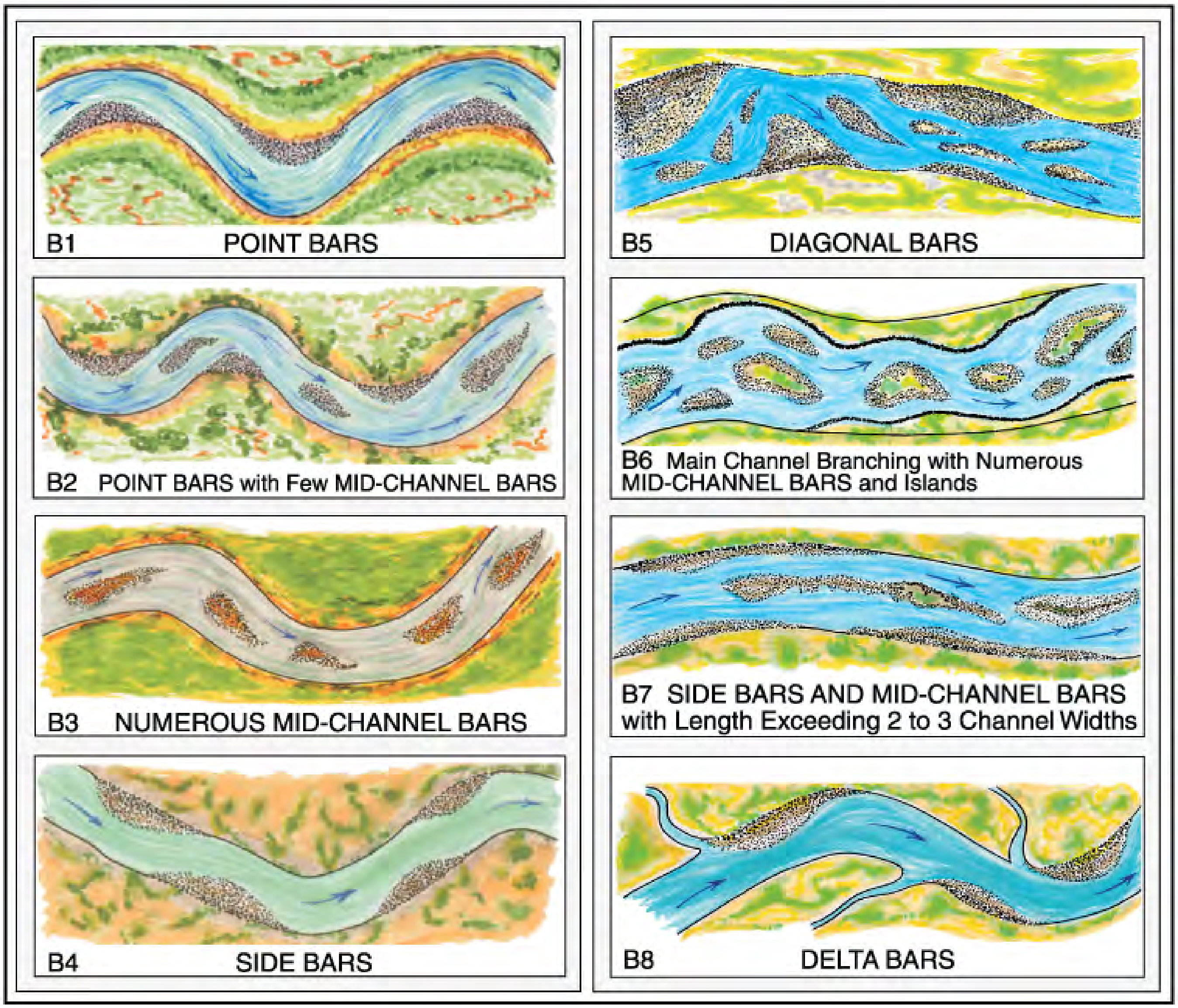
M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns						
Stream:	**Fourmile Canyon Creek**		Reach: **Reach 10**			
Observers:	**Lucas Babbitt**		Date: **8/20/2015**			
List ALL CATEGORIES that APPLY ☞		**B1**	**B5**	**B7**		

Various Depositional Features modified from Galay et al. (1973)

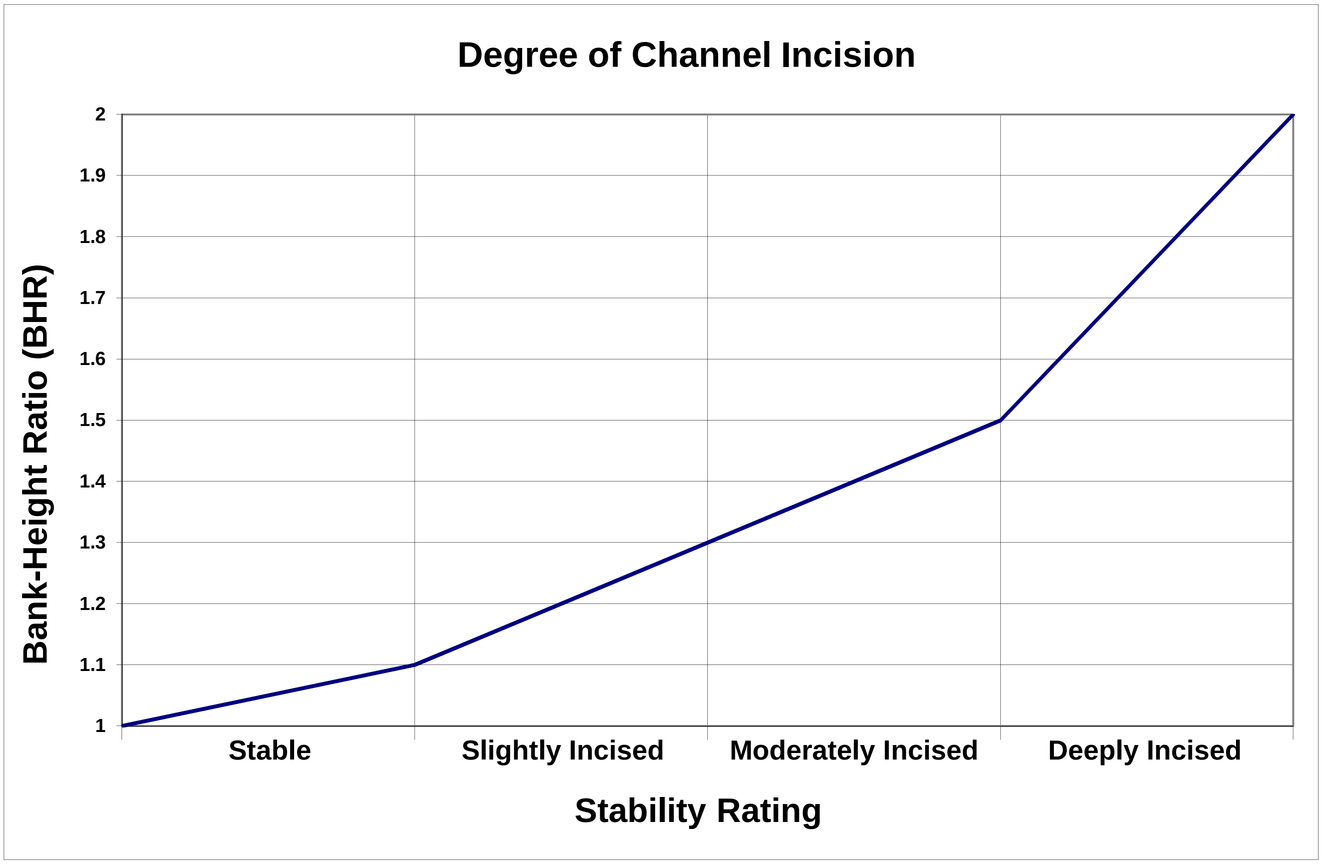


Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream: **Fourmile Canyon Creek**		Location: **Reach 10**	
Observers: **Lucas Babbitt**		Date: **8/20/2015**	
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☐
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☑
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

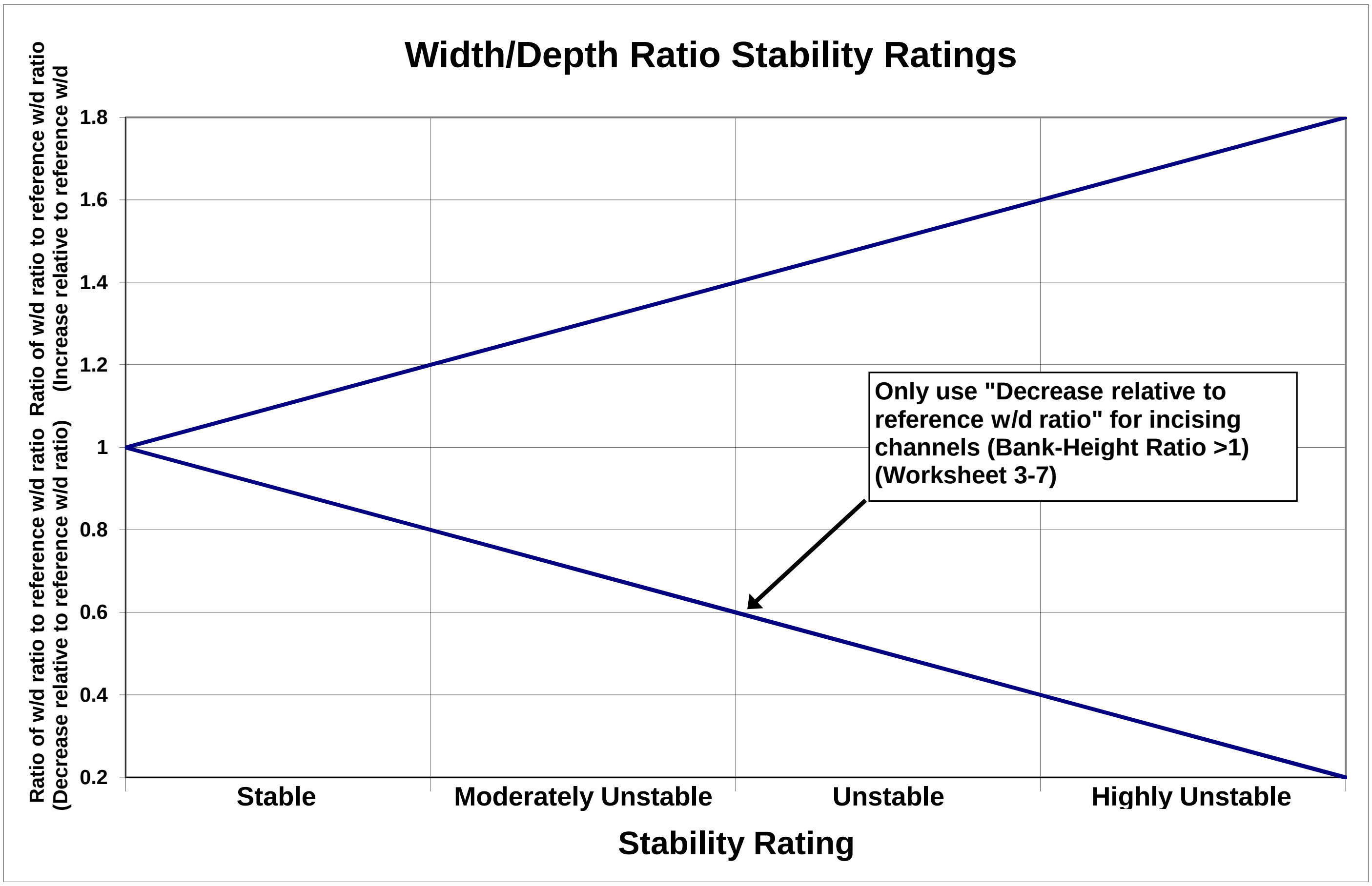
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision			
Low Bank Height:	6.46	Bank-Height Ratio:	1.1
Max Bankfull Depth:	6.11		
Degree of Channel Incision Stability Rating ☞		Stable	



Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State			
Existing Width/Depth Ratio:	**34.15**	Ratio of existing W/d to reference W/d:	**1.48**
Reference Width/Depth Ratio:	**23**		
Width/Depth Ratio State Stability Rating ☞		**Unstable**	

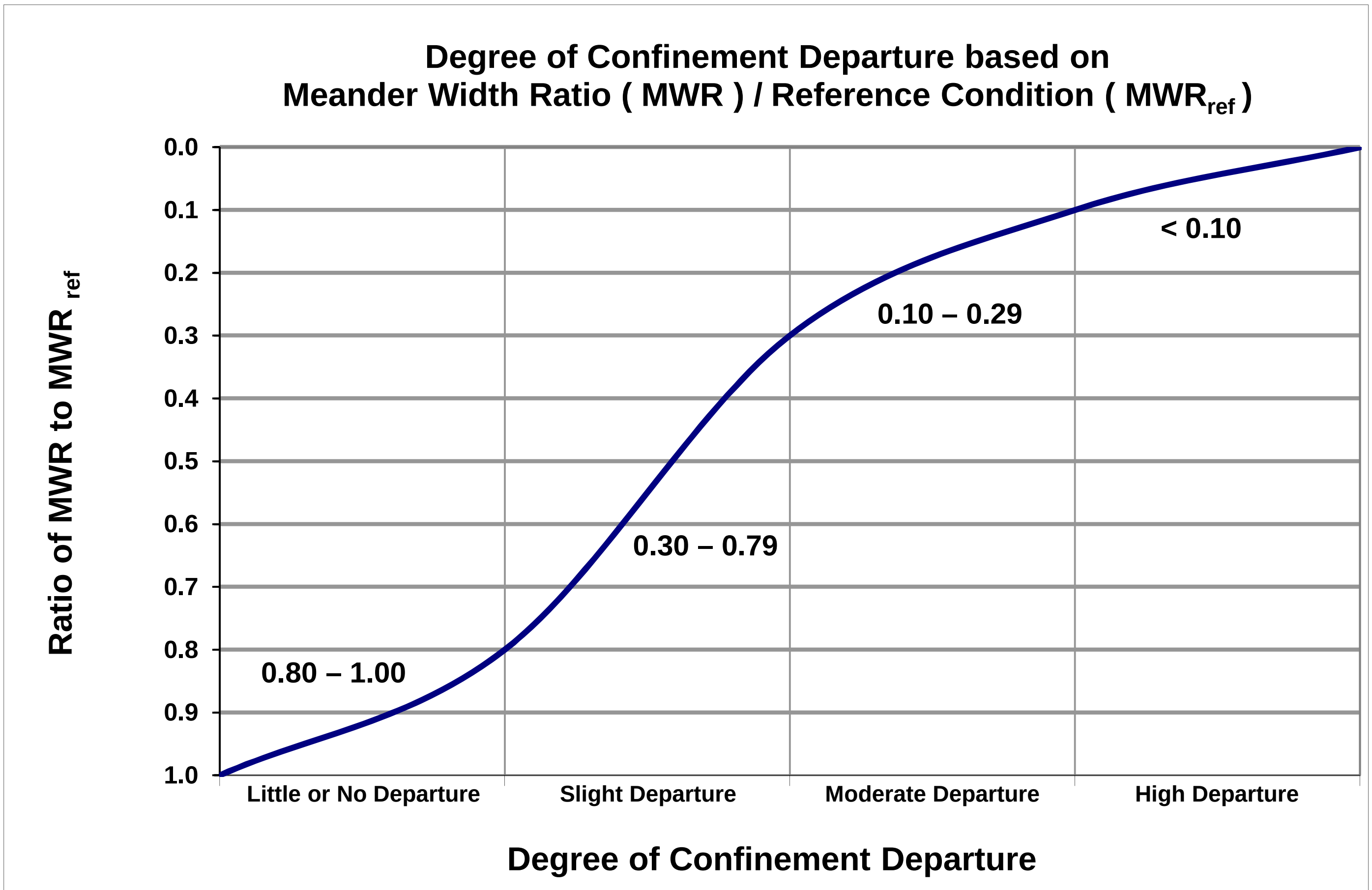


Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement

Existing Meander Width Ratio (MWR):	1	Ratio of MWR to MWR_{ref}:	0.25
Reference Meander Width Ratio (MWR_{ref}):	4		

Degree of Confinement Stability Rating ☞ **Confined**



Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**		Stream Type:	**B 4**	
Location:	**Reach 10**		Valley Type:	**XIII**	
Observers:	**Lucas Babbitt**		Date:	**08/20/2015**	

Enter Required Information for Existing Condition

45.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.583	D_{max}	Largest particle from bar sample (ft)	**177.8**	**(mm)**	304.8 mm/ft
0.03512	S	Existing bankfull water surface slope (ft/ft)			
0.73	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
3.95	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \dfrac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \dfrac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Sediment Competence Using Dimensional Shear Stress

1.600		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft²) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **127.2**	CO **214.8**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.206**	CO **1.237**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **1.01**	CO **0.56**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \dfrac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0484**	CO **0.0272**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \dfrac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: Fourmile Canyon Creek	Stream Type: **B 4**
Location: **Reach 10**	Valley Type: **XIII**
Observers: **Lucas Babbitt**	Date: **08/20/2015**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☐ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☑ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Fourmile Canyon Creek**			Stream Type:	**B 4**	
Location:	**Reach 10**			Valley Type:	**XIII**	
Observers:	**Lucas Babbitt**			Date:	**08/20/2015**	

Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**6**
2 **Depositional Patterns (Worksheet 3-5)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**4**
3 **Meander Patterns (Worksheet 3-4)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)**	< 0.006 **(2)**	0.006 - 0.04 **(4)**	0.041 - 0.07 **(6)**	> 0.07 **(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	> 0.8 **(1)**	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**3**
				Total Points	**14**

Overall Lateral Stability Category (use total points and check stability rating)	**Lateral Stability Category Point Range**			
	Stable **< 10** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**B 4**
Location:	**Reach 10**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points** (from each row)
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 **Sediment competence (Worksheet 3-14)**	Sufficient depth and/or slope to transport largest size available **(2)**	Trend toward insufficient depth and/or slope- slightly incompetent **(4)**	Cannot move D_{35} of bed material and/or D_{100} of bar material **(6)**	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size **(8)**	**2**
2 **Sediment Capacity (POWERSED)**	Sufficient capacity to transport annual load **(2)**	Trend toward insufficient sediment capacity **(4)**	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand **(6)**	Reduction over 25% of annual sediment yield for bedload and/or suspended sand **(8)**	**2**
3 **W/d Ratio State (Worksheet 3-8)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**6**
4 **Stream Succession States (Worksheet 3-16)**	Current stream type at potential or does not indicate deposition/ aggradation **(2)**	(E→C) **(4)**	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b) **(6)**	(C→D), (F→D) **(8)**	**2**
5 **Depositional Patterns (Worksheet 3-5)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	B6, B7, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 3-6)**	D1, D2, D3 **(1)**	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**4**
				Total Points	**17**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition < 15 ☐	***Moderate Deposition*** 15 – 20 ☑	***Excess Deposition*** 21 – 30 ☐	***Aggradation*** > 30 ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**B 4**
Location:	**Reach 10**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points** (from each row)
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 **Sediment Competence** (Worksheet 3-14)	Does not indicate excess competence **(2)**	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed **(4)**	D_{100} of bed moved **(6)**	Particles much larger than D_{100} of bed moved **(8)**	**6**
2 **Sediment Capacity (POWERSED)**	Does not indicate excess capacity **(2)**	Slight excess energy: up to 10% increase above reference **(4)**	Excess energy sufficient to increase load up to 50% of annual load **(6)**	Excess energy transporting more than 50% of annual load **(8)**	**6**
3 **Degree of Channel Incision (BHR) (Worksheet 3-7)**	1.00 – 1.10 **(2)**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**2**
4 **Stream Succession States (Worksheets 3-16 and 3-7)**	Does not indicate incision or degradation **(2)**	If BHR > 1.1 and stream type has W/d between 5–10 **(4)**	If BHR > 1.1 and stream type has W/d less than 5 **(6)**	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A) **(8)**	**8**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 3-9)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**3**
				Total Points	**25**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **< 12** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☑	***Degradation*** **> 27** ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Fourmile Canyon Creek**				Stream Type: **B 4**	
Location: **Reach 10**				Valley Type: **XIII**	
Observers: **Lucas Babbitt**				Date: **08/20/2015**	
Channel Enlargement Prediction Criteria (choose one stability category for each criterion 1–4)	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 **Successional Stage Shift (Worksheet 3-16)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(B→High W/d B), (C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F) **(8)**	**6**
2 **Lateral Stability (Worksheet 3-17)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**6**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**4**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**6**
				Total Points	**22**
	Category Point Range				
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐	

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: **Fourmile Canyon Creek**		Stream Type:	**B 4**
Location: **Reach 10**		Valley Type:	**XIII**
Observers:		Date:	**08/20/2015**
Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 3-17)	***Stable***	**1**	**3**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	***No Deposition***	**1**	**2**
	Mod. Deposition	**2**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	***Not Incised***	**1**	**3**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 Channel Enlargement Prediction (Worksheet 3-20)	***No Increase***	**1**	**3**
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**4**	
5 Pfankuch Channel Stability (Worksheet 3-10)	***Good: Stable***	**1**	**1**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**4**	
		Total Points	**12**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **< 6** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☑	***Very High*** **> 15** ☐

Worksheet 3-22. Summary of stability condition categories.

	A	B – AM
1	Stream:	**Fourmile Canyon Creek** · Location: **Reach 10**
2	Observers:	**Lucas Babbitt** · Date: **8/20/2015** · Stream Type: **B 4** · Valley Type: **XIII**
3–4	**Channel Dimension**	Mean Bankfull Depth (ft): **0.73** · Bankfull Width (ft): **24.93** · Cross-Sectional Area (ft^2): **18.11** · Width/Depth Ratio: **34.15** · Entrenchment Ratio: **1.49**
5–6	**Channel Pattern**	Mean: / Range: · λ/W_{bkf}: **6.98** / **4.21 - 10.91** · L_m/W_{bkf}: **8.74** / **6.58 - 12.11** · R_c/W_{bkf}: **2.73** / **0.92 - 4.61** · MWR: **1** / **0.52 - 1.56** · Sinuosity: **1.11**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec): **5.551** · Bankfull Discharge (Q_{bkf}): **128.006** · Estimation Method: · Drainage Area (mi^2): **7.42**
9	**River Profile & Bed Features**	Check: ☐ Riffle/Pool ☐ Step/Pool ☐ Plane Bed ☐ Convergence/Divergence ☐ Dunes/Antidunes/Smooth Bed
10–12		Max Bankfull Depth (ft): Riffle **1.7**, Pool **1.9** · Depth Ratio (max to mean): Riffle **2.33**, Pool **1.71** · Pool-to-Pool Spacing: Ratio **0** · Slope: Valley: **0.041**, Water Surface: **0.03512**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation · Current Composition/Density: **See description** · Potential Composition/Density: **Same as existing native speci** · Remarks: Condition, Vigor & Usage of Existing Reach: **Density and potentially some species impacted by 2(**
15–16		Flow Regime: **P 1 2 8** · Stream Size & Order: **S-4(3)** · Meander Patterns: **M1 M3 M4** · Depositional Patterns: **B1 B5 B7** · Debris/Channel Blockages: **D3 D10**
17–18		Degree of Incision (Bank-Height Ratio): **1.06** · Degree of Incision Stability Rating: **Stable** · Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **109 -**
19–20		Width/depth Ratio (W/d): **34.15** · Reference W/d Ratio (W/d_{ref}): **23** · Width/Depth Ratio State (W/d) / (W/d_{ref}): **1.48** · W/d Ratio State Stability Rating: **Unstable**
21–22		Meander Width Ratio (MWR): **1** · Reference MWR_{ref}: **4** · Degree of confinement (MWR / MWR_{ref}): **0.25** · MWR / MWR_{ref} Stability Rating: **Unstable**
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft): **0** · Annual Streambank Erosion Rate: **0** (tons/yr) **0** (tons/yr/ft) · Curve Used: · Remarks:
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity ☐ Insufficient Capacity ☐ Excess Capacity · Remarks:
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm): **177.8** · $\tau =$ **1.237** · $\tau^* =$ **0** · Existing Depth: **0.73** · Required Depth: **0.56** · Existing Slope: **####** · Required Slope: **####**
28–29	**Successional Stage Shift**	→ → → → → · Existing Stream State (Type): **B 4** · Potential Stream State (Type):
30	**Lateral Stability**	☐ *Stable* ☐ *Mod. Unstable* ☑ *Unstable* ☐ *Highly Unstable* · Remarks/causes:
31	**Vertical Stability (Aggradation)**	☐ *No Deposition* ☑ *Mod. Deposition* ☐ *Ex. Deposition* ☐ *Aggradation* · Remarks/causes:
32	**Vertical Stability (Degradation)**	☐ *Not Incised* ☐ *Slightly Incised* ☑ *Mod. Incised* ☐ *Degradation* · Remarks/causes:
33	**Channel Enlargement**	☐ *No Increase* ☐ *Slight Increase* ☑ *Mod. Increase* ☐ *Extensive* · Remarks/causes:
34–35	**Sediment Supply (Channel Source)**	☐ *Low* ☐ *Moderate* ☑ *High* ☐ *Very High* · Remarks/causes:

Reference Reach Data

XS A= 25.3

	Entry Number & Variable	Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach US Riffle	Pre-Flood Assessment of FMCC	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
	1 Valley Type (I–XII)							V		VIII
	2 Valley Width (W_{val})							290-600		
	3 Stream Type	C4/B4	C4/B4	C4/B4	C4/B4		C4/B4	C3		C3b
	4 Drainage Area, mi^2 (DA)	4.97	4.97	4.97	4.97		4.97	49.9		4.4
	5 Bankfull Discharge, cfs (Q_{bkf})	120.0	120.0	120.0	120.0		120	375		110.0
Riffle Dimensions	6 Riffle Width, ft (W_{bkf})	Mean: 21.5 Min: 21.5 Max: 21.5	Mean: 21.5 Min: 21.5 Max: 21.5	Mean: 21.5 Min: 21.5 Max: 21.5	Mean: 21.5 Min: 21.5 Max: 21.5	Mean: 25.0 Min: 25.0 Max: 25.0	Mean: 24.2 Min: 23.2 Max: 25.2	Mean: 38.8 Min: 37.8 Max: 39.9	Mean: 19.5 Min: 15.0 Max: 21.9	Mean: 15.1 Min: 12.8 Max: 18.7
Riffle Dimensions	7 Riffle Mean Depth, ft (d_{bkf})	Mean: 1.2 Min: 1.2 Max: 1.2	Mean: 1.2 Min: 1.2 Max: 1.2	Mean: 1.2 Min: 1.2 Max: 1.2	Mean: 1.2 Min: 1.2 Max: 1.2	Mean: 1.08 Min: 1.08 Max: 1.08	Mean: 1.05 Min: 1.00 Max: 1.09	Mean: 1.70 Min: 1.51 Max: 1.88	Mean: 1.3 Min: 1.2 Max: 1.7	Mean: 1.1 Min: 0.8 Max: 1.4
Riffle Dimensions	8 Riffle Width/Depth Ratio (W_{bkf}/d_{bkf})	Mean: 18.2 Min: 18.2 Max: 18.2	Mean: 18.2 Min: 18.2 Max: 18.2	Mean: 18.2 Min: 18.2 Max: 18.2	Mean: 18.2 Min: 18.2 Max: 18.2	Mean: 23.1 Min: 23.1 Max: 23.1	Mean: 23.1 Min: 21.2 Max: 25.1	Mean: 23.1 Min: 21.2 Max: 25.1	Mean: 15.0 Min: 8.9 Max: 18.9	Mean: 15.0 Min: 8.9 Max: 18.9
Riffle Dimensions	9 Riffle Cross-Sectional Area, ft^2 (A_{bkf})	Mean: 25.3 Min: 25.3 Max: 25.3	Mean: 25.3 Min: 25.3 Max: 25.3	Mean: 25.3 Min: 25.3 Max: 25.3	Mean: 25.3 Min: 25.3 Max: 25.3	Mean: 28.0 Min: 28.0 Max: 28.0	Mean: 25.3	Mean: 66.0 Min: 57.0 Max: 75.1	Mean: 25.3	Mean: 15.9 Min: 10.8 Max: 18.6
Riffle Dimensions	10 Riffle Maximum Depth (d_{max})	Mean: 1.9 Min: 1.9 Max: 1.9	Mean: 1.9 Min: 1.9 Max: 1.9	Mean: 1.9 Min: 1.9 Max: 1.9	Mean: 1.9 Min: 1.9 Max: 1.9	Mean: 2.00 Min: 2.00 Max: 2.00	Mean: 1.76 Min: 1.64 Max: 1.92	Mean: 2.79 Min: 2.65 Max: 2.95	Mean: 2.6 Min: 2.3 Max: 2.9	Mean: 2.1 Min: 1.8 Max: 2.5
Riffle Dimensions	11 Riffle Maximum Depth to Riffle Mean Depth (d_{max}/d_{bkf})	Mean: 1.6 Min: 1.6 Max: 1.6	Mean: 1.6 Min: 1.6 Max: 1.6	Mean: 1.6 Min: 1.6 Max: 1.6	Mean: 1.6 Min: 1.6 Max: 1.6	Mean: 1.852 Min: 1.852 Max: 1.852	Mean: 1.686 Min: 1.569 Max: 1.834	Mean: 1.686 Min: 1.569 Max: 1.834	Mean: 2.0 Min: 1.7 Max: 2.2	Mean: 2.0 Min: 1.7 Max: 2.2
Riffle Dimensions	12 Width of Flood-Prone Area at Elevation of 2 * d_{max}, ft (W_{fpa})	Mean: 49.9 Min: 22.8 Max: 108.9	Mean: 49.9 Min: 22.8 Max: 108.9	Mean: 49.9 Min: 22.8 Max: 108.9	Mean: 49.9 Min: 22.8 Max: 108.9	Mean: 100.0 Min: 100.0 Max: 100.0	Mean: 51.0 Min: 35.0 Max: 85.0	Mean: 280.7 Min: 220.0 Max: 320.0	Mean: Min: Max:	Mean: 59.3 Min: 46.4 Max: 79.4
Riffle Dimensions	13 Entrenchment Ratio (W_{fpa}/W_{bkf})	Mean: 2.3 Min: 1.1 Max: 5.1	Mean: 2.3 Min: 1.1 Max: 5.1	Mean: 2.3 Min: 1.1 Max: 5.1	Mean: 2.3 Min: 1.1 Max: 5.1	Mean: 4.0 Min: 4.0 Max: 4.0	Mean: 2.1 Min: 1.5 Max: 3.4	Mean: 7.3 Min: 5.5 Max: 8.5	Mean: 0.0 Min: 0.0 Max: 0.0	Mean: 4.2 Min: 2.5 Max: 6.2
e Inner Berm Dimensions	14 Riffle Inner Berm Width, ft (W_{ib})	Mean: 9.5 Min: 9.5 Max: 9.5	Mean: 9.5 Min: 9.5 Max: 9.5	Mean: 9.5 Min: 9.5 Max: 9.5	Mean: 9.5 Min: 9.5 Max: 9.5	Mean: 14.0 Min: 14.0 Max: 14.0	Mean: 13.4 Min: 11.7 Max: 14.2	Mean: 21.3 Min: 18.3 Max: 23.3	Mean: 13.0 Min: 9.9 Max: 15.4	Mean: 10.2 Min: 7.0 Max: 14.8
e Inner Berm Dimensions	15 Riffle Inner Berm Width to Riffle Width (W_{ib}/W_{bkf})	Mean: 0.4 Min: 0.4 Max: 0.4	Mean: 0.4 Min: 0.4 Max: 0.4	Mean: 0.4 Min: 0.4 Max: 0.4	Mean: 0.4 Min: 0.4 Max: 0.4	Mean: 0.560 Min: 0.560 Max: 0.560	Mean: 0.552 Min: 0.485 Max: 0.586	Mean: 0.552 Min: 0.485 Max: 0.586	Mean: 0.7 Min: 0.5 Max: 0.8	Mean: 0.7 Min: 0.5 Max: 0.8
e Inner Berm Dimensions	16 Riffle Inner Berm Mean Depth, ft (d_{ib})	Mean: 0.6 Min: 0.6 Max: 0.6	Mean: 0.6 Min: 0.6 Max: 0.6	Mean: 0.6 Min: 0.6 Max: 0.6	Mean: 0.6 Min: 0.6 Max: 0.6	Mean: 0.45 Min: 0.45 Max: 0.45	Mean: 0.41 Min: 0.33 Max: 0.46	Mean: 0.66 Min: 0.51 Max: 0.79	Mean: 0.8 Min: 0.8 Max: 0.9	Mean: 0.7 Min: 0.5 Max: 0.8
e Inner Berm Dimensions	17 Riffle Inner Berm Mean Depth to Riffle Mean Depth (d_{ib}/d_{bkf})	Mean: 0.5 Min: 0.5 Max: 0.5	Mean: 0.5 Min: 0.5 Max: 0.5	Mean: 0.5 Min: 0.5 Max: 0.5	Mean: 0.5 Min: 0.5 Max: 0.5	Mean: 0.417 Min: 0.417 Max: 0.417	Mean: 0.394 Min: 0.320 Max: 0.444	Mean: 0.394 Min: 0.320 Max: 0.444	Mean: 0.6 Min: 0.6 Max: 0.7	Mean: 0.6 Min: 0.6 Max: 0.7
e Inner Berm Dimensions	18 Riffle Inner Berm Width/Depth Ratio (W_{ib}/d_{ib})	Mean: 15.3 Min: 15.3	Mean: 15.3 Min: 15.3	Mean: 15.3 Min: 15.3	Mean: 15.3 Min: 15.3	Mean: 31.1 Min: 31.1	Mean: 33.6 Min: 27.4	Mean: 33.6 Min: 27.4	Mean: 16.5 Min: 10.7	Mean: 16.5 Min: 10.7

Section	Entry Number & Variable		Stat	Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach US Riffle	Pre-Flood Assessment of FMCC	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
Riffl		(W_{ib}/d_{ib})	Max:	15.3	15.3	15.3	15.3	31.1	43.6	43.6	25.5	25.5
	19	Riffle Inner Berm Cross-Sectional Area (A_{ib})	Mean:	5.9	5.9	5.9	5.9	6.3	5.5	14.0	10.2	6.6
			Min:	5.9	5.9	5.9	5.9	6.3	4.7	11.4	8.6	3.7
			Max:	5.9	5.9	5.9	5.9	6.3	6.2	18.4	11.8	8.6
	20	Riffle Inner Berm Cross-Sectional Area to Riffle Cross-Sectional Area (A_{ib}/A_{bkf})	Mean:	0.2	0.2	0.2	0.2	0.225	0.216	0.216	0.4	0.4
			Min:	0.2	0.2	0.2	0.2	0.225	0.187	0.187	0.3	0.3
			Max:	0.2	0.2	0.2	0.2	0.225	0.245	0.245	0.5	0.5
Pool Dimensions	21	Pool Width, ft (W_{bkfp})	Mean:	23.5	23.5	23.5	23.5	25.0	21.7	35.8	14.2	11.0
			Min:	23.5	23.5	23.5	23.5	25.0	19.1	31.5	14.2	11.0
			Max:	23.5	23.5	23.5	23.5	25.0	24.3	40.0	14.2	11.0
	22	Pool Width to Riffle Width (W_{bkfp}/W_{bkf})	Mean:	1.1	1.1	1.1	1.1	1.000	0.897	0.897	0.7	0.7
			Min:	1.1	1.1	1.1	1.1	1.000	0.790	0.790	0.7	0.7
			Max:	1.1	1.1	1.1	1.1	1.000	1.004	1.004	0.7	0.7
	23	Pool Mean Depth, ft (d_{bkfp})	Mean:	1.3	1.5	1.3	1.3	1.40	1.29	2.32	1.3	1.1
			Min:	1.3	1.5	1.3	1.3	1.40	1.26	2.27	1.3	1.1
			Max:	1.3	1.5	1.3	1.3	1.40	1.32	2.37	1.3	1.1
	24	Pool Mean Depth to Riffle Mean Depth (d_{bkfp}/d_{bkf})	Mean:	1.1	1.3	1.1	1.1	1.296	1.234	1.234	1.0	1.0
			Min:	1.1	1.3	1.1	1.1	1.296	1.207	1.207	1.0	1.0
			Max:	1.1	1.3	1.1	1.1	1.296	1.261	1.261	1.0	1.0
	25	Pool Width/Depth Ratio (W_{bkfp}/d_{bkfp})	Mean:	18.1	15.7	18.1	18.1	17.9	15.4	15.4	10.2	10.2
			Min:	18.1	15.7	18.1	18.1	17.9	13.3	13.3	10.2	10.2
			Max:	18.1	15.7	18.1	18.1	17.9	17.6	17.6	10.2	10.2
	26	Pool Cross-Sectional Area, ft^2 (A_{bkfp})	Mean:	31.0	35.0	29.9	31.0	35.0	28.0	83.2	18.9	11.9
			Min:	31.0	35.0	29.9	31.0	35.0	24.1	71.6	18.9	11.9
			Max:	31.0	35.0	29.9	31.0	35.0	31.9	94.7	18.9	11.9
	27	Pool Area to Riffle Area (A_{bkfp}/A_{bkf})	Mean:	1.2	1.4	1.2	1.2	1.250	1.107	1.107	0.7	0.7
			Min:	1.2	1.4	1.2	1.2	1.250	0.954	0.954	0.7	0.7
			Max:	1.2	1.4	1.2	1.2	1.250	1.261	1.261	0.7	0.7
	28	Pool Maximum Depth (d_{maxp})	Mean:	2.3	2.6	2.3	2.3	3.10	2.73	4.90	3.0	2.5
			Min:	2.3	2.6	2.3	2.3	3.10	2.51	4.52	3.0	2.5
			Max:	2.3	2.6	2.3	2.3	3.10	2.93	5.27	3.0	2.5
	29	Pool Maximum Depth to Riffle Mean Depth (d_{maxp}/d_{bkf})	Mean:	1.9	2.2	1.9	1.9	2.870	2.606	2.606	2.3	2.3
			Min:	1.9	2.2	1.9	1.9	2.870	2.404	2.404	2.3	2.3
			Max:	1.9	2.2	1.9	1.9	2.870	2.803	2.803	2.3	2.3
	30	Point Bar Slope (S_{pb})	Mean:	8.5	8.6	11.0	8.5		33.300	33.300	5.6	5.6
			Min:	8.5	8.6	11.0	8.5		28.600	28.600	10.0	10.0
			Max:	8.5	8.6	11.0	8.5		38.000	38.000	2.5	2.5
erm Dimensions	31	Pool Inner Berm Width, ft (W_{ibp})	Mean:	12.0	10.8	10.8	12.0	12.0	11.5	16.9	7.3	4.1
			Min:	12.0	10.8	10.8	12.0	12.0	11.4	15.1	7.3	4.1
			Max:	12.0	10.8	10.8	12.0	12.0	11.6	18.8	7.3	4.1
	32	Pool Inner Berm Width to Pool Width (W_{ibp}/W_{bkfp})	Mean:	0.5	0.5	0.5	0.5	0.480	0.530	0.475	0.5	0.4
			Min:	0.5	0.5	0.5	0.5	0.480	0.524	0.470	0.5	0.4
			Max:	0.5	0.5	0.5	0.5	0.480	0.535	0.480	0.5	0.4
	33	Pool Inner Berm Mean Depth, ft (d_{ibp})	Mean:	1.0	1.0	1.0	1.0	1.10	1.05	1.89	0.4	0.4
			Min:	1.0	1.0	1.0	1.0	1.10	0.92	1.68	0.4	0.4
			Max:	1.0	1.0	1.0	1.0	1.10	1.19	2.09	0.4	0.4
	34	Pool Inner Berm Mean Depth to Pool Mean Depth (d_{ibp}/d_{bkfp})	Mean:	0.7	0.7	0.8	0.7	0.786	0.815	0.815	0.3	0.3
			Min:	0.7	0.7	0.8	0.7	0.786	0.709	0.709	0.3	0.3

Section	Entry Number & Variable	Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach US Riffle	Pre-Flood Assessment of FMCC	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
Pool Inner Be	Mean Depth (d_{ibp}/d_{bkfp})	Max: 0.7	Max: 0.7	Max: 0.8	Max: 0.7	Max: 0.786	Max: 0.921	Max: 0.921	Max: 0.3	Max: 0.3
	35 Pool Inner Berm Width/Depth Ratio (W_{ibp}/d_{ibp})	Mean: 12.4	Mean: 10.6	Mean: 10.6	Mean: 12.4	Mean: 10.9	Mean: 9.2	Mean: 9.2	Mean: 11.1	Mean: 11.1
		Min: 12.4	Min: 10.6	Min: 10.6	Min: 12.4	Min: 10.9	Min: 7.2	Min: 7.2	Min: 11.1	Min: 11.1
		Max: 12.4	Max: 10.6	Max: 10.6	Max: 12.4	Max: 10.9	Max: 11.2	Max: 11.2	Max: 11.1	Max: 11.1
	36 Pool Inner Berm Cross-Sectional Area (A_{ibp})	Mean: 11.5	Mean: 11.0	Mean: 11.0	Mean: 11.5	Mean: 13.2	Mean: 10.8	Mean: 31.6	Mean: 2.4	Mean: 1.5
		Min: 11.5	Min: 11.0	Min: 11.0	Min: 11.5	Min: 13.2	Min: 9.3	Min: 31.6	Min: 2.4	Min: 1.5
		Max: 11.5	Max: 11.0	Max: 11.0	Max: 11.5	Max: 13.2	Max: 12.4	Max: 31.6	Max: 2.4	Max: 1.5
	37 Pool Inner Berm Cross-Sectional Area to Pool Cross-Sectional Area (A_{ibp}/A_{bkfp})	Mean: 0.4	Mean: 0.3	Mean: 0.4	Mean: 0.4	Mean: 0.377	Mean: 0.387	Mean: 0.387	Mean: 0.1	Mean: 0.1
		Min: 0.4	Min: 0.3	Min: 0.4	Min: 0.4	Min: 0.377	Min: 0.333	Min: 0.333	Min: 0.1	Min: 0.1
		Max: 0.4	Max: 0.3	Max: 0.4	Max: 0.4	Max: 0.377	Max: 0.441	Max: 0.441	Max: 0.1	Max: 0.1
Run Dimensions	38 Run Width, ft (W_{bkfr})				Mean:	Mean:	Mean: 24.6	Mean: 40.5	Mean: 21.4	Mean: 16.5
					Min:	Min:	Min:	Min:	Min: 14.4	Min: 11.1
					Max:	Max:	Max:	Max:	Max: 34.2	Max: 26.4
	39 Run Width to Riffle Width (W_{bkfr}/W_{bkf})				Mean: 0.0	Mean: 0.000	Mean: 1.015	Mean: 1.015	Mean: 1.1	Mean: 1.1
					Min: 0.0	Min: 0.000	Min:	Min:	Min: 0.7	Min: 0.7
					Max: 0.0	Max: 0.000	Max:	Max:	Max: 1.8	Max: 1.8
	40 Run Mean Depth, ft (d_{bkfr})				Mean:	Mean:	Mean: 1.01	Mean: 1.82	Mean: 0.9	Mean: 0.8
					Min:	Min:	Min:	Min:	Min: 0.5	Min: 0.4
					Max:	Max:	Max:	Max:	Max: 1.4	Max: 1.2
	41 Run Mean Depth to Riffle Mean Depth (d_{bkfr}/d_{bkf})				Mean: 0.0	Mean: 0.000	Mean: 0.968	Mean: 0.968	Mean: 0.7	Mean: 0.7
					Min: 0.0	Min: 0.000	Min:	Min:	Min: 0.4	Min: 0.4
					Max: 0.0	Max: 0.000	Max:	Max:	Max: 1.1	Max: 1.1
	42 Run Width/Depth Ratio (W_{bkfr}/d_{bkfr})				Mean: #DIV/0!	Mean: #DIV/0!	Mean: 22.2	Mean: 22.2	Mean: 30.6	Mean: 30.6
					Min: #DIV/0!	Min: #DIV/0!	Min:	Min:	Min: 15.9	Min: 9.3
					Max: #DIV/0!	Max: #DIV/0!	Max:	Max:	Max: 10.8	Max: 64.3
	43 Run Cross-Sectional Area, ft^2 (A_{bkfr})				Mean:	Mean:	Mean: 24.9	Mean: 73.8	Mean: 17.0	Mean: 10.7
					Min:	Min:	Min:	Min:	Min: 12.7	Min: 7.9
					Max:	Max:	Max:	Max:	Max: 21.1	Max: 13.2
	44 Run Area to Riffle Area (A_{bkfr}/A_{bkf})				Mean: 0.0	Mean: 0.000	Mean: 0.982	Mean: 0.982	Mean: 0.7	Mean: 0.7
					Min: 0.0	Min: 0.000	Min:	Min:	Min: 0.5	Min: 0.5
					Max: 0.0	Max: 0.000	Max:	Max:	Max: 0.8	Max: 0.8
	45 Run Maximum Depth (d_{maxr})				Mean: 2.2	Mean: 2.20	Mean: 1.89	Mean: 3.39	Mean: 2.0	Mean: 1.7
					Min: 2.2	Min: 2.20	Min:	Min:	Min: 1.6	Min: 1.3
					Max: 2.2	Max: 2.20	Max:	Max:	Max: 2.6	Max: 2.1
	46 Run Maximum Depth to Riffle Mean Depth (d_{maxr}/d_{bkf})				Mean: 1.9	Mean: 2.037	Mean: 1.803	Mean: 1.803	Mean: 1.6	Mean: 1.6
					Min: 1.9	Min: 2.037	Min:	Min:	Min: 1.2	Min: 1.2
					Max: 1.9	Max: 2.037	Max:	Max:	Max: 2.0	Max: 2.0
s	47 Glide Width, ft (W_{bkfg})				Mean:	Mean:	Mean: 25.9	Mean: 42.7	Mean: 32.4	Mean: 25.0
					Min:	Min:	Min: 23.8	Min: 39.3	Min: 32.4	Min: 25.0
					Max:	Max:	Max: 27.9	Max: 46.0	Max: 32.4	Max: 25.0
	48 Glide Width to Riffle Width (W_{bkfg}/W_{bkf})				Mean: 0.0	Mean: 0.000	Mean: 1.070	Mean: 1.070	Mean: 1.7	Mean: 1.7
					Min: 0.0	Min: 0.000	Min: 0.986	Min: 0.986	Min: 1.7	Min: 1.7
					Max: 0.0	Max: 0.000	Max: 1.154	Max: 1.154	Max: 1.7	Max: 1.7
	49 Glide Mean Depth, ft (d_{bkfg})				Mean:	Mean:	Mean: 0.93	Mean: 1.68	Mean: 0.5	Mean: 0.4
					Min:	Min:	Min: 0.85	Min: 1.52	Min: 0.5	Min: 0.4
					Max:	Max:	Max: 1.02	Max: 1.84	Max: 0.5	Max: 0.4
	50 Glide Mean Depth to Riffle Mean Depth (d_{bkfg}/d_{bkf})				Mean: 0.0	Mean: 0.000	Mean: 0.894	Mean: 0.894	Mean: 0.4	Mean: 0.4
					Min: 0.0	Min: 0.000	Min: 0.809	Min: 0.809	Min: 0.4	Min: 0.4

Section	#	Entry Number & Variable		Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach US Riffle	Pre-Flood Assessment of FMCC	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
Glide Dimensions		Depth (d_{bkfg}/d_{bkf})					*Max:* 0.0	*Max:* 0.000	*Max:* 0.979	*Max:* 0.979	*Max:* 0.4	*Max:* 0.4
	51	Glide Width/Depth Ratio (W_{bkfg}/d_{bkfg})					*Mean:* #DIV/0!	*Mean:* #DIV/0!	*Mean:* 25.4	*Mean:* 25.4	*Mean:* 62.4	*Mean:* 62.4
							Min: #DIV/0!	*Min:* #DIV/0!	*Min:* 25.0	*Min:* 25.0	*Min:* 62.4	*Min:* 62.4
							Max: #DIV/0!	*Max:* #DIV/0!	*Max:* 25.9	*Max:* 25.9	*Max:* 62.4	*Max:* 62.4
	52	Glide Cross-Sectional Area, ft^2 (A_{bkfg})					*Mean:*	*Mean:*	*Mean:* 24.3	*Mean:* 72.2	*Mean:* 15.8	*Mean:* 9.9
							Min:	*Min:*	*Min:* 20.1	*Min:* 59.6	*Min:* 15.8	*Min:* 9.9
							Max:	*Max:*	*Max:* 28.6	*Max:* 84.8	*Max:* 15.8	*Max:* 9.9
	53	Glide Area to Riffle Area (A_{bkfg}/A_{bkf})					*Mean:* 0.0	*Mean:* 0.000	*Mean:* 0.961	*Mean:* 0.961	*Mean:* 0.6	*Mean:* 0.6
							Min: 0.0	*Min:* 0.000	*Min:* 0.794	*Min:* 0.794	*Min:* 0.6	*Min:* 0.6
							Max: 0.0	*Max:* 0.000	*Max:* 1.129	*Max:* 1.129	*Max:* 0.6	*Max:* 0.6
	54	Glide Maximum Depth (d_{maxg})					*Mean:* 1.6	*Mean:* 1.60	*Mean:* 1.26	*Mean:* 2.27	*Mean:* 2.0	*Mean:* 1.6
							Min: 1.6	*Min:* 1.60	*Min:* 1.19	*Min:* 2.14	*Min:* 2.0	*Min:* 1.6
							Max: 1.6	*Max:* 1.60	*Max:* 1.34	*Max:* 2.40	*Max:* 2.0	*Max:* 1.6
	55	Glide Maximum Depth to Riffle Mean Depth (d_{maxg}/d_{bkf})					*Mean:* 1.4	*Mean:* 1.481	*Mean:* 1.207	*Mean:* 1.207	*Mean:* 1.5	*Mean:* 1.5
							Min: 1.4	*Min:* 1.481	*Min:* 1.138	*Min:* 1.138	*Min:* 1.5	*Min:* 1.5
							Max: 1.4	*Max:* 1.481	*Max:* 1.277	*Max:* 1.277	*Max:* 1.5	*Max:* 1.5
Glide Inner Berm Dimensions	56	Glide Inner Berm Width, ft (W_{ibg})					*Mean:*	*Mean:*	*Mean:* 14.9	*Mean:* 24.7	*Mean:* 6.0	*Mean:* 4.6
							Min:	*Min:*	*Min:* 13.7	*Min:* 20.8	*Min:* 6.0	*Min:* 4.6
							Max:	*Max:*	*Max:* 16.1	*Max:* 28.6	*Max:* 6.0	*Max:* 4.6
	57	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})					*Mean:* #DIV/0!	*Mean:* #DIV/0!	*Mean:* 0.575	*Mean:* 0.575	*Mean:* 0.2	*Mean:* 0.2
							Min: #DIV/0!	*Min:* #DIV/0!	*Min:* 0.528	*Min:* 0.528	*Min:* 0.2	*Min:* 0.2
							Max: #DIV/0!	*Max:* #DIV/0!	*Max:* 0.622	*Max:* 0.622	*Max:* 0.2	*Max:* 0.2
	58	Glide Inner Berm Mean Depth, ft (d_{ibg})					*Mean:*	*Mean:*	*Mean:* 0.25	*Mean:* 0.43	*Mean:* 0.6	*Mean:* 0.5
							Min:	*Min:*	*Min:* 0.17	*Min:* 0.34	*Min:* 0.6	*Min:* 0.5
							Max:	*Max:*	*Max:* 0.32	*Max:* 0.52	*Max:* 0.6	*Max:* 0.5
	59	Glide Inner Berm Mean Depth to Glide Mean Depth (d_{ibg}/d_{bkfg})					*Mean:* #DIV/0!	*Mean:* #DIV/0!	*Mean:* 0.265	*Mean:* 0.265	*Mean:* 1.2	*Mean:* 1.2
							Min: #DIV/0!	*Min:* #DIV/0!	*Min:* 0.185	*Min:* 0.185	*Min:* 1.2	*Min:* 1.2
							Max: #DIV/0!	*Max:* #DIV/0!	*Max:* 0.345	*Max:* 0.345	*Max:* 1.2	*Max:* 1.2
	60	Glide Inner Berm Width/Depth Ratio (W_{ibg}/d_{ibg})					*Mean:* #DIV/0!	*Mean:* #DIV/0!	*Mean:* 61.9	*Mean:* 61.9	*Mean:* 9.3	*Mean:* 9.3
							Min: #DIV/0!	*Min:* #DIV/0!	*Min:* 39.6	*Min:* 39.6	*Min:* 9.3	*Min:* 9.3
							Max: #DIV/0!	*Max:* #DIV/0!	*Max:* 84.2	*Max:* 84.2	*Max:* 9.3	*Max:* 9.3
	61	Glide Inner Berm Cross-Sectional Area (A_{ibg})					*Mean:*	*Mean:*	*Mean:* 3.6	*Mean:* 10.3	*Mean:* 3.6	*Mean:* 2.3
							Min:	*Min:*	*Min:* 2.8	*Min:* 9.7	*Min:* 3.6	*Min:* 2.3
							Max:	*Max:*	*Max:* 4.5	*Max:* 10.9	*Max:* 3.6	*Max:* 2.3
	62	Glide Inner Berm Area to Glide Area (A_{ibg}/A_{bkfg})					*Mean:* #DIV/0!	*Mean:* #DIV/0!	*Mean:* 0.149	*Mean:* 0.149	*Mean:* 0.2	*Mean:* 0.2
							Min: #DIV/0!	*Min:* #DIV/0!	*Min:* 0.115	*Min:* 0.115	*Min:* 0.2	*Min:* 0.2
							Max: #DIV/0!	*Max:* #DIV/0!	*Max:* 0.183	*Max:* 0.183	*Max:* 0.2	*Max:* 0.2
s	63	Step Width, ft (W_{bkfs})					*Mean:*	*Mean:*	*Mean:* N/A	*Mean:* N/A	*Mean:* 0.0	*Mean:* 0.0
							Min:	*Min:*	*Min:*	*Min:*	*Min:* 0.0	*Min:* 0.0
							Max:	*Max:*	*Max:*	*Max:*	*Max:* 0.0	*Max:* 0.0
	64	Step Width to Riffle Width (W_{bkfs}/W_{bkf})					*Mean:* 0.0	*Mean:* 0.000	*Mean:* N/A	*Mean:* N/A	*Mean:* 0.0	*Mean:* 0.0
							Min: 0.0	*Min:* 0.000	*Min:*	*Min:*	*Min:* 0.0	*Min:* 0.0
							Max: 0.0	*Max:* 0.000	*Max:*	*Max:*	*Max:* 0.0	*Max:* 0.0
	65	Step Mean Depth, ft (d_{bkfs})					*Mean:*	*Mean:*	*Mean:* N/A	*Mean:* N/A	*Mean:* 0.0	*Mean:* 0.0
							Min:	*Min:*	*Min:*	*Min:*	*Min:* 0.0	*Min:* 0.0
							Max:	*Max:*	*Max:*	*Max:*	*Max:* 0.0	*Max:* 0.0
	66	Step Mean Depth to Riffle Mean Depth					*Mean:* 0.0	*Mean:* 0.000	*Mean:* N/A	*Mean:* N/A	*Mean:* 0.0	*Mean:* 0.0
							Min: 0.0	*Min:* 0.000	*Min:*	*Min:*	*Min:* 0.0	*Min:* 0.0

	Entry Number & Variable			Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach US Riffle	Pre-Flood Assessment of FMCC	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
Step Dimension		Depth (d_{bkfs}/d_{bkf})					Max: 0.0	Max: 0.000	Max:	Max:	Max: 0.0	Max: 0.0
	67	Step Width/Depth Ratio (W_{bkfs}/d_{bkfs})					Mean: #DIV/0!	Mean: #DIV/0!	Mean:	Mean:	Mean: 0.0	Mean: 0.0
							Min: #DIV/0!	Min: #DIV/0!	Min:	Min:	Min: 0.0	Min: 0.0
							Max: #DIV/0!	Max: #DIV/0!	Max:	Max:	Max: 0.0	Max: 0.0
	68	Step Cross-Sectional Area, ft^2 (A_{bkfs})					Mean:	Mean:	Mean: N/A	Mean:	Mean: 0.0	Mean: 0.0
							Min:	Min:	Min:	Min:	Min: 0.0	Min: 0.0
							Max:	Max:	Max:	Max:	Max: 0.0	Max: 0.0
	69	Step Area to Riffle Area (A_{bkfs}/A_{bkf})					Mean: 0.0	Mean: 0.000	Mean: N/A	Mean: N/A	Mean: 0.0	Mean: 0.0
							Min: 0.0	Min: 0.000	Min:	Min:	Min: 0.0	Min: 0.0
							Max: 0.0	Max: 0.000	Max:	Max:	Max: 0.0	Max: 0.0
	70	Step Maximum Depth (d_{maxs})					Mean:	Mean:	Mean: N/A	Mean:	Mean: 0.0	Mean: 0.0
							Min:	Min:	Min:	Min:	Min: 0.0	Min: 0.0
							Max:	Max:	Max:	Max:	Max: 0.0	Max: 0.0
	71	Step Maximum Depth to Riffle Mean Depth (d_{maxs}/d_{bkf})					Mean: 0.0	Mean: 0.00	Mean: N/A	Mean: N/A	Mean: 0.0	Mean: 0.0
							Min: 0.0	Min: 0.00	Min:	Min:	Min: 0.0	Min: 0.0
							Max: 0.0	Max: 0.00	Max:	Max:	Max: 0.0	Max: 0.0
Channel Pattern	72	Linear Wavelength, ft (λ)					Mean: 143.0	Mean: 98.3	Mean: 291.3	Mean: 467.2	Mean: 72.6	Mean: 56.0
							Min: 40.9	Min: 18.8	Min: 261.3	Min: 419.0	Min: 54.4	Min: 42.0
							Max: 595.2	Max: 278.3	Max: 309.6	Max: 496.6	Max: 99.8	Max: 77.0
	73	Linear Wavelength to Riffle Width (λ/W_{bkf})					Mean: 6.7	Mean: 3.933	Mean: 12.040	Mean: 12.040	Mean: 3.7	Mean: 3.7
							Min: 1.9	Min: 0.751	Min: 10.800	Min: 10.800	Min: 2.8	Min: 2.8
							Max: 27.7	Max: 11.133	Max: 12.800	Max: 12.800	Max: 5.1	Max: 5.1
	74	Stream Meander Length, ft (L_m)					Mean: 149.0	Mean: 104.5	Mean: 331.4	Mean: 531.6	Mean: 84.2	Mean: 65.0
							Min: 48.5	Min: 19.8	Min: 297.5	Min: 477.2	Min: 58.3	Min: 45.0
							Max: 611.2	Max: 334.6	Max: 365.3	Max: 585.9	Max: 103.7	Max: 80.0
	75	Stream Meander Length Ratio (L_m/W_{bkf})					Mean: 6.9	Mean: 4.182	Mean: 13.700	Mean: 13.700	Mean: 4.3	Mean: 4.3
							Min: 2.3	Min: 0.792	Min: 12.300	Min: 12.300	Min: 3.0	Min: 3.0
							Max: 28.4	Max: 13.385	Max: 15.100	Max: 15.100	Max: 5.3	Max: 5.3
	76	Belt Width, ft (W_{blt})					Mean: 65.0	Mean: 65.0	Mean: 121.9	Mean: 195.6	Mean: 53.1	Mean: 41.0
							Min: 0.0	Min: 0.0	Min: 97.0	Min: 155.6	Min: 38.9	Min: 30.0
							Max: 0.0	Max: 0.0	Max: 171.8	Max: 275.5	Max: 71.3	Max: 55.0
	77	Meander Width Ratio (W_{blt}/W_{bkf})					Mean: 3.0	Mean: 2.600	Mean: 5.040	Mean: 5.040	Mean: 2.7	Mean: 2.7
							Min: 0.0	Min: 0.000	Min: 4.010	Min: 4.010	Min: 2.0	Min: 2.0
							Max: 0.0	Max: 0.000	Max: 7.100	Max: 7.100	Max: 3.7	Max: 3.7
	78	Radius of Curvature, ft (R_c)					Mean: 75.4	Mean: 58.2	Mean: 82.5	Mean: 132.4	Mean: 16.8	Mean: 13.0
							Min: 10.0	Min: 3.7	Min: 53.2	Min: 85.4	Min: 5.2	Min: 4.0
							Max: 300.0	Max: 383.0	Max: 109.2	Max: 175.2	Max: 36.3	Max: 28.0
	79	Radius of Curvature to Riffle Width (R_c/W_{bkf})					Mean: 3.5	Mean: 2.326	Mean: 3.412	Mean: 3.412	Mean: 0.9	Mean: 0.9
							Min: 0.5	Min: 0.148	Min: 2.200	Min: 2.200	Min: 0.3	Min: 0.3
							Max: 14.0	Max: 15.319	Max: 4.516	Max: 4.516	Max: 1.9	Max: 1.9
	80	Arc Length, ft (L_a)					Mean: 44.2	Mean: 58.2	Mean: 87.4	Mean: 140.2	Mean: 33.7	Mean: 26.0
							Min: 8.9	Min: 3.7	Min: 50.8	Min: 81.5	Min: 15.6	Min: 12.0
							Max: 136.2	Max: 383.0	Max: 123.8	Max: 198.6	Max: 59.6	Max: 46.0
	81	Arc Length to Riffle Width (L_a/W_{bkf})					Mean: 2.1	Mean: 2.326	Mean: 3.613	Mean: 3.613	Mean: 1.7	Mean: 1.7
							Min: 0.4	Min: 0.148	Min: 2.100	Min: 2.100	Min: 0.8	Min: 0.8
							Max: 6.3	Max: 15.319	Max: 5.119	Max: 5.119	Max: 3.1	Max: 3.1
	82	Riffle Length (L_r), ft					Mean: 60.7	Mean: 24.5	Mean: 75.0	Mean: 120.3	Mean: 21.7	Mean: 16.7
							Min: 2.5	Min: 0.1	Min: 50.8	Min: 81.5	Min: 10.4	Min: 8.0

	Entry Number & Variable		Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach US Riffle	Pre-Flood Assessment of FMCC	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
						Max: **290.3**	*Max:* **116.3**	*Max:* **97.0**	*Max:* **155.6**	*Max:* **40.3**	*Max:* **31.1**
	83 Riffle Length to Riffle Width (L_r/W_{bkf})					*Mean:* **2.8** *Min:* **0.1** *Max:* **13.5**	*Mean:* **0.982** *Min:* **0.003** *Max:* **4.650**	*Mean:* **3.100** *Min:* **2.100** *Max:* **4.010**	*Mean:* **3.100** *Min:* **2.100** *Max:* **4.010**	*Mean:* **1.1** *Min:* **0.5** *Max:* **2.1**	*Mean:* **1.1** *Min:* **0.5** *Max:* **2.1**
	84 Individual Pool Length, ft (L_p)					*Mean:* **31.0** *Min:* **6.2** *Max:* **95.3**	*Mean:* **40.7** *Min:* **2.6** *Max:* **268.1**	*Mean:* **53.2** *Min:* **43.5** *Max:* **66.5**	*Mean:* **85.4** *Min:* **69.8** *Max:* **106.7**	*Mean:* **23.0** *Min:* **8.2** *Max:* **79.0**	*Mean:* **17.8** *Min:* **6.4** *Max:* **61.0**
	85 Pool Length to Riffle Width (L_p/W_{bkf})					*Mean:* **1.4** *Min:* **0.3** *Max:* **4.4**	*Mean:* **1.628** *Min:* **0.104** *Max:* **10.723**	*Mean:* **2.200** *Min:* **1.800** *Max:* **2.750**	*Mean:* **2.200** *Min:* **1.800** *Max:* **2.750**	*Mean:* **1.2** *Min:* **0.4** *Max:* **4.1**	*Mean:* **1.2** *Min:* **0.4** *Max:* **4.1**
	86 Pool-to-Pool Spacing, ft (P_s)					*Mean:* **74.7** *Min:* **16.3** *Max:* **328.8**	*Mean:* **51.3** *Min:* **8.2** *Max:* **189.8**	*Mean:* **153.1** *Min:* **121.0** *Max:* **181.4**	*Mean:* **245.6** *Min:* **194.0** *Max:* **291.0**	*Mean:* **57.4** *Min:* **15.5** *Max:* **114.5**	*Mean:* **44.3** *Min:* **12.0** *Max:* **88.3**
	87 Pool-to-Pool Spacing to Riffle Width (P_s/W_{bkf})					*Mean:* **3.5** *Min:* **0.8** *Max:* **15.3**	*Mean:* **2.053** *Min:* **0.328** *Max:* **7.591**	*Mean:* **6.330** *Min:* **5.000** *Max:* **7.500**	*Mean:* **6.330** *Min:* **5.000** *Max:* **7.500**	*Mean:* **2.9** *Min:* **0.8** *Max:* **5.9**	*Mean:* **2.9** *Min:* **0.8** *Max:* **5.9**
Sinuosity and Slope	**88** Stream Length (SL)					**7228.6**	**7696.0**		**3420.0**		**3420.0**
Sinuosity and Slope	**89** Valley Length (VL)					**6786.0**	**6786.0**		**3000.0**		**3000.0**
Sinuosity and Slope	**90** Valley Slope (S_{val})					**0.0442**	**0.0442**	**#DIV/0!**	**0.0114**	**#DIV/0!**	**0.0336**
Sinuosity and Slope	**91** Sinuosity (k)					SL/VL: **1.07**	SL/VL: **1.13**	SL/VL:	SL/VL: **1.14** VS/S: **1.14**	SL/VL:	SL/VL: **1.14** VS/S: **1.14**
Sinuosity and Slope	**92** Average Water Surface Slope (S)					**0.0423**	**0.0397**	$S = S_{val}/k$ **#DIV/0!**	**0.0100**	$S = S_{val}/k$ **#DIV/0!**	**0.0294**
Floodplain	**93** Floodplain Width, ft (W_f)					*Mean:* *Min:* *Max:*		*Mean:* *Min:* *Max:*	*Mean:* **305.000** *Min:* **210.000** *Max:* **400.000**		*Mean:* **305.000** *Min:* **210.000** *Max:* **400.000**
Floodplain	**94** Floodplain Surface Depth Limit, ft (d_f)					*Mean:* *Min:* *Max:*		*Mean:* *Min:* *Max:*	*Mean:* **2.0** *Min:* **1.8** *Max:* **2.2**		*Mean:* **2.0** *Min:* **1.8** *Max:* **2.2**
Low Terrace	**95** Low Terrace Width, ft (W_{lt})					*Mean:* *Min:* *Max:*		*Mean:* *Min:* *Max:*	*Mean:* **450.000** *Min:* **290.000** *Max:* **620.000**		*Mean:* **450.000** *Min:* **290.000** *Max:* **620.000**
Low Terrace	**96** Low Terrace Surface Depth Limit, ft (d_{lt})					*Mean:* *Min:* *Max:*		*Mean:* *Min:* *Max:*	*Mean:* **5.6** *Min:* **5.3** *Max:* **6.0**		*Mean:* **5.6** *Min:* **5.3** *Max:* **6.0**
Flood-Prone Area	**97** Flood-Prone Area Width, ft (W_{fpa})					*Mean:* **42.500** *Min:* *Max:*		*Mean:* *Min:* *Max:*	*Mean:* **450.000** *Min:* **290.000** *Max:* **610.000**		*Mean:* **450.000** *Min:* **290.000** *Max:* **610.000**
Flood-Prone Area	**98** Flood-Prone Area Surface Depth Limit, ft (d_{fpa})					*Mean:* *Min:* *Max:*		*Mean:* *Min:* *Max:*	*Mean:* **5.6** *Min:* **5.3** *Max:* **6.0**		*Mean:* **5.6** *Min:* **5.3** *Max:* **6.0**
ision	**99** Low Bank Height (LBH)					*Mean:* *Min:* *Max:*		*Mean:* *Min:* *Max:*	*Mean:* **2.575** *Min:* **2.310** *Max:* **2.840**		*Mean:* **0.000** *Min:* **0.000** *Max:* **0.000**

	Entry Number & Variable		Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach US Riffle	Pre-Flood Assessment of FMCC	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
Degree of Inci	**100** Maximum Bankfull Depth (d_{max}) at Same Location as Low Bank Height (LBH) Measurement					*Mean:*		*Mean:*	*Mean:* **2.6**		*Mean:* **2.1**
						Min:		*Min:*	*Min:* **2.3**		*Min:* **2.1**
						Max:		*Max:*	*Max:* **2.8**		*Max:* **2.1**
	101 Bank-Height Ratio (LBH/d_{max})					*Mean:*		*Mean:*	*Mean:* **1.000**		*Mean:* **0.000**
						Min:		*Min:*	*Min:* **1.000**		*Min:* **0.000**
						Max:		*Max:*	*Max:* **1.000**		*Max:* **0.000**
Bed Feature Max Depth Measurements and Dimensionless Ratios from Profile	**102** Riffle Maximum Depth, ft (d_{max})					*Mean:*		*Mean:* **1.8**	*Mean:* **3.3**	**2.0**	*Mean:* **1.6**
						Min:		*Min:* **1.7**	*Min:* **3.0**	**0.5**	*Min:* **0.4**
						Max:		*Max:* **1.9**	*Max:* **3.4**	**2.5**	*Max:* **2.0**
	103 Riffle Maximum Depth to Riffle Mean Depth (d_{max}/d_{bkf})					*Mean:*		*Mean:* **1.734**	*Mean:* **1.734**	**1.505**	*Mean:* **1.505**
						Min:		*Min:* **1.617**	*Min:* **1.617**	**0.355**	*Min:* **0.355**
						Max:		*Max:* **1.803**	*Max:* **1.803**	**1.897**	*Max:* **1.897**
	104 Pool Maximum Depth, ft (d_{maxp})					*Mean:*		*Mean:* **2.7**	*Mean:* **4.9**	**3.2**	*Mean:* **2.6**
						Min:		*Min:* **2.4**	*Min:* **4.2**	**2.2**	*Min:* **1.8**
						Max:		*Max:* **2.9**	*Max:* **5.3**	**4.7**	*Max:* **3.9**
	105 Pool Maximum Depth to Riffle Mean Depth (d_{maxp}/d_{bkf})					*Mean:*		*Mean:* **2.606**	*Mean:* **2.606**	**2.467**	*Mean:* **2.467**
						Min:		*Min:* **2.255**	*Min:* **2.255**	**1.682**	*Min:* **1.682**
						Max:		*Max:* **2.793**	*Max:* **2.793**	**3.607**	*Max:* **3.607**
	106 Run Maximum Depth, ft (d_{maxr})					*Mean:*		*Mean:* **1.9**	*Mean:* **3.4**	**2.4**	*Mean:* **1.9**
						Min:		*Min:* **1.8**	*Min:* **3.2**	**1.6**	*Min:* **1.3**
						Max:		*Max:* **2.1**	*Max:* **3.7**	**3.2**	*Max:* **2.7**
	107 Run Maximum Depth to Riffle Mean Depth (d_{maxr}/d_{bkf})					*Mean:*		*Mean:* **1.824**	*Mean:* **1.824**	**1.813**	*Mean:* **1.813**
						Min:		*Min:* **1.681**	*Min:* **1.681**	**1.206**	*Min:* **1.206**
						Max:		*Max:* **1.963**	*Max:* **1.963**	**2.486**	*Max:* **2.486**
	108 Glide Maximum Depth, ft (d_{maxg})					*Mean:*		*Mean:* **1.4**	*Mean:* **2.5**	**2.1**	*Mean:* **1.7**
						Min:		*Min:* **1.2**	*Min:* **2.2**	**1.0**	*Min:* **0.8**
						Max:		*Max:* **1.5**	*Max:* **2.8**	**2.9**	*Max:* **2.4**
	109 Glide Maximum Depth to Riffle Mean Depth (d_{maxg}/d_{bkf})					*Mean:*		*Mean:* **1.309**	*Mean:* **1.309**	**1.607**	*Mean:* **1.607**
						Min:		*Min:* **1.149**	*Min:* **1.149**	**0.757**	*Min:* **0.757**
						Max:		*Max:* **1.473**	*Max:* **1.473**	**2.215**	*Max:* **2.215**
	110 Step Maximum Depth, ft (d_{maxs})					*Mean:*		*Mean:* **N/A**	*Mean:* **N/A**	**0.0**	*Mean:* **0.0**
						Min:		*Min:*	*Min:*	**0.0**	*Min:* **0.0**
						Max:		*Max:*	*Max:*	**0.0**	*Max:* **0.0**
	111 Step Maximum Depth to Riffle Mean Depth (d_{maxs}/d_{bkf})					*Mean:*		*Mean:* **N/A**	*Mean:* **N/A**	**0.000**	*Mean:* **0.000**
						Min:		*Min:*	*Min:*	**0.000**	*Min:* **0.000**
						Max:		*Max:*	*Max:*	**0.000**	*Max:* **0.000**

XS A= 26.7

		Entry Number & Variable	Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach DS Riffle	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
	1	Valley Type (I–XII)						V		VIII
	2	Valley Width (W_{val})						290-600		
	3	Stream Type	C4/B4	C4/B4	C4/B4	C4/B4	C4/B4	C3		C3b
	4	Drainage Area, mi^2 (DA)	7.19	7.19	7.19	7.19	7.19	49.9		4.4
	5	Bankfull Discharge, cfs (Q_{bkf})	130	130.0	130.0	130.0	130	375		110.0
Riffle Dimensions	6	Riffle Width, ft (W_{bkf})	*Mean:* 22.5	*Mean:* 22.5	*Mean:* 22.5	*Mean:* 22.5	*Mean:* 24.9	*Mean:* 38.8	*Mean:* 20.0	*Mean:* 15.1
			Min: 22.5	*Min:* 22.5	*Min:* 22.5	*Min:* 22.5	*Min:* 23.8	*Min:* 37.8	*Min:* 15.4	*Min:* 12.8
			Max: 22.5	*Max:* 22.5	*Max:* 22.5	*Max:* 22.5	*Max:* 25.9	*Max:* 39.9	*Max:* 22.5	*Max:* 18.7
	7	Riffle Mean Depth, ft (d_{bkf})	*Mean:* 1.2	*Mean:* 1.2	*Mean:* 1.2	*Mean:* 1.2	*Mean:* 1.07	*Mean:* 1.70	*Mean:* 1.3	*Mean:* 1.1
			Min: 1.2	*Min:* 1.2	*Min:* 1.2	*Min:* 1.2	*Min:* 1.03	*Min:* 1.51	*Min:* 1.2	*Min:* 0.8
			Max: 1.2	*Max:* 1.2	*Max:* 1.2	*Max:* 1.2	*Max:* 1.12	*Max:* 1.88	*Max:* 1.7	*Max:* 1.4
	8	Riffle Width/Depth Ratio (W_{bkf}/d_{bkf})	*Mean:* 19.1	*Mean:* 19.1	*Mean:* 19.1	*Mean:* 19.1	*Mean:* 23.1	*Mean:* 23.1	*Mean:* 15.0	*Mean:* 15.0
			Min: 19.1	*Min:* 19.1	*Min:* 19.1	*Min:* 19.1	*Min:* 21.2	*Min:* 21.2	*Min:* 8.9	*Min:* 8.9
			Max: 19.1	*Max:* 19.1	*Max:* 19.1	*Max:* 19.1	*Max:* 25.1	*Max:* 25.1	*Max:* 18.9	*Max:* 18.9
	9	Riffle Cross-Sectional Area, ft^2 (A_{bkf})	*Mean:* 26.7	*Mean:* 26.7	*Mean:* 26.7	*Mean:* 26.7	*Mean:* 26.7	*Mean:* 66.0	*Mean:* 26.7	*Mean:* 15.9
			Min: 26.7	*Min:* 26.7	*Min:* 26.7	*Min:* 26.7		*Min:* 57.0		*Min:* 10.8
			Max: 26.7	*Max:* 26.7	*Max:* 26.7	*Max:* 26.7		*Max:* 75.1		*Max:* 18.6
	10	Riffle Maximum Depth (d_{max})	*Mean:* 2.0	*Mean:* 2.0	*Mean:* 2.0	*Mean:* 2.0	*Mean:* 1.81	*Mean:* 2.79	*Mean:* 2.7	*Mean:* 2.1
			Min: 2.0	*Min:* 2.0	*Min:* 2.0	*Min:* 2.0	*Min:* 1.69	*Min:* 2.65	*Min:* 2.3	*Min:* 1.8
			Max: 2.0	*Max:* 2.0	*Max:* 2.0	*Max:* 2.0	*Max:* 1.97	*Max:* 2.95	*Max:* 3.0	*Max:* 2.5
	11	Riffle Maximum Depth to Riffle Mean Depth (d_{max}/d_{bkf})	*Mean:* 1.7	*Mean:* 1.7	*Mean:* 1.7	*Mean:* 1.7	*Mean:* 1.686	*Mean:* 1.686	*Mean:* 2.0	*Mean:* 2.0
			Min: 1.7	*Min:* 1.7	*Min:* 1.7	*Min:* 1.7	*Min:* 1.569	*Min:* 1.569	*Min:* 1.7	*Min:* 1.7
			Max: 1.7	*Max:* 1.7	*Max:* 1.7	*Max:* 1.7	*Max:* 1.834	*Max:* 1.834	*Max:* 2.2	*Max:* 2.2
	12	Width of Flood-Prone Area at Elevation of 2 * d_{max}, ft (W_{fpa})	*Mean:* 42.5	*Mean:* 42.5	*Mean:* 42.5	*Mean:* 42.5	*Mean:* 51.0	*Mean:* 280.7	*Mean:*	*Mean:* 59.3
			Min: 37.1	*Min:* 37.1	*Min:* 37.1	*Min:* 37.1	*Min:* 35.0	*Min:* 220.0	*Min:*	*Min:* 46.4
			Max: 47.8	*Max:* 47.8	*Max:* 47.8	*Max:* 47.8	*Max:* 85.0	*Max:* 320.0	*Max:*	*Max:* 79.4
	13	Entrenchment Ratio (W_{fpa}/W_{bkf})	*Mean:* 1.9	*Mean:* 1.9	*Mean:* 1.9	*Mean:* 1.9	*Mean:* 2.1	*Mean:* 7.3	*Mean:* 0.0	*Mean:* 4.2
			Min: 1.6	*Min:* 1.6	*Min:* 1.6	*Min:* 1.6	*Min:* 1.5	*Min:* 5.5	*Min:* 0.0	*Min:* 2.5
			Max: 2.1	*Max:* 2.1	*Max:* 2.1	*Max:* 2.1	*Max:* 3.3	*Max:* 8.5	*Max:* 0.0	*Max:* 6.2
ensions	14	Riffle Inner Berm Width, ft (W_{ib})	*Mean:* 10.5	*Mean:* 10.5	*Mean:* 10.5	*Mean:* 10.5	*Mean:* 13.7	*Mean:* 21.3	*Mean:* 13.4	*Mean:* 10.2
			Min: 10.5	*Min:* 10.5	*Min:* 10.5	*Min:* 10.5	*Min:* 12.1	*Min:* 18.3	*Min:* 10.2	*Min:* 7.0
			Max: 10.5	*Max:* 10.5	*Max:* 10.5	*Max:* 10.5	*Max:* 14.6	*Max:* 23.3	*Max:* 15.9	*Max:* 14.8
	15	Riffle Inner Berm Width to Riffle Width (W_{ib}/W_{bkf})	*Mean:* 0.5	*Mean:* 0.5	*Mean:* 0.5	*Mean:* 0.5	*Mean:* 0.552	*Mean:* 0.552	*Mean:* 0.7	*Mean:* 0.7
			Min: 0.5	*Min:* 0.5	*Min:* 0.5	*Min:* 0.5	*Min:* 0.485	*Min:* 0.485	*Min:* 0.5	*Min:* 0.5
			Max: 0.5	*Max:* 0.5	*Max:* 0.5	*Max:* 0.5	*Max:* 0.586	*Max:* 0.586	*Max:* 0.8	*Max:* 0.8
	16	Riffle Inner Berm Mean Depth, ft (d_{ib})	*Mean:* 0.7	*Mean:* 0.7	*Mean:* 0.7	*Mean:* 0.7	*Mean:* 0.42	*Mean:* 0.66	*Mean:* 0.8	*Mean:* 0.7
			Min: 0.7	*Min:* 0.7	*Min:* 0.7	*Min:* 0.7	*Min:* 0.34	*Min:* 0.51	*Min:* 0.8	*Min:* 0.5

Group	No.	Entry Number & Variable	Stat	Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach DS Riffle	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
Riffle Inner Berm Dime		(d_{ib})	Max:	0.7	0.7	0.7	0.7	0.48	0.79	0.9	0.8
	17	Riffle Inner Berm Mean Depth to Riffle Mean Depth (d_{ib}/d_{bkf})	Mean:	0.6	0.6	0.6	0.6	0.394	0.394	0.6	0.6
			Min:	0.6	0.6	0.6	0.6	0.320	0.320	0.6	0.6
			Max:	0.6	0.6	0.6	0.6	0.444	0.444	0.7	0.7
	18	Riffle Inner Berm Width/Depth Ratio (W_{ib}/d_{ib})	Mean:	15.9	15.9	15.9	15.9	33.6	33.6	16.5	16.5
			Min:	15.9	15.9	15.9	15.9	27.4	27.4	10.7	10.7
			Max:	15.9	15.9	15.9	15.9	43.6	43.6	25.5	25.5
	19	Riffle Inner Berm Cross-Sectional Area (A_{ib})	Mean:	7.0	7.0	7.0	7.0	5.8	14.0	10.8	6.6
			Min:	7.0	7.0	7.0	7.0	5.0	11.4	9.0	3.7
			Max:	7.0	7.0	7.0	7.0	6.5	18.4	12.4	8.6
	20	Riffle Inner Berm Cross-Sectional Area to Riffle Cross-Sectional Area (A_{ib}/A_{bkf})	Mean:	0.3	0.3	0.3	0.3	0.216	0.216	0.4	0.4
			Min:	0.3	0.3	0.3	0.3	0.187	0.187	0.3	0.3
			Max:	0.3	0.3	0.3	0.3	0.245	0.245	0.5	0.5
Pool Dimensions	21	Pool Width, ft (W_{bkfp})	Mean:	23.5	23.5	23.5		22.3	35.8	14.6	11.0
			Min:	23.5	23.5	23.5		19.6	31.5	14.6	11.0
			Max:	23.5	23.5	23.5		24.9	40.0	14.6	11.0
	22	Pool Width to Riffle Width (W_{bkfp}/W_{bkf})	Mean:	1.0	1.0	1.0	0.0	0.897	0.897	0.7	0.7
			Min:	1.0	1.0	1.0	0.0	0.790	0.790	0.7	0.7
			Max:	1.0	1.0	1.0	0.0	1.004	1.004	0.7	0.7
	23	Pool Mean Depth, ft (d_{bkfp})	Mean:	1.3	1.5	1.3		1.33	2.32	1.3	1.1
			Min:	1.3	1.5	1.3		1.30	2.27	1.3	1.1
			Max:	1.3	1.5	1.3		1.35	2.37	1.3	1.1
	24	Pool Mean Depth to Riffle Mean Depth (d_{bkfp}/d_{bkf})	Mean:	1.1	1.3	1.1	0.0	1.234	1.234	1.0	1.0
			Min:	1.1	1.3	1.1	0.0	1.207	1.207	1.0	1.0
			Max:	1.1	1.3	1.1	0.0	1.261	1.261	1.0	1.0
	25	Pool Width/Depth Ratio (W_{bkfp}/d_{bkfp})	Mean:	18.1	15.7	18.1	#DIV/0!	15.4	15.4	10.2	10.2
			Min:	18.1	15.7	18.1	#DIV/0!	13.3	13.3	10.2	10.2
			Max:	18.1	15.7	18.1	#DIV/0!	17.6	17.6	10.2	10.2
	26	Pool Cross-Sectional Area, ft^2 (A_{bkfp})	Mean:	31.0	35.0	29.9		29.6	83.2	19.9	11.9
			Min:	31.0	35.0	29.9		25.5	71.6	19.9	11.9
			Max:	31.0	35.0	29.9		33.7	94.7	19.9	11.9
	27	Pool Area to Riffle Area (A_{bkfp}/A_{bkf})	Mean:	1.2	1.3	1.1	0.0	1.107	1.107	0.7	0.7
			Min:	1.2	1.3	1.1	0.0	0.954	0.954	0.7	0.7
			Max:	1.2	1.3	1.1	0.0	1.261	1.261	0.7	0.7
	28	Pool Maximum Depth (d_{maxp})	Mean:	2.3	2.6	2.3		2.80	4.90	3.1	2.5
			Min:	2.3	2.6	2.3		2.58	4.52	3.1	2.5
			Max:	2.3	2.6	2.3		3.01	5.27	3.1	2.5
	29	Pool Maximum Depth to Riffle Mean Depth (d_{maxp}/d_{bkf})	Mean:	1.9	2.2	1.9	0.0	2.606	2.606	2.3	2.3
			Min:	1.9	2.2	1.9	0.0	2.404	2.404	2.3	2.3
			Max:	1.9	2.2	1.9	0.0	2.803	2.803	2.3	2.3
	30	Point Bar Slope (S_{pb})	Mean:	8.5	8.6	11.0		33.300	33.300	5.6	5.6
			Min:	8.5	8.6	11.0		28.600	28.600	10.0	10.0

	Entry Number & Variable		Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach DS Riffle	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
			Max: **8.5**	*Max:* **8.6**	*Max:* **11.0**	*Max:*	*Max:* **38.000**	*Max:* **38.000**	*Max:* **2.5**	*Max:* **2.5**
Pool Inner Berm Dimensions	**31** Pool Inner Berm Width, ft (W_{ibp})		*Mean:* **12.0**	*Mean:* **10.8**	*Mean:* **10.8**	*Mean:*	*Mean:* **11.8**	*Mean:* **16.9**	*Mean:* **7.5**	*Mean:* **4.1**
			Min: **12.0**	*Min:* **10.8**	*Min:* **10.8**	*Min:*	*Min:* **11.7**	*Min:* **15.1**	*Min:* **7.5**	*Min:* **4.1**
			Max: **12.0**	*Max:* **10.8**	*Max:* **10.8**	*Max:*	*Max:* **11.9**	*Max:* **18.8**	*Max:* **7.5**	*Max:* **4.1**
	32 Pool Inner Berm Width to Pool Width (W_{ibp}/W_{bkfp})		*Mean:* **0.5**	*Mean:* **0.5**	*Mean:* **0.5**	*Mean:* **#DIV/0!**	*Mean:* **0.530**	*Mean:* **0.475**	*Mean:* **0.5**	*Mean:* **0.4**
			Min: **0.5**	*Min:* **0.5**	*Min:* **0.5**	*Min:* **#DIV/0!**	*Min:* **0.524**	*Min:* **0.470**	*Min:* **0.5**	*Min:* **0.4**
			Max: **0.5**	*Max:* **0.5**	*Max:* **0.5**	*Max:* **#DIV/0!**	*Max:* **0.535**	*Max:* **0.480**	*Max:* **0.5**	*Max:* **0.4**
	33 Pool Inner Berm Mean Depth, ft (d_{ibp})		*Mean:* **1.0**	*Mean:* **1.0**	*Mean:* **1.0**	*Mean:*	*Mean:* **1.08**	*Mean:* **1.89**	*Mean:* **0.5**	*Mean:* **0.4**
			Min: **1.0**	*Min:* **1.0**	*Min:* **1.0**	*Min:*	*Min:* **0.94**	*Min:* **1.68**	*Min:* **0.5**	*Min:* **0.4**
			Max: **1.0**	*Max:* **1.0**	*Max:* **1.0**	*Max:*	*Max:* **1.22**	*Max:* **2.09**	*Max:* **0.5**	*Max:* **0.4**
	34 Pool Inner Berm Mean Depth to Pool Mean Depth (d_{ibp}/d_{bkfp})		*Mean:* **0.7**	*Mean:* **0.7**	*Mean:* **0.8**	*Mean:* **#DIV/0!**	*Mean:* **0.815**	*Mean:* **0.815**	*Mean:* **0.3**	*Mean:* **0.3**
			Min: **0.7**	*Min:* **0.7**	*Min:* **0.8**	*Min:* **#DIV/0!**	*Min:* **0.709**	*Min:* **0.709**	*Min:* **0.3**	*Min:* **0.3**
			Max: **0.7**	*Max:* **0.7**	*Max:* **0.8**	*Max:* **#DIV/0!**	*Max:* **0.921**	*Max:* **0.921**	*Max:* **0.3**	*Max:* **0.3**
	35 Pool Inner Berm Width/Depth Ratio (W_{ibp}/d_{ibp})		*Mean:* **12.4**	*Mean:* **10.6**	*Mean:* **10.6**	*Mean:* **#DIV/0!**	*Mean:* **9.2**	*Mean:* **9.2**	*Mean:* **11.1**	*Mean:* **11.1**
			Min: **12.4**	*Min:* **10.6**	*Min:* **10.6**	*Min:* **#DIV/0!**	*Min:* **7.2**	*Min:* **7.2**	*Min:* **11.1**	*Min:* **11.1**
			Max: **12.4**	*Max:* **10.6**	*Max:* **10.6**	*Max:* **#DIV/0!**	*Max:* **11.2**	*Max:* **11.2**	*Max:* **11.1**	*Max:* **11.1**
	36 Pool Inner Berm Cross-Sectional Area (A_{ibp})		*Mean:* **11.5**	*Mean:* **11.0**	*Mean:* **11.0**	*Mean:*	*Mean:* **11.4**	*Mean:* **31.6**	*Mean:* **2.6**	*Mean:* **1.5**
			Min: **11.5**	*Min:* **11.0**	*Min:* **11.0**	*Min:*	*Min:* **9.8**	*Min:* **31.6**	*Min:* **2.6**	*Min:* **1.5**
			Max: **11.5**	*Max:* **11.0**	*Max:* **11.0**	*Max:*	*Max:* **13.0**	*Max:* **31.6**	*Max:* **2.6**	*Max:* **1.5**
	37 Pool Inner Berm Cross-Sectional Area to Pool Cross-Sectional Area (A_{ibp}/A_{bkfp})		*Mean:* **0.4**	*Mean:* **0.3**	*Mean:* **0.4**	*Mean:* **#DIV/0!**	*Mean:* **0.387**	*Mean:* **0.387**	*Mean:* **0.1**	*Mean:* **0.1**
			Min: **0.4**	*Min:* **0.3**	*Min:* **0.4**	*Min:* **#DIV/0!**	*Min:* **0.333**	*Min:* **0.333**	*Min:* **0.1**	*Min:* **0.1**
			Max: **0.4**	*Max:* **0.3**	*Max:* **0.4**	*Max:* **#DIV/0!**	*Max:* **0.441**	*Max:* **0.441**	*Max:* **0.1**	*Max:* **0.1**
Run Dimensions	**38** Run Width, ft (W_{bkfr})					*Mean:*	*Mean:* **25.2**	*Mean:* **40.5**	*Mean:* **22.0**	*Mean:* **16.5**
						Min:	*Min:*	*Min:*	*Min:* **14.8**	*Min:* **11.1**
						Max:	*Max:*	*Max:*	*Max:* **35.1**	*Max:* **26.4**
	39 Run Width to Riffle Width (W_{bkfr}/W_{bkf})					*Mean:* **0.0**	*Mean:* **1.015**	*Mean:* **1.015**	*Mean:* **1.1**	*Mean:* **1.1**
						Min: **0.0**	*Min:*	*Min:*	*Min:* **0.7**	*Min:* **0.7**
						Max: **0.0**	*Max:*	*Max:*	*Max:* **1.8**	*Max:* **1.8**
	40 Run Mean Depth, ft (d_{bkfr})					*Mean:*	*Mean:* **1.04**	*Mean:* **1.82**	*Mean:* **0.9**	*Mean:* **0.8**
						Min:	*Min:*	*Min:*	*Min:* **0.5**	*Min:* **0.4**
						Max:	*Max:*	*Max:*	*Max:* **1.5**	*Max:* **1.2**
	41 Run Mean Depth to Riffle Mean Depth (d_{bkfr}/d_{bkf})					*Mean:* **0.0**	*Mean:* **0.968**	*Mean:* **0.968**	*Mean:* **0.7**	*Mean:* **0.7**
						Min: **0.0**	*Min:*	*Min:*	*Min:* **0.4**	*Min:* **0.4**
						Max: **0.0**	*Max:*	*Max:*	*Max:* **1.1**	*Max:* **1.1**
	42 Run Width/Depth Ratio (W_{bkfr}/d_{bkfr})					*Mean:* **#DIV/0!**	*Mean:* **22.2**	*Mean:* **22.2**	*Mean:* **30.6**	*Mean:* **30.6**
						Min: **#DIV/0!**	*Min:*	*Min:*	*Min:* **15.9**	*Min:* **9.3**
						Max: **#DIV/0!**	*Max:*	*Max:*	*Max:* **10.8**	*Max:* **64.3**
	43 Run Cross-Sectional Area, ft^2 (A_{bkfr})					*Mean:*	*Mean:* **26.2**	*Mean:* **73.8**	*Mean:* **17.9**	*Mean:* **10.7**
						Min:	*Min:*	*Min:*	*Min:* **13.4**	*Min:* **7.9**
						Max:	*Max:*	*Max:*	*Max:* **22.3**	*Max:* **13.2**
	44 Run Area to Riffle Area (A_{bkfr}/A_{bkf})					*Mean:* **0.0**	*Mean:* **0.982**	*Mean:* **0.982**	*Mean:* **0.7**	*Mean:* **0.7**
						Min: **0.0**	*Min:*	*Min:*	*Min:* **0.5**	*Min:* **0.5**

	Entry Number & Variable	Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach DS Riffle	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
					Max: 0.0	*Max:*	*Max:*	*Max:* 0.8	*Max:* 0.8
	45 Run Maximum Depth (d_{maxr})				*Mean:* 2.2	*Mean:* 1.94	*Mean:* 3.39	*Mean:* 2.1	*Mean:* 1.7
					Min: 2.2	*Min:*	*Min:*	*Min:* 1.7	*Min:* 1.3
					Max: 2.2	*Max:*	*Max:*	*Max:* 2.7	*Max:* 2.1
	46 Run Maximum Depth to Riffle Mean Depth (d_{maxr}/d_{bkf})				*Mean:* 1.9	*Mean:* 1.803	*Mean:* 1.803	*Mean:* 1.6	*Mean:* 1.6
					Min: 1.9	*Min:*	*Min:*	*Min:* 1.2	*Min:* 1.2
					Max: 1.9	*Max:*	*Max:*	*Max:* 2.0	*Max:* 2.0
Glide Dimensions	**47** Glide Width, ft (W_{bkfg})				*Mean:*	*Mean:* 26.6	*Mean:* 42.7	*Mean:* 33.2	*Mean:* 25.0
					Min:	*Min:* 24.5	*Min:* 39.3	*Min:* 33.2	*Min:* 25.0
					Max:	*Max:* 28.7	*Max:* 46.0	*Max:* 33.2	*Max:* 25.0
	48 Glide Width to Riffle Width (W_{bkfg}/W_{bkf})				*Mean:* 0.0	*Mean:* 1.070	*Mean:* 1.070	*Mean:* 1.7	*Mean:* 1.7
					Min: 0.0	*Min:* 0.986	*Min:* 0.986	*Min:* 1.7	*Min:* 1.7
					Max: 0.0	*Max:* 1.154	*Max:* 1.154	*Max:* 1.7	*Max:* 1.7
	49 Glide Mean Depth, ft (d_{bkfg})				*Mean:*	*Mean:* 0.96	*Mean:* 1.68	*Mean:* 0.5	*Mean:* 0.4
					Min:	*Min:* 0.87	*Min:* 1.52	*Min:* 0.5	*Min:* 0.4
					Max:	*Max:* 1.05	*Max:* 1.84	*Max:* 0.5	*Max:* 0.4
	50 Glide Mean Depth to Riffle Mean Depth (d_{bkfg}/d_{bkf})				*Mean:* 0.0	*Mean:* 0.894	*Mean:* 0.894	*Mean:* 0.4	*Mean:* 0.4
					Min: 0.0	*Min:* 0.809	*Min:* 0.809	*Min:* 0.4	*Min:* 0.4
					Max: 0.0	*Max:* 0.979	*Max:* 0.979	*Max:* 0.4	*Max:* 0.4
	51 Glide Width/Depth Ratio (W_{bkfg}/d_{bkfg})				*Mean:* #DIV/0!	*Mean:* 25.4	*Mean:* 25.4	*Mean:* 62.4	*Mean:* 62.4
					Min: #DIV/0!	*Min:* 25.0	*Min:* 25.0	*Min:* 62.4	*Min:* 62.4
					Max: #DIV/0!	*Max:* 25.9	*Max:* 25.9	*Max:* 62.4	*Max:* 62.4
	52 Glide Cross-Sectional Area, ft^2 (A_{bkfg})				*Mean:*	*Mean:* 25.7	*Mean:* 72.2	*Mean:* 16.6	*Mean:* 9.9
					Min:	*Min:* 21.2	*Min:* 59.6	*Min:* 16.6	*Min:* 9.9
					Max:	*Max:* 30.1	*Max:* 84.8	*Max:* 16.6	*Max:* 9.9
	53 Glide Area to Riffle Area (A_{bkfg}/A_{bkf})				*Mean:* 0.0	*Mean:* 0.961	*Mean:* 0.961	*Mean:* 0.6	*Mean:* 0.6
					Min: 0.0	*Min:* 0.794	*Min:* 0.794	*Min:* 0.6	*Min:* 0.6
					Max: 0.0	*Max:* 1.129	*Max:* 1.129	*Max:* 0.6	*Max:* 0.6
	54 Glide Maximum Depth (d_{maxg})				*Mean:* 1.6	*Mean:* 1.30	*Mean:* 2.27	*Mean:* 2.0	*Mean:* 1.6
					Min: 1.6	*Min:* 1.22	*Min:* 2.14	*Min:* 2.0	*Min:* 1.6
					Max: 1.6	*Max:* 1.37	*Max:* 2.40	*Max:* 2.0	*Max:* 1.6
	55 Glide Maximum Depth to Riffle Mean Depth (d_{maxg}/d_{bkf})				*Mean:* 1.4	*Mean:* 1.207	*Mean:* 1.207	*Mean:* 1.5	*Mean:* 1.5
					Min: 1.4	*Min:* 1.138	*Min:* 1.138	*Min:* 1.5	*Min:* 1.5
					Max: 1.4	*Max:* 1.277	*Max:* 1.277	*Max:* 1.5	*Max:* 1.5
...ensions	**56** Glide Inner Berm Width, ft (W_{ibg})				*Mean:*	*Mean:* 15.3	*Mean:* 24.7	*Mean:* 6.1	*Mean:* 4.6
					Min:	*Min:* 14.0	*Min:* 20.8	*Min:* 6.1	*Min:* 4.6
					Max:	*Max:* 16.5	*Max:* 28.6	*Max:* 6.1	*Max:* 4.6
	57 Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})				*Mean:* #DIV/0!	*Mean:* 0.575	*Mean:* 0.575	*Mean:* 0.2	*Mean:* 0.2
					Min: #DIV/0!	*Min:* 0.528	*Min:* 0.528	*Min:* 0.2	*Min:* 0.2
					Max: #DIV/0!	*Max:* 0.622	*Max:* 0.622	*Max:* 0.2	*Max:* 0.2
	58 Glide Inner Berm Mean Depth, ft				*Mean:*	*Mean:* 0.25	*Mean:* 0.43	*Mean:* 0.6	*Mean:* 0.5
					Min:	*Min:* 0.18	*Min:* 0.34	*Min:* 0.6	*Min:* 0.5

Section	Entry Number & Variable		Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach DS Riffle	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
Glide Inner Berm Dime	(d_{ibg})					*Max:*	*Max:* **0.33**	*Max:* **0.52**	*Max:* **0.6**	*Max:* **0.5**
	59 Glide Inner Berm Mean Depth to Glide Mean Depth (d_{ibg}/d_{bkfg})					*Mean:* **#DIV/0!**	*Mean:* **0.265**	*Mean:* **0.265**	*Mean:* **1.2**	*Mean:* **1.2**
						Min: **#DIV/0!**	*Min:* **0.185**	*Min:* **0.185**	*Min:* **1.2**	*Min:* **1.2**
						Max: **#DIV/0!**	*Max:* **0.345**	*Max:* **0.345**	*Max:* **1.2**	*Max:* **1.2**
	60 Glide Inner Berm Width/Depth Ratio (W_{ibg}/d_{ibg})					*Mean:* **#DIV/0!**	*Mean:* **61.9**	*Mean:* **61.9**	*Mean:* **9.3**	*Mean:* **9.3**
						Min: **#DIV/0!**	*Min:* **39.6**	*Min:* **39.6**	*Min:* **9.3**	*Min:* **9.3**
						Max: **#DIV/0!**	*Max:* **84.2**	*Max:* **84.2**	*Max:* **9.3**	*Max:* **9.3**
	61 Glide Inner Berm Cross-Sectional Area (A_{ibg})					*Mean:*	*Mean:* **3.8**	*Mean:* **10.3**	*Mean:* **3.8**	*Mean:* **2.3**
						Min:	*Min:* **3.0**	*Min:* **9.7**	*Min:* **3.8**	*Min:* **2.3**
						Max:	*Max:* **4.7**	*Max:* **10.9**	*Max:* **3.8**	*Max:* **2.3**
	62 Glide Inner Berm Area to Glide Area (A_{ibg}/A_{bkfg})					*Mean:* **#DIV/0!**	*Mean:* **0.149**	*Mean:* **0.149**	*Mean:* **0.2**	*Mean:* **0.2**
						Min: **#DIV/0!**	*Min:* **0.115**	*Min:* **0.115**	*Min:* **0.2**	*Min:* **0.2**
						Max: **#DIV/0!**	*Max:* **0.183**	*Max:* **0.183**	*Max:* **0.2**	*Max:* **0.2**
Step Dimensions	**63** Step Width, ft (W_{bkfs})					*Mean:*	*Mean:* **N/A**	*Mean:* **N/A**	*Mean:* **0.0**	*Mean:* **0.0**
						Min:	*Min:*	*Min:*	*Min:* **0.0**	*Min:* **0.0**
						Max:	*Max:*	*Max:*	*Max:* **0.0**	*Max:* **0.0**
	64 Step Width to Riffle Width (W_{bkfs}/W_{bkf})					*Mean:* **0.0**	*Mean:* **N/A**	*Mean:* **N/A**	*Mean:* **0.0**	*Mean:* **0.0**
						Min: **0.0**	*Min:*	*Min:*	*Min:* **0.0**	*Min:* **0.0**
						Max: **0.0**	*Max:*	*Max:*	*Max:* **0.0**	*Max:* **0.0**
	65 Step Mean Depth, ft (d_{bkfs})					*Mean:*	*Mean:* **N/A**	*Mean:* **N/A**	*Mean:* **0.0**	*Mean:* **0.0**
						Min:	*Min:*	*Min:*	*Min:* **0.0**	*Min:* **0.0**
						Max:	*Max:*	*Max:*	*Max:* **0.0**	*Max:* **0.0**
	66 Step Mean Depth to Riffle Mean Depth (d_{bkfs}/d_{bkf})					*Mean:* **0.0**	*Mean:* **N/A**	*Mean:* **N/A**	*Mean:* **0.0**	*Mean:* **0.0**
						Min: **0.0**	*Min:*	*Min:*	*Min:* **0.0**	*Min:* **0.0**
						Max: **0.0**	*Max:*	*Max:*	*Max:* **0.0**	*Max:* **0.0**
	67 Step Width/Depth Ratio (W_{bkfs}/d_{bkfs})					*Mean:* **#DIV/0!**	*Mean:*	*Mean:*	*Mean:* **0.0**	*Mean:* **0.0**
						Min: **#DIV/0!**	*Min:*	*Min:*	*Min:* **0.0**	*Min:* **0.0**
						Max: **#DIV/0!**	*Max:*	*Max:*	*Max:* **0.0**	*Max:* **0.0**
	68 Step Cross-Sectional Area, ft^2 (A_{bkfs})					*Mean:*	*Mean:* **N/A**	*Mean:*	*Mean:* **0.0**	*Mean:* **0.0**
						Min:	*Min:*	*Min:*	*Min:* **0.0**	*Min:* **0.0**
						Max:	*Max:*	*Max:*	*Max:* **0.0**	*Max:* **0.0**
	69 Step Area to Riffle Area (A_{bkfs}/A_{bkf})					*Mean:* **0.0**	*Mean:* **N/A**	*Mean:* **N/A**	*Mean:* **0.0**	*Mean:* **0.0**
						Min: **0.0**	*Min:*	*Min:*	*Min:* **0.0**	*Min:* **0.0**
						Max: **0.0**	*Max:*	*Max:*	*Max:* **0.0**	*Max:* **0.0**
	70 Step Maximum Depth (d_{maxs})					*Mean:*	*Mean:* **N/A**	*Mean:*	*Mean:* **0.0**	*Mean:* **0.0**
						Min:	*Min:*	*Min:*	*Min:* **0.0**	*Min:* **0.0**
						Max:	*Max:*	*Max:*	*Max:* **0.0**	*Max:* **0.0**
	71 Step Maximum Depth to Riffle Mean Depth (d_{maxs}/d_{bkf})					*Mean:* **0.0**	*Mean:* **N/A**	*Mean:* **N/A**	*Mean:* **0.0**	*Mean:* **0.0**
						Min: **0.0**	*Min:*	*Min:*	*Min:* **0.0**	*Min:* **0.0**
						Max: **0.0**	*Max:*	*Max:*	*Max:* **0.0**	*Max:* **0.0**
	72 Linear Wavelength, ft (λ)					*Mean:* **143.0**	*Mean:* **299.2**	*Mean:* **467.2**	*Mean:* **74.6**	*Mean:* **56.0**
						Min: **40.9**	*Min:* **268.4**	*Min:* **419.0**	*Min:* **55.9**	*Min:* **42.0**

	Entry Number & Variable		Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach DS Riffle	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
Channel Pattern						*Max:* 595.2	*Max:* 318.1	*Max:* 496.6	*Max:* 102.5	*Max:* 77.0
	73 Linear Wavelength to Riffle Width (λ/W_{bkf})					*Mean:* 6.4	*Mean:* 12.040	*Mean:* 12.040	*Mean:* 3.7	*Mean:* 3.7
						Min: 1.8	*Min:* 10.800	*Min:* 10.800	*Min:* 2.8	*Min:* 2.8
						Max: 26.5	*Max:* 12.800	*Max:* 12.800	*Max:* 5.1	*Max:* 5.1
	74 Stream Meander Length, ft (L_m)					*Mean:* 149.0	*Mean:* 340.5	*Mean:* 531.6	*Mean:* 86.5	*Mean:* 65.0
						Min: 48.5	*Min:* 305.7	*Min:* 477.2	*Min:* 59.9	*Min:* 45.0
						Max: 611.2	*Max:* 375.2	*Max:* 585.9	*Max:* 106.5	*Max:* 80.0
	75 Stream Meander Length Ratio (L_m/W_{bkf})					*Mean:* 6.6	*Mean:* 13.700	*Mean:* 13.700	*Mean:* 4.3	*Mean:* 4.3
						Min: 2.2	*Min:* 12.300	*Min:* 12.300	*Min:* 3.0	*Min:* 3.0
						Max: 27.2	*Max:* 15.100	*Max:* 15.100	*Max:* 5.3	*Max:* 5.3
	76 Belt Width, ft (W_{blt})					*Mean:* 65.0	*Mean:* 125.2	*Mean:* 195.6	*Mean:* 54.6	*Mean:* 41.0
						Min: 0.0	*Min:* 99.7	*Min:* 155.6	*Min:* 39.9	*Min:* 30.0
						Max: 0.0	*Max:* 176.4	*Max:* 275.5	*Max:* 73.2	*Max:* 55.0
	77 Meander Width Ratio (W_{blt}/W_{bkf})					*Mean:* 2.9	*Mean:* 5.040	*Mean:* 5.040	*Mean:* 2.7	*Mean:* 2.7
						Min: 0.0	*Min:* 4.010	*Min:* 4.010	*Min:* 2.0	*Min:* 2.0
						Max: 0.0	*Max:* 7.100	*Max:* 7.100	*Max:* 3.7	*Max:* 3.7
	78 Radius of Curvature, ft (R_c)					*Mean:* 75.4	*Mean:* 84.8	*Mean:* 132.4	*Mean:* 17.3	*Mean:* 13.0
						Min: 10.0	*Min:* 54.7	*Min:* 85.4	*Min:* 5.3	*Min:* 4.0
						Max: 300.0	*Max:* 112.2	*Max:* 175.2	*Max:* 37.3	*Max:* 28.0
	79 Radius of Curvature to Riffle Width (R_c/W_{bkf})					*Mean:* 3.4	*Mean:* 3.412	*Mean:* 3.412	*Mean:* 0.9	*Mean:* 0.9
						Min: 0.4	*Min:* 2.200	*Min:* 2.200	*Min:* 0.3	*Min:* 0.3
						Max: 13.3	*Max:* 4.516	*Max:* 4.516	*Max:* 1.9	*Max:* 1.9
	80 Arc Length, ft (L_a)					*Mean:* 44.2	*Mean:* 89.8	*Mean:* 140.2	*Mean:* 34.6	*Mean:* 26.0
						Min: 8.9	*Min:* 52.2	*Min:* 81.5	*Min:* 16.0	*Min:* 12.0
						Max: 136.2	*Max:* 127.2	*Max:* 198.6	*Max:* 61.2	*Max:* 46.0
	81 Arc Length to Riffle Width (L_a/W_{bkf})					*Mean:* 2.0	*Mean:* 3.613	*Mean:* 3.613	*Mean:* 1.7	*Mean:* 1.7
						Min: 0.4	*Min:* 2.100	*Min:* 2.100	*Min:* 0.8	*Min:* 0.8
						Max: 6.1	*Max:* 5.119	*Max:* 5.119	*Max:* 3.1	*Max:* 3.1
	82 Riffle Length (L_r), ft					*Mean:* 60.7	*Mean:* 77.0	*Mean:* 120.3	*Mean:* 22.3	*Mean:* 16.7
						Min: 2.5	*Min:* 52.2	*Min:* 81.5	*Min:* 10.6	*Min:* 8.0
						Max: 290.3	*Max:* 99.7	*Max:* 155.6	*Max:* 41.4	*Max:* 31.1
	83 Riffle Length to Riffle Width (L_r/W_{bkf})					*Mean:* 2.7	*Mean:* 3.100	*Mean:* 3.100	*Mean:* 1.1	*Mean:* 1.1
						Min: 0.1	*Min:* 2.100	*Min:* 2.100	*Min:* 0.5	*Min:* 0.5
						Max: 12.9	*Max:* 4.010	*Max:* 4.010	*Max:* 2.1	*Max:* 2.1
	84 Individual Pool Length, ft (L_p)					*Mean:* 31.0	*Mean:* 54.7	*Mean:* 85.4	*Mean:* 23.7	*Mean:* 17.8
						Min: 6.2	*Min:* 44.7	*Min:* 69.8	*Min:* 8.5	*Min:* 6.4
						Max: 95.3	*Max:* 68.3	*Max:* 106.7	*Max:* 81.2	*Max:* 61.0
	85 Pool Length to Riffle Width (L_p/W_{bkf})					*Mean:* 1.4	*Mean:* 2.200	*Mean:* 2.200	*Mean:* 1.2	*Mean:* 1.2
						Min: 0.3	*Min:* 1.800	*Min:* 1.800	*Min:* 0.4	*Min:* 0.4
						Max: 4.2	*Max:* 2.750	*Max:* 2.750	*Max:* 4.1	*Max:* 4.1
	86 Pool-to-Pool Spacing, ft (P_s)					*Mean:* 74.7	*Mean:* 157.3	*Mean:* 245.6	*Mean:* 59.0	*Mean:* 44.3
						Min: 16.3	*Min:* 124.3	*Min:* 194.0	*Min:* 16.0	*Min:* 12.0

Group	Entry Number & Variable			Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach DS Riffle	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
							Max: 328.8	*Max:* 186.4	*Max:* 291.0	*Max:* 117.6	*Max:* 88.3
	87	Pool-to-Pool Spacing to Riffle Width (P_s/W_{bkf})					*Mean:* 3.3 *Min:* 0.7 *Max:* 14.6	*Mean:* 6.330 *Min:* 5.000 *Max:* 7.500	*Mean:* 6.330 *Min:* 5.000 *Max:* 7.500	*Mean:* 2.9 *Min:* 0.8 *Max:* 5.9	*Mean:* 2.9 *Min:* 0.8 *Max:* 5.9
Sinuosity and Slope	88	Stream Length (SL)					7228.6	12820.0	3420.0	12824.0	3420.0
Sinuosity and Slope	89	Valley Length (VL)					6786.0	12009.0	3000.0	12009.0	3000.0
Sinuosity and Slope	90	Valley Slope (S_{val})					0.0442	0.0389	0.0114	0.0389	0.0336
Sinuosity and Slope	91	Sinuosity (k)					SL/VL: 1.07	SL/VL: 1.07	SL/VL: 1.14 VS/S: 1.14	SL/VL: 1.07	SL/VL: 1.14 VS/S: 1.14
Sinuosity and Slope	92	Average Water Surface Slope (S)					0.0423	$S = S_{val}/k$ 0.0364	0.0100	$S = S_{val}/k$ 0.0364	0.0294
Floodplain	93	Floodplain Width, ft (W_f)					*Mean:* *Min:* *Max:*	*Mean:* *Min:* *Max:*	*Mean:* 305.000 *Min:* 210.000 *Max:* 400.000		*Mean:* 305.000 *Min:* 210.000 *Max:* 400.000
Floodplain	94	Floodplain Surface Depth Limit, ft (d_f)					*Mean:* *Min:* *Max:*	*Mean:* *Min:* *Max:*	*Mean:* 2.0 *Min:* 1.8 *Max:* 2.2		*Mean:* 2.0 *Min:* 1.8 *Max:* 2.2
Low Terrace	95	Low Terrace Width, ft (W_{lt})					*Mean:* *Min:* *Max:*	*Mean:* *Min:* *Max:*	*Mean:* 450.000 *Min:* 290.000 *Max:* 620.000		*Mean:* 450.000 *Min:* 290.000 *Max:* 620.000
Low Terrace	96	Low Terrace Surface Depth Limit, ft (d_{lt})					*Mean:* *Min:* *Max:*	*Mean:* *Min:* *Max:*	*Mean:* 5.6 *Min:* 5.3 *Max:* 6.0		*Mean:* 5.6 *Min:* 5.3 *Max:* 6.0
Flood-Prone Area	97	Flood-Prone Area Width, ft (W_{fpa})					*Mean:* 42.500 *Min:* *Max:*	*Mean:* *Min:* *Max:*	*Mean:* 450.000 *Min:* 290.000 *Max:* 610.000		*Mean:* 450.000 *Min:* 290.000 *Max:* 610.000
Flood-Prone Area	98	Flood-Prone Area Surface Depth Limit, ft (d_{fpa})					*Mean:* *Min:* *Max:*	*Mean:* *Min:* *Max:*	*Mean:* 5.6 *Min:* 5.3 *Max:* 6.0		*Mean:* 5.6 *Min:* 5.3 *Max:* 6.0
Degree of Incision	99	Low Bank Height (LBH)					*Mean:* *Min:* *Max:*	*Mean:* *Min:* *Max:*	*Mean:* 2.575 *Min:* 2.310 *Max:* 2.840		*Mean:* 0.000 *Min:* 0.000 *Max:* 0.000
Degree of Incision	100	Maximum Bankfull Depth (d_{max}) at Same Location as Low Bank Height (LBH) Measurement					*Mean:* *Min:* *Max:*	*Mean:* *Min:* *Max:*	*Mean:* 2.6 *Min:* 2.3 *Max:* 2.8		*Mean:* 2.1 *Min:* 2.1 *Max:* 2.1
Degree of Incision	101	Bank-Height Ratio (LBH/d_{max})					*Mean:* *Min:* *Max:*	*Mean:* *Min:* *Max:*	*Mean:* 1.000 *Min:* 1.000 *Max:* 1.000		*Mean:* 0.000 *Min:* 0.000 *Max:* 0.000

Bed Feature Max Depth Measurements and Dimensionless Ratios from Profile

Entry Number & Variable		Design Reach Pool-1	Design Reach Pool-2	Design Reach Pool-3	Design Reach DS Riffle	Target Design Based on Reference	E. Fork Arkansas Reference	Target Design Based on Reference	N. Fork of N. Elk Creek Reference
102	Riffle Maximum Depth, ft (d_{max})				*Mean:*	*Mean:* **1.9**	*Mean:* **3.3**	**2.0**	*Mean:* **1.6**
					Min:	*Min:* **1.7**	*Min:* **3.0**	**0.5**	*Min:* **0.4**
					Max:	*Max:* **1.9**	*Max:* **3.4**	**2.5**	*Max:* **2.0**
103	Riffle Maximum Depth to Riffle Mean Depth (d_{max}/d_{bkf})				*Mean:*	*Mean:* **1.734**	*Mean:* **1.734**	**1.505**	*Mean:* **1.505**
					Min:	*Min:* **1.617**	*Min:* **1.617**	**0.355**	*Min:* **0.355**
					Max:	*Max:* **1.803**	*Max:* **1.803**	**1.897**	*Max:* **1.897**
104	Pool Maximum Depth, ft (d_{maxp})				*Mean:*	*Mean:* **2.8**	*Mean:* **4.9**	**3.3**	*Mean:* **2.6**
					Min:	*Min:* **2.4**	*Min:* **4.2**	**2.2**	*Min:* **1.8**
					Max:	*Max:* **3.0**	*Max:* **5.3**	**4.8**	*Max:* **3.9**
105	Pool Maximum Depth to Riffle Mean Depth (d_{maxp}/d_{bkf})				*Mean:*	*Mean:* **2.606**	*Mean:* **2.606**	**2.467**	*Mean:* **2.467**
					Min:	*Min:* **2.255**	*Min:* **2.255**	**1.682**	*Min:* **1.682**
					Max:	*Max:* **2.793**	*Max:* **2.793**	**3.607**	*Max:* **3.607**
106	Run Maximum Depth, ft (d_{maxr})				*Mean:*	*Mean:* **2.0**	*Mean:* **3.4**	**2.4**	*Mean:* **1.9**
					Min:	*Min:* **1.8**	*Min:* **3.2**	**1.6**	*Min:* **1.3**
					Max:	*Max:* **2.1**	*Max:* **3.7**	**3.3**	*Max:* **2.7**
107	Run Maximum Depth to Riffle Mean Depth (d_{maxr}/d_{bkf})				*Mean:*	*Mean:* **1.824**	*Mean:* **1.824**	**1.813**	*Mean:* **1.813**
					Min:	*Min:* **1.681**	*Min:* **1.681**	**1.206**	*Min:* **1.206**
					Max:	*Max:* **1.963**	*Max:* **1.963**	**2.486**	*Max:* **2.486**
108	Glide Maximum Depth, ft (d_{maxg})				*Mean:*	*Mean:* **1.4**	*Mean:* **2.5**	**2.1**	*Mean:* **1.7**
					Min:	*Min:* **1.2**	*Min:* **2.2**	**1.0**	*Min:* **0.8**
					Max:	*Max:* **1.6**	*Max:* **2.8**	**3.0**	*Max:* **2.4**
109	Glide Maximum Depth to Riffle Mean Depth (d_{maxg}/d_{bkf})				*Mean:*	*Mean:* **1.309**	*Mean:* **1.309**	**1.607**	*Mean:* **1.607**
					Min:	*Min:* **1.149**	*Min:* **1.149**	**0.757**	*Min:* **0.757**
					Max:	*Max:* **1.473**	*Max:* **1.473**	**2.215**	*Max:* **2.215**
110	Step Maximum Depth, ft (d_{maxs})				*Mean:*	*Mean:* **N/A**	*Mean:* **N/A**	**0.0**	*Mean:* **0.0**
					Min:	*Min:*	*Min:*	**0.0**	*Min:* **0.0**
					Max:	*Max:*	*Max:*	**0.0**	*Max:* **0.0**
111	Step Maximum Depth to Riffle Mean Depth (d_{maxs}/d_{bkf})				*Mean:*	*Mean:* **N/A**	*Mean:* **N/A**	**0.000**	*Mean:* **0.000**
					Min:	*Min:*	*Min:*	**0.000**	*Min:* **0.000**
					Max:	*Max:*	*Max:*	**0.000**	*Max:* **0.000**

USGS StreamStats Summary

USGS Colorado StreamStats

Streamstats Ungaged Site Report

Date: Tue May 19 2015 15:57:48 Mountain Daylight Time
Site Location: Colorado
NAD27 Latitude: 40.0643 (40 03 51)
NAD27 Longitude: -105.3081 (-105 18 29)
NAD83 Latitude: 40.0643 (40 03 51)
NAD83 Longitude: -105.3087 (-105 18 31)
Drainage Area: 4.92 mi2

Peak-Flows Basin Characteristics

10% Mountain Region Peak Flow (0.5 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	4.92	1	1060
Mean Basin Slope from 10m DEM (percent)	36.2	7.6	60.2
Mean Annual Precipitation (inches)	20.71	18	47

90% Plains Region Peak Flow (4.42 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	4.92	0.5	2930
6 Hour 100 Year Precipitation (inches)	3.24	2.4	5.1

Low-Flows Basin Characteristics

10% Mountain Region Min Flow (0.5 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	4.92	1	1060
Mean Annual Precipitation (inches)	20.71	18	47
Mean Basin Elevation (feet)	6950 (below min value 8600)	8600	12000

90% Undefined Region (4.42 mi2)

Warning: The selected watershed is partly in an area for which flow equations were not defined. Whole-watershed flow estimates have been provided using the regional equations that are available for other parts of the watershed. Weighted flows were not calculated. Users should be careful to evaluate the applicability of the provided estimates.

Some parameters are outside the suggested range. Estimates will be extrapolations with unknown errors.

Flow-Duration Basin Characteristics

10% Mountain Region Flow Duration (0.5 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	4.92	1	1060
Mean Annual Precipitation (inches)	20.71	18	47

90% Undefined Region (4.42 mi2)

Warning: The selected watershed is partly in an area for which flow equations were not defined. Whole-watershed flow estimates have been provided using the regional equations that are available for other parts of the watershed. Weighted flows were not calculated. Users should be careful to evaluate the applicability of the provided estimates.

Maximum-Flows Basin Characteristics

10% Mountain Region Max Flow (0.5 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	4.92	1	1060

Mean Annual Precipitation (inches)	20.71	18	47
90% Undefined Region (4.42 mi2)			

Warning: The selected watershed is partly in an area for which flow equations were not defined. Whole-watershed flow estimates have been provided using the regional equations that are available for other parts of the watershed. Weighted flows were not calculated. Users should be careful to evaluate the applicability of the provided estimates.

Mean-Flows Basin Characteristics

10% Mountain Region Mean Flow (0.5 mi2)			
Parameter	**Value**	**Regression Equation Valid Range**	
		Min	**Max**
Drainage Area (square miles)	4.92	1	1060
Mean Annual Precipitation (inches)	20.71	18	47
90% Undefined Region (4.42 mi2)			

Warning: The selected watershed is partly in an area for which flow equations were not defined. Whole-watershed flow estimates have been provided using the regional equations that are available for other parts of the watershed. Weighted flows were not calculated. Users should be careful to evaluate the applicability of the provided estimates.

Peak-Flows Streamflow Statistics Area-Averaged

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record
PK2	59.9	170	
PK5	139	130	
PK10	210	130	
PK25	345	130	
PK50	464	130	
PK100	630	130	
PK200	1160	150	
PK500	1110	130	

Peak-Flows Streamflow Statistics Mountain Region Peak Flow

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
PK2	33	49			
PK5	50.9	44			
PK10	63.3	41			
PK25	81	40			
PK50	99.3	39			
PK100	113	36			
PK200	126	36			
PK500	154	33			

Peak-Flows Streamflow Statistics Plains Region Peak Flow

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
PK2	62.9	180			
PK5	148	140			
PK10	227	140			
PK25	375	140			
PK50	505	140			
PK100	688	140			
PK200	1280	160			

PK500	1220	140			

Low-Flows Streamflow Statistics Mountain Region Min Flow

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
M7D2Y	0.0227				
M7D10Y	0.00494				
M7D50Y	0.0237				

Flow-Duration Streamflow Statistics Mountain Region Flow Duration

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
D10	7.9	45			
D25	2.14	55			
D50	0.89	55			
D75	0.49	64			
D90	0.25	85			

Maximum-Flows Streamflow Statistics Mountain Region Max Flow

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
V7D2Y	20.7	46			
V7D10Y	35.6	35			
V7D50Y	51.8	31			

Mean-Flows Streamflow Statistics Mountain Region Mean Flow

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
Q1	0.54	50			
Q2	0.51	51			
Q3	0.54	49			
Q4	0.99	44			
Q5	8.83	46			
Q6	19	46			
Q7	5.2	76			
Q8	2.36	80			
Q9	1.34	59			
QA	3.54	33			
Q10	0.97	45			
Q11	0.76	46			
Q12	0.62	47			

Colorado StreamStats

Streamstats Ungaged Site Report

Date: Tue May 19 2015 15:54:59 Mountain Daylight Time
Site Location: Colorado
NAD27 Latitude: 40.0636 (40 03 49)
NAD27 Longitude: -105.2979 (-105 17 53)
NAD83 Latitude: 40.0636 (40 03 49)
NAD83 Longitude: -105.2985 (-105 17 55)
Drainage Area: 7.19 mi2

Peak-Flows Basin Characteristics

7% Mountain Region Peak Flow (0.5 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	7.19	1	1060
Mean Basin Slope from 10m DEM (percent)	36.5	7.6	60.2
Mean Annual Precipitation (inches)	20.63	18	47

93% Plains Region Peak Flow (6.69 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	7.19	0.5	2930
6 Hour 100 Year Precipitation (inches)	3.32	2.4	5.1

Low-Flows Basin Characteristics

7% Mountain Region Min Flow (0.5 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	7.19	1	1060
Mean Annual Precipitation (inches)	20.63	18	47
Mean Basin Elevation (feet)	6820 (below min value 8600)	8600	12000

93% Undefined Region (6.69 mi2)

Warning: The selected watershed is partly in an area for which flow equations were not defined. Whole-watershed flow estimates have been provided using the regional equations that are available for other parts of the watershed. Weighted flows were not calculated. Users should be careful to evaluate the applicability of the provided estimates.

Some parameters are outside the suggested range. Estimates will be extrapolations with unknown errors.

Flow-Duration Basin Characteristics

7% Mountain Region Flow Duration (0.5 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	7.19	1	1060
Mean Annual Precipitation (inches)	20.63	18	47

93% Undefined Region (6.69 mi2)

Warning: The selected watershed is partly in an area for which flow equations were not defined. Whole-watershed flow estimates have been provided using the regional equations that are available for other parts of the watershed. Weighted flows were not calculated. Users should be careful to evaluate the applicability of the provided estimates.

Maximum-Flows Basin Characteristics

7% Mountain Region Max Flow (0.5 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	7.19	1	1060

Mean Annual Precipitation (inches)	20.63	18	47
93% Undefined Region (6.69 mi2)			

Warning: The selected watershed is partly in an area for which flow equations were not defined. Whole-watershed flow estimates have been provided using the regional equations that are available for other parts of the watershed. Weighted flows were not calculated. Users should be careful to evaluate the applicability of the provided estimates.

Mean-Flows Basin Characteristics			
7% Mountain Region Mean Flow (0.5 mi2)			
Parameter	**Value**	**Regression Equation Valid Range**	
		Min	**Max**
Drainage Area (square miles)	7.19	1	1060
Mean Annual Precipitation (inches)	20.63	18	47
93% Undefined Region (6.69 mi2)			

Warning: The selected watershed is partly in an area for which flow equations were not defined. Whole-watershed flow estimates have been provided using the regional equations that are available for other parts of the watershed. Weighted flows were not calculated. Users should be careful to evaluate the applicability of the provided estimates.

Peak-Flows Streamflow Statistics Area-Averaged			
Statistic	**Flow (ft^3/s)**	**Prediction Error (percent)**	**Equivalent years of record**
PK2	75	170	
PK5	183	140	
PK10	284	130	
PK25	476	130	
PK50	646	130	
PK100	885	130	
PK200	1650	150	
PK500	1590	130	

Peak-Flows Streamflow Statistics Mountain Region Peak Flow					
Statistic	**Flow (ft^3/s)**	**Prediction Error (percent)**	**Equivalent years of record**	**90-Percent Prediction Interval**	
				Minimum	**Maximum**
PK2	44.1	49			
PK5	67.8	44			
PK10	84.4	41			
PK25	107	40			
PK50	131	39			
PK100	150	36			
PK200	167	36			
PK500	203	33			

Peak-Flows Streamflow Statistics Plains Region Peak Flow					
Statistic	**Flow (ft^3/s)**	**Prediction Error (percent)**	**Equivalent years of record**	**90-Percent Prediction Interval**	
				Minimum	**Maximum**
PK2	77.2	180			
PK5	192	140			
PK10	299	140			
PK25	503	140			
PK50	684	140			
PK100	939	140			
PK200	1760	160			

PK500	1700	140			

Low-Flows Streamflow Statistics Mountain Region Min Flow

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
M7D2Y	0.031				
M7D10Y	0.00674				
M7D50Y	0.0343				

Flow-Duration Streamflow Statistics Mountain Region Flow Duration

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
D10	11	45			
D25	3.06	55			
D50	1.28	55			
D75	0.72	64			
D90	0.37	85			

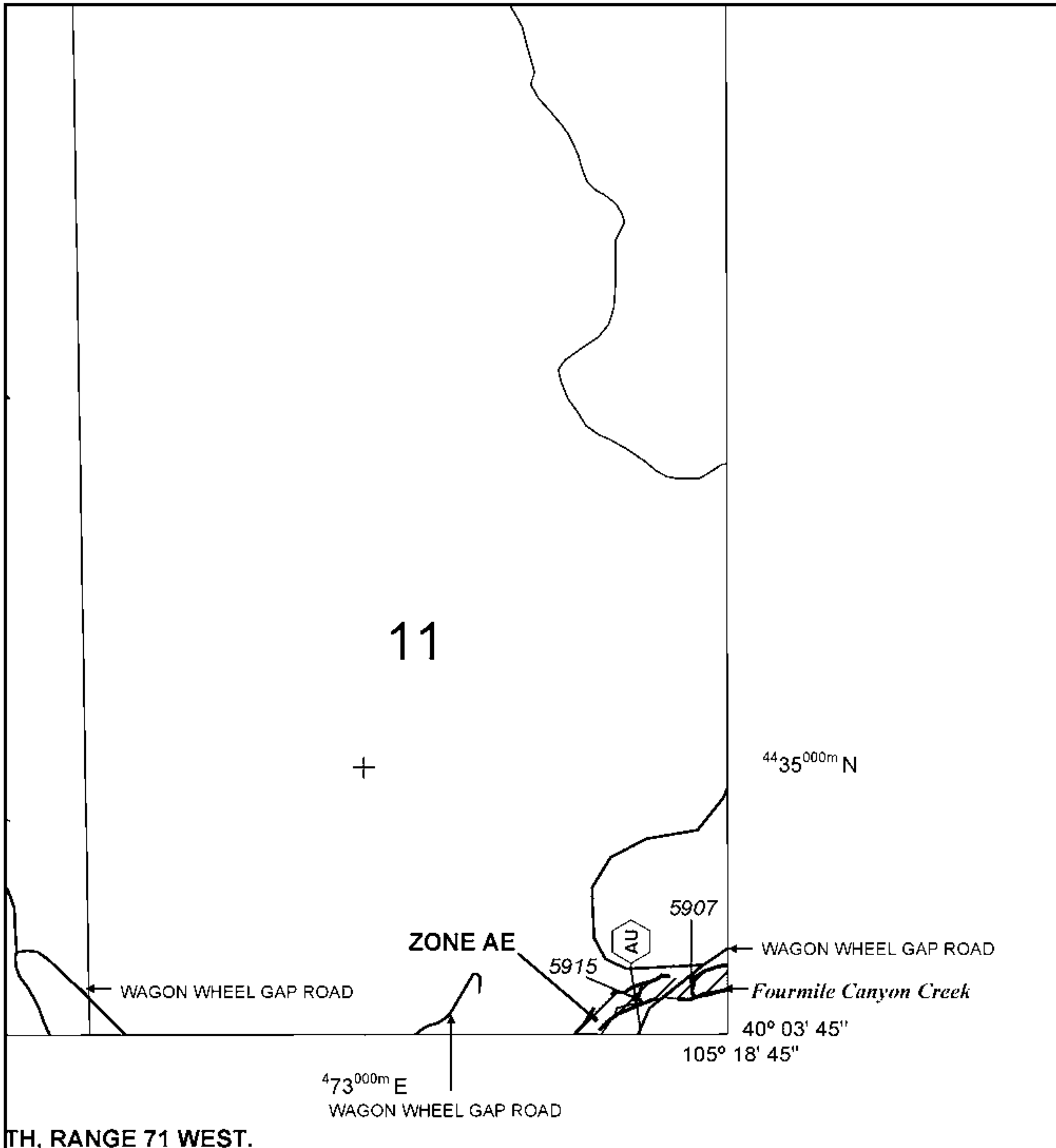
Maximum-Flows Streamflow Statistics Mountain Region Max Flow

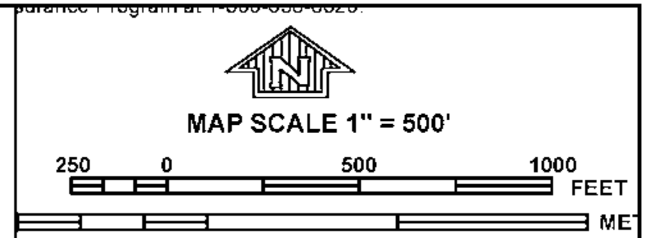
Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
V7D2Y	28	46			
V7D10Y	48.8	35			
V7D50Y	71.1	31			

Mean-Flows Streamflow Statistics Mountain Region Mean Flow

Statistic	Flow (ft^3/s)	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
				Minimum	Maximum
Q1	0.79	50			
Q2	0.75	51			
Q3	0.8	49			
Q4	1.52	44			
Q5	12.5	46			
Q6	25.7	46			
Q7	7.1	76			
Q8	3.23	80			
Q9	1.89	59			
QA	4.92	33			
Q10	1.39	45			
Q11	1.09	46			
Q12	0.9	47			

FEMA FIRM





NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0379J

FIRM

FLOOD INSURANCE RATE MAP

BOULDER COUNTY, COLORADO

AND INCORPORATED AREAS

PANEL 379 OF 615

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOULDER COUNTY	080023	0379	J

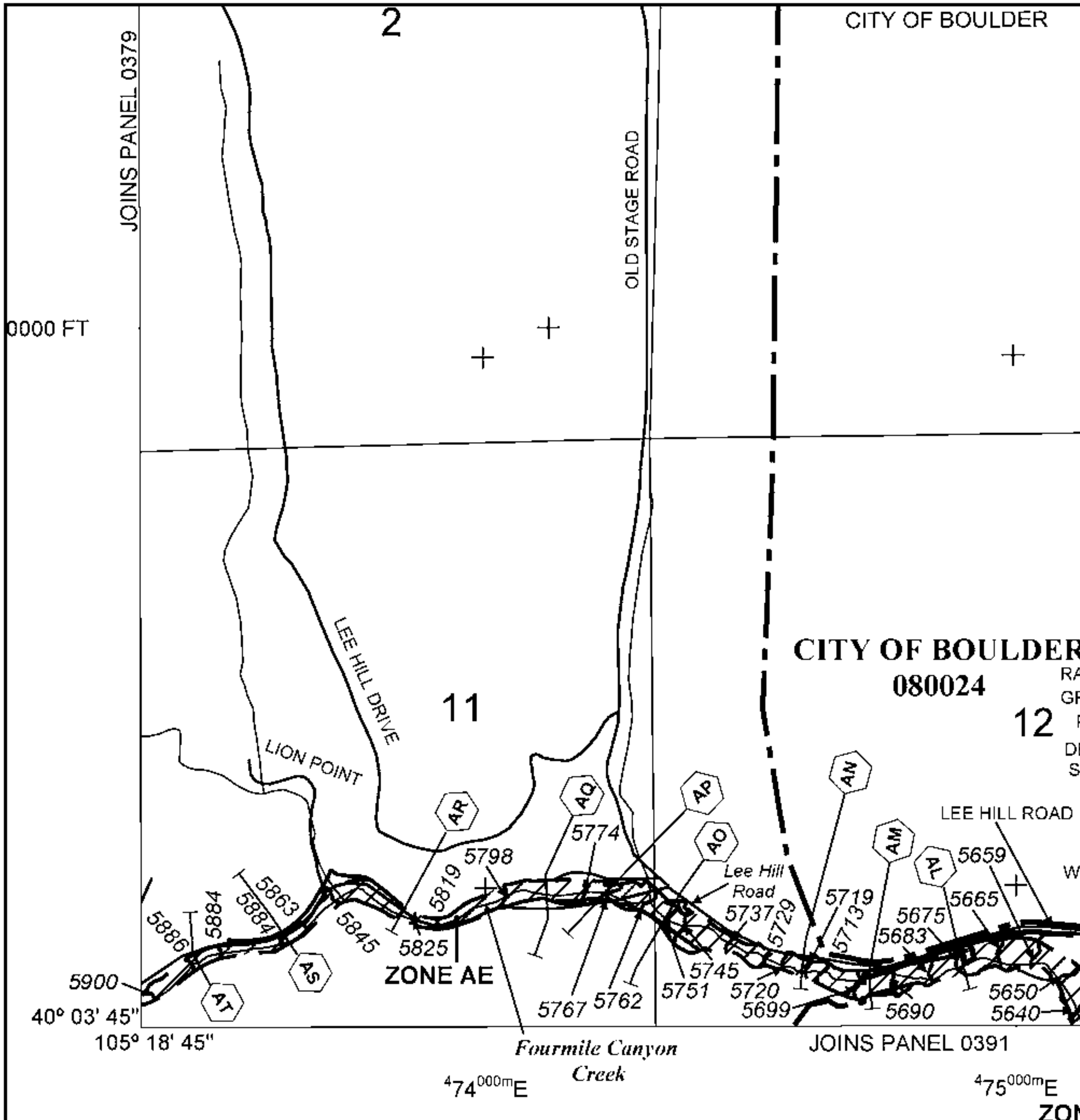
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
08013C0379J

MAP REVISED
DECEMBER 18, 2012

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0385J

FIRM

FLOOD INSURANCE RATE MAP

BOULDER COUNTY, COLORADO

AND INCORPORATED AREAS

PANEL 385 OF 615

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOULDER, CITY OF	080024	0385	J
BOULDER COUNTY	080023	0385	J

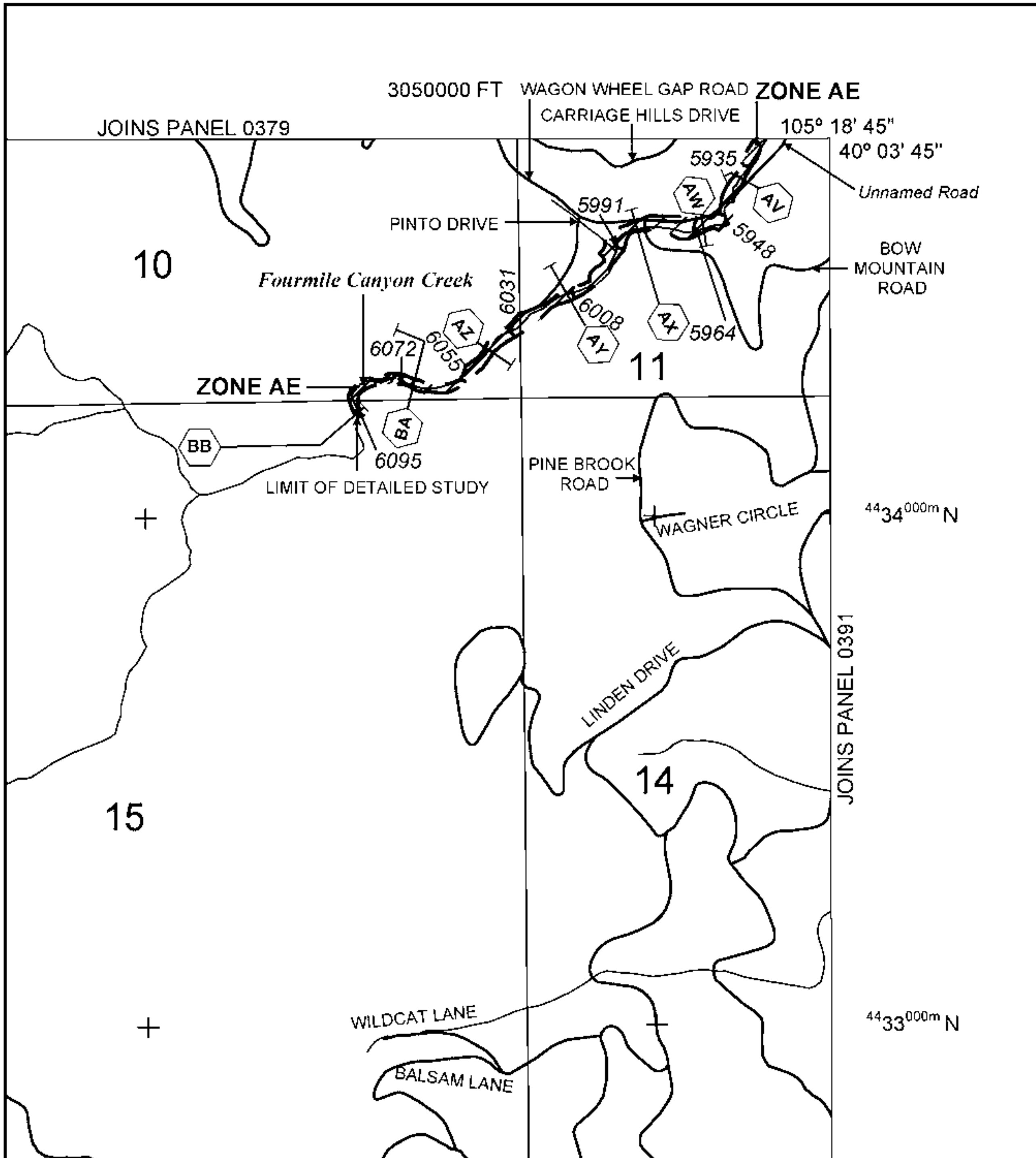
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
08013C0385J

MAP REVISED
DECEMBER 18, 2012

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METER

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0390J

FIRM

FLOOD INSURANCE RATE MAP

BOULDER COUNTY, COLORADO

AND INCORPORATED AREAS

PANEL 390 OF 615

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOULDER COUNTY	080023	0390	J

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

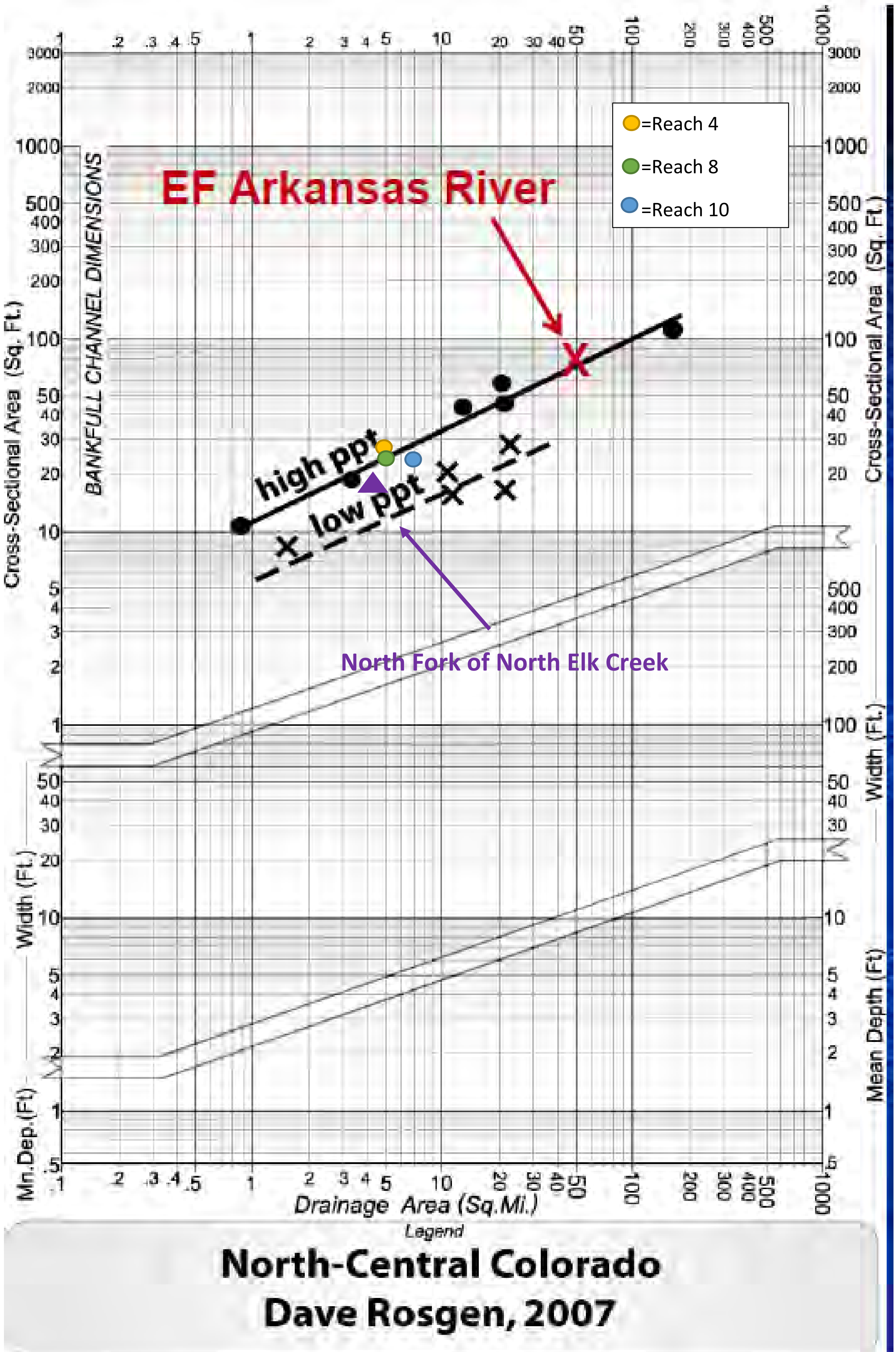
MAP NUMBER
08013C0390J

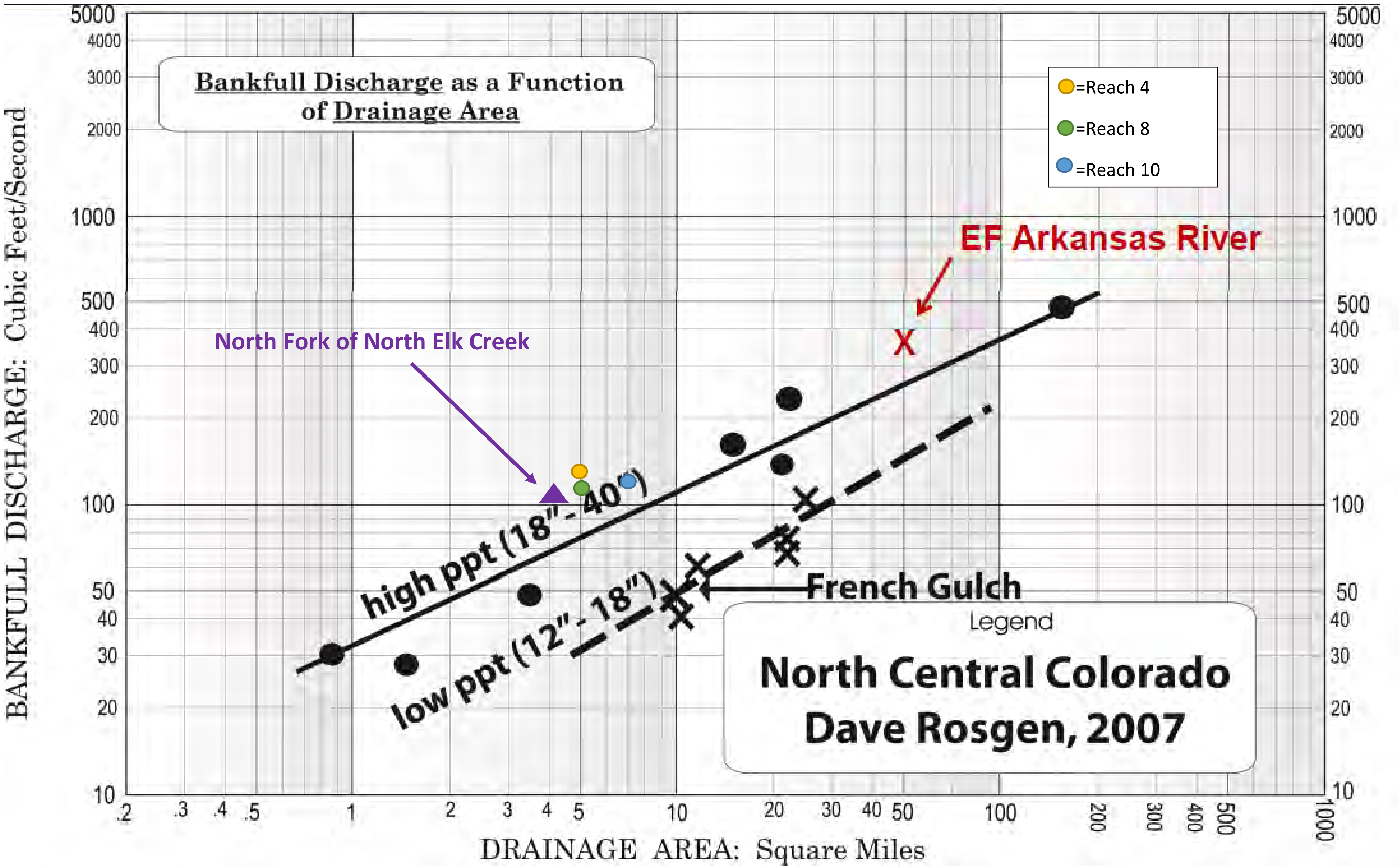
MAP REVISED
DECEMBER 18, 2012

Federal Emergency Management Agency

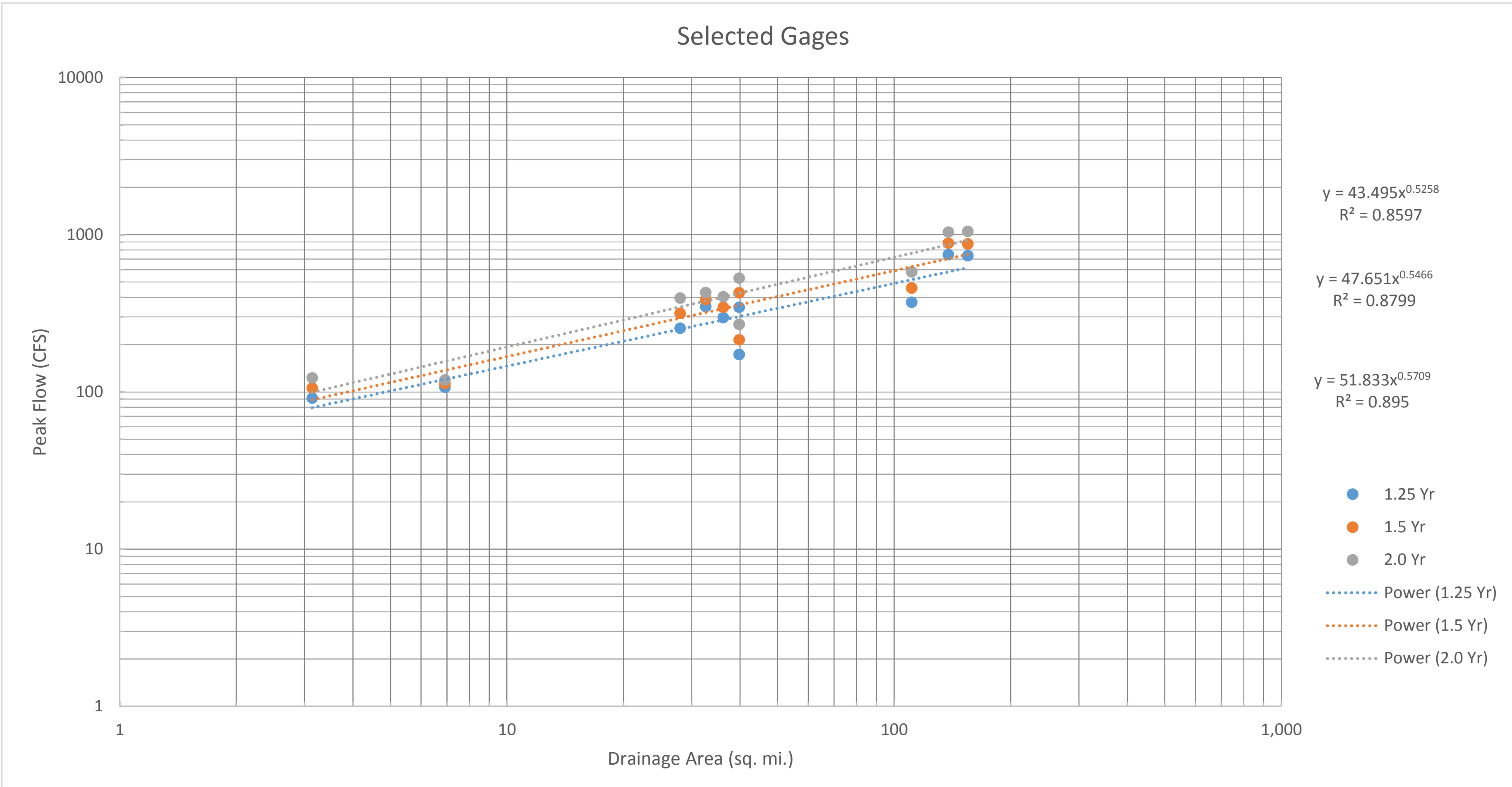
Regional Curves

Fourmile Canyon Creek Stream Survey Compared to Regional Curves

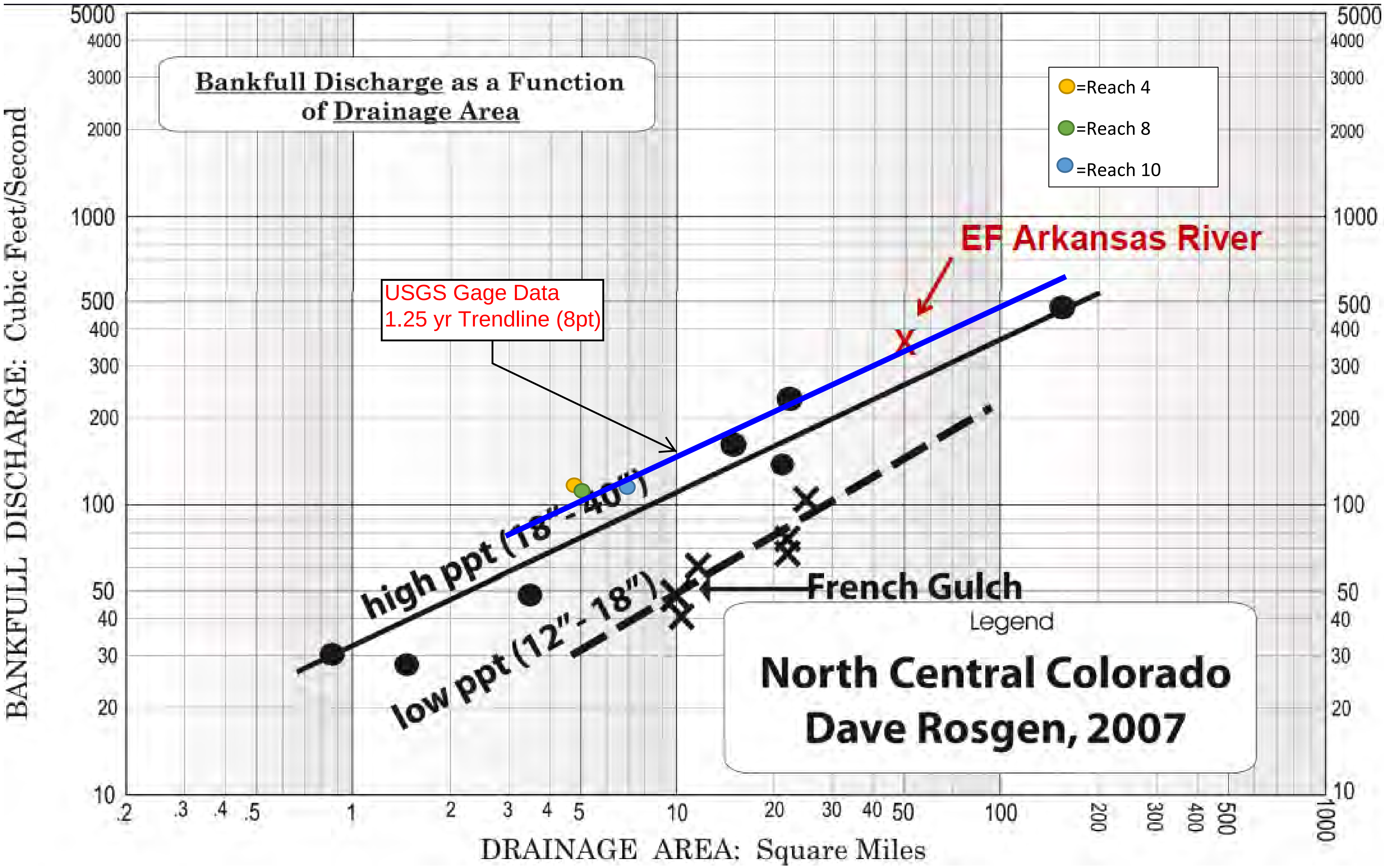



Bankfull Discharge as a Function of Drainage Area
=Reach 4
=Reach 8
=Reach 10
EF Arkansas River
North Fork of North Elk Creek
high ppt (18"- 40")
low ppt (12"- 18")
French Gulch
Legend
North Central Colorado
Dave Rosgen, 2007
BANKFULL DISCHARGE: Cubic Feet/Second
DRAINAGE AREA: Square Miles

Statistical Analysis of USGS Gage Data



Selected Gages
10000
1000
100
10
1
Peak Flow (CFS)
1
10
100
1,000
Drainage Area (sq. mi.)
y = 43.495x^0.5258
R² = 0.8597
y = 47.651x^0.5466
R² = 0.8799
y = 51.833x^0.5709
R² = 0.895
1.25 Yr
1.5 Yr
2.0 Yr
Power (1.25 Yr)
Power (1.5 Yr)
Power (2.0 Yr)


Bankfull Discharge as a Function of Drainage Area
=Reach 4
=Reach 8
=Reach 10
EF Arkansas River
USGS Gage Data
1.25 yr Trendline (8pt)
high ppt (18"-40")
low ppt (12"-18")
French Gulch
Legend
North Central Colorado
Dave Rosgen, 2007
BANKFULL DISCHARGE: Cubic Feet/Second
DRAINAGE AREA: Square Miles

Hydraulic Modeling Results

Hydraulic Analysis Report

Project Data

Project Title: Project - FMCC

Designer:

Project Date: Wednesday, January 06, 2016

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Reach 8

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
0.00	4.90	0.0500
0.50	2.90	0.0500
3.50	2.70	0.0500
6.80	1.70	0.0500
9.50	1.60	0.0500
10.50	1.00	0.0500
14.25	0.80	0.0500
18.00	1.00	0.0500
19.00	1.60	0.0500
21.70	1.70	0.0500
25.00	2.70	0.0500
28.00	2.90	0.0500
28.50	4.90	-----

Longitudinal Slope: 0.0650 ft/ft

Depth: 1.9000 ft

Result Parameters

Flow: 209.1005 cfs

Area of Flow: 25.2700 ft^2

Wetted Perimeter: 22.1431 ft

Hydraulic Radius: 1.1412 ft

Average Velocity: 8.2747 ft/s

Top Width: 21.5000 ft

Froude Number: 1.3451

Critical Depth: 2.2191 ft

Critical Velocity: 6.2514 ft/s

Critical Slope: 0.0356 ft/ft

Critical Top Width: 27.56 ft

Calculated Max Shear Stress: 7.7064 lb/ft^2

Calculated Avg Shear Stress: 4.6288 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0500

Channel Analysis: Reach 9B

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
0.00	4.90	0.0500
0.50	2.90	0.0500
3.50	2.70	0.0500
6.80	1.70	0.0500
9.50	1.60	0.0500
10.50	1.00	0.0500
14.25	0.80	0.0500
18.00	1.00	0.0500
19.00	1.60	0.0500
21.70	1.70	0.0500
25.00	2.70	0.0500
28.00	2.90	0.0500
28.50	4.90	-----

Longitudinal Slope: 0.0600 ft/ft

Depth: 1.9000 ft

Result Parameters

Flow: 200.8972 cfs

Area of Flow: 25.2700 ft^2

Wetted Perimeter: 22.1431 ft

Hydraulic Radius: 1.1412 ft

Average Velocity: 7.9500 ft/s

Top Width: 21.5000 ft

Froude Number: 1.2923

Critical Depth: 2.1869 ft

Critical Velocity: 6.1698 ft/s

Critical Slope: 0.0358 ft/ft

Critical Top Width: 27.54 ft

Calculated Max Shear Stress: 7.1136 lb/ft^2

Calculated Avg Shear Stress: 4.2727 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0500

Channel Analysis: Pool-1

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
0.00	3.30	0.0500
9.35	2.20	0.0500
11.40	1.00	0.0500
15.15	1.00	0.0500
18.90	1.00	0.0500
21.30	2.20	0.0500
23.50	3.30	-----

Longitudinal Slope: 0.0550 ft/ft

Depth: 2.3000 ft

Result Parameters

Flow: 255.5157 cfs

Area of Flow: 31.1675 ft^2

Wetted Perimeter: 24.4328 ft

Hydraulic Radius: 1.2756 ft

Average Velocity: 8.1981 ft/s

Top Width: 23.5000 ft

Froude Number: 1.2545

Critical Depth: 2.5164 ft

Critical Velocity: 7.0480 ft/s

Critical Slope: 0.0332 ft/ft

Critical Top Width: 23.50 ft

Calculated Max Shear Stress: 7.8936 lb/ft^2

Calculated Avg Shear Stress: 4.3780 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0500

Channel Analysis: Pool-2

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
0.00	3.60	0.0500
11.97	2.20	0.0500
14.70	1.00	0.0500
18.45	1.00	0.0500
22.20	1.00	0.0500
22.80	2.20	0.0500
23.50	3.60	-----

Longitudinal Slope: 0.0550 ft/ft

Depth: 2.6000 ft

Result Parameters

Flow: 302.2328 cfs

Area of Flow: 35.0329 ft^2

Wetted Perimeter: 25.4403 ft

Hydraulic Radius: 1.3771 ft

Average Velocity: 8.6271 ft/s

Top Width: 23.5000 ft

Froude Number: 1.2452

Critical Depth: 2.8347 ft

Critical Velocity: 7.4538 ft/s

Critical Slope: 0.0338 ft/ft

Critical Top Width: 23.50 ft

Calculated Max Shear Stress: 8.9232 lb/ft^2

Calculated Avg Shear Stress: 4.7261 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0500

Channel Analysis: Pool-3

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
0.00	3.30	0.0500
12.12	2.20	0.0500
14.85	1.00	0.0500
18.60	1.00	0.0500
22.35	1.00	0.0500
22.95	2.20	0.0500
23.50	3.30	-----

Longitudinal Slope: 0.0550 ft/ft

Depth: 2.3000 ft

Result Parameters

Flow: 233.2042 cfs

Area of Flow: 29.8829 ft^2

Wetted Perimeter: 25.2231 ft

Hydraulic Radius: 1.1847 ft

Average Velocity: 7.8039 ft/s

Top Width: 23.5000 ft

Froude Number: 1.2196

Critical Depth: 2.4799 ft

Critical Velocity: 6.8366 ft/s

Critical Slope: 0.0354 ft/ft

Critical Top Width: 23.50 ft

Calculated Max Shear Stress: 7.8936 lb/ft^2

Calculated Avg Shear Stress: 4.0660 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.0500

Client: Boulder County
Project: Fourmile Canyon Creek Stream Restoration
Description: **LPSTP Toe Protection for Bankfull Flow in Pool-1 at Maximum Velocity**

By: SMA
Date: 31-Dec-15

METHOD 1 - CORPS OF ENGINEERS

SOURCE: *U.S. Army Corps of Engineers. 1994. Hydraulic Design of Flood Control Channels. EM 1110-2-1601, Change 1. June 30.*
Revetment Method (Recommended for slopes < 2%)

INPUT DATA

y = 2.3 Depth of Flow
Sf = 1.1 Safety Factor
Cs = 0.3 Stability Coefficient (0.3 for angular rock, 0.375 for rounded)

Calculate Cv for channel bend:
Rc = 50 radius of curvature (ft From design pattern min
T = 23.5 Topwidth (ft) Bankfull
Cv = 1.22 Velocity Distribution Coeff. (Use 1.0 for Rc/T > 26)
Ct = 4.5 Blanket Thickness Coefficient

Calculate design velocity (Vss) for channel bend:
Vavg = 8.198 Avg Channel Velocity U/S of Bend (ft/s)
Vss = 12.9 Design velocity (bank area of bend in natural channel)

Theta = 76 Bank Angle in Degrees *Measured on outside of pool cross section from toe*
Phi = 90 Angle of repose (degrees) of riprap material (normally 40 degrees)
Sg = 2.65 Rock Specific Gravity
g = 32.2 Gravity

COMPUTED DATA

K1 = 0.24 Side slope correction factor
D30 = 35.8 ft
D50 = 43.0 ft

Max D50 = 43.0 ft

METHOD 2 - UDFCD/SPRINGS

SOURCE: *Urban Storm Drainage Criteria Manual, Vol. 2*
Uban Drainage and Flood Control District, Denver, Colorado
Rev. April 2008

City of Colorado Springs/El Paso County Drainage Criteria Manual
12-Oct-94

INPUT DATA

V = 8.198 Mean channel flow velocity (ft/s) 0

Adjust Velocity for Bend (UDFCD EQ. MD-10, pg MD-47). No Adjustment for Rc/T > 8.
Rc = 50 radius of curvature (ft From design pattern min
T = 23.5 Topwidth (ft) Bankfull
Va = 15 Velocity adjusted for bend (ft/s)

S = 0.055 Channel slope (ft/ft) from proposed grading
S_s = 2.65 Rock specific gravity

COMPUTED DATA

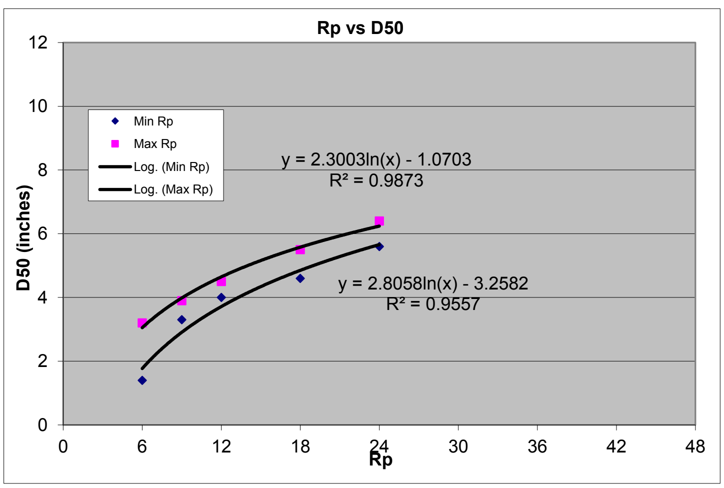
Class/Type
R_p = 6.7
Riprap **D50 (ft) = >2.0!!! !NA!**
Boulder **D50 (ft) = 2.50 B30**

Values in UDFCD Manual

Extrapolated from UDFCD Values
(See Curves Below)

Min Rp	Max Rp	Riprap Type	D50 (inches)
1.4	3.2	VL	6
3.3	3.9	L	9
4	4.5	M	12
4.6	5.5	H	18
5.6	6.4	VH	24
6.3	6.8		30
6.8	7.2		36
7.2	7.5		42
7.6	7.8		48
7.9	8.1		54
8.2	8.3		60

Min Rp	Max Rp	Boulder Class	D50 (inches)
4.6	5.5	B18	18
5.6	6.4	B24	24
6.5	7.1	B30	30
7.2	7.8	B36	36
7.9	8.4	B42	42
8.5	9.0	B48	48



Client: Boulder County
Project: Fourmile Canyon Creek Stream Restoration
Description: **LPSTP Toe Protection for Bankfull Flow in Pool-2 at Maximum Velocity**

By: SMA
Date: 31-Dec-15

METHOD 1 - CORPS OF ENGINEERS

SOURCE: *U.S. Army Corps of Engineers. 1994. Hydraulic Design of Flood Control Channels. EM 1110-2-1601, Change 1. June 30.*
Revetment Method (Recommended for slopes < 2%)

INPUT DATA

y = 2.6 Depth of Flow
Sf = 1.1 Safety Factor
Cs = 0.3 Stability Coefficient (0.3 for angular rock, 0.375 for rounded)

Calculate Cv for channel bend:
Rc = 50 radius of curvature (ft From design pattern min
T = 23.5 Topwidth (ft) Bankfull
Cv = 1.22 Velocity Distribution Coeff. (Use 1.0 for Rc/T > 26)
Ct = 4.5 Blanket Thickness Coefficient

Calculate design velocity (Vss) for channel bend:
Vavg = 8.627 Avg Channel Velocity U/S of Bend (ft/s)
Vss = 13.5 Design velocity (bank area of bend in natural channel)

Theta = 76 Bank Angle in Degrees *Measured on outside of pool cross section from toe*
Phi = 90 Angle of repose (degrees) of riprap material (normally 40 degrees)
Sg = 2.65 Rock Specific Gravity
g = 32.2 Gravity

COMPUTED DATA

K1 = 0.24 Side slope correction factor
D30 = 39.5 ft
D50 = 47.4 ft

Max D50 = 47.4 ft

METHOD 2 - UDFCD/SPRINGS

SOURCE: *Urban Storm Drainage Criteria Manual, Vol. 2*
Uban Drainage and Flood Control District, Denver, Colorado
Rev. April 2008

City of Colorado Springs/El Paso County Drainage Criteria Manual
12-Oct-94

INPUT DATA

V = 8.627 Mean channel flow velocity (ft/s) 0

Adjust Velocity for Bend (UDFCD EQ. MD-10, pg MD-47). No Adjustment for Rc/T > 8.
Rc = 50 radius of curvature (ft From design pattern min
T = 23.5 Topwidth (ft) Bankfull
Va = 16 Velocity adjusted for bend (ft/s)

S = 0.055 Channel slope (ft/ft) from proposed grading
S_s = 2.65 Rock specific gravity

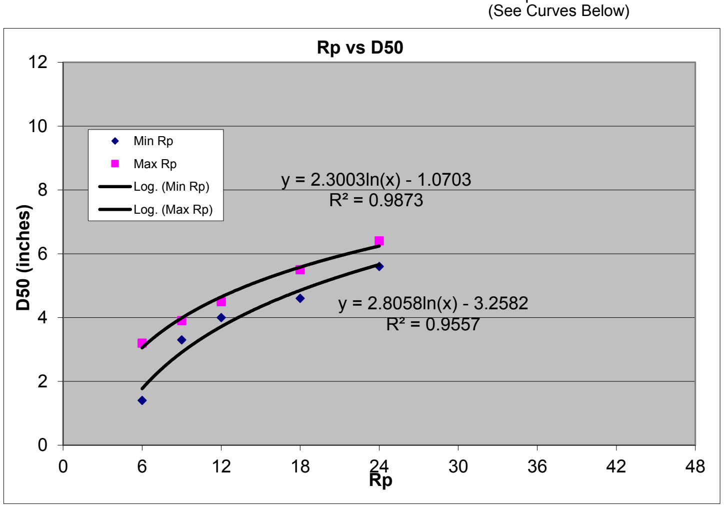
COMPUTED DATA

Class/Type
R_p = 7.1
Riprap **D50 (ft) = >2.0!!! !NA!**
Boulder **D50 (ft) = 2.50 B30**

Values in UDFCD Manual (first five rows); Extrapolated from UDFCD Values (See Curves Below) (remaining rows)

Min Rp	Max Rp	Riprap Type	D50 (inches)
1.4	3.2	VL	6
3.3	3.9	L	9
4	4.5	M	12
4.6	5.5	H	18
5.6	6.4	VH	24
6.3	6.8		30
6.8	7.2		36
7.2	7.5		42
7.6	7.8		48
7.9	8.1		54
8.2	8.3		60

Min Rp	Max Rp	Boulder Class	D50 (inches)
4.6	5.5	B18	18
5.6	6.4	B24	24
6.5	7.1	B30	30
7.2	7.8	B36	36
7.9	8.4	B42	42
8.5	9.0	B48	48



Client: Boulder County
Project: Fourmile Canyon Creek Stream Restoration
Description: **LPSTP Toe Protection for Bankfull Flow in Pool-3 at Maximum Velocity**

By: SMA
Date: 31-Dec-15

METHOD 1 - CORPS OF ENGINEERS

SOURCE: *U.S. Army Corps of Engineers. 1994. Hydraulic Design of Flood Control Channels. EM 1110-2-1601, Change 1. June 30.*
Revetment Method (Recommended for slopes < 2%)

INPUT DATA

y = 2.3 Depth of Flow
Sf = 1.1 Safety Factor
Cs = 0.3 Stability Coefficient (0.3 for angular rock, 0.375 for rounded)

Calculate Cv for channel bend:
Rc = 50 radius of curvature (ft From design pattern min
T = 23.5 Topwidth (ft) Bankfull
Cv = 1.22 Velocity Distribution Coeff. (Use 1.0 for Rc/T > 26)
Ct = 4.5 Blanket Thickness Coefficient

Calculate design velocity (Vss) for channel bend:
Vavg = 7.894 Avg Channel Velocity U/S of Bend (ft/s)
Vss = 12.4 Design velocity (bank area of bend in natural channel)

Theta = 76 Bank Angle in Degrees *Measured on outside of pool cross section from toe*
Phi = 90 Angle of repose (degrees) of riprap material (normally 40 degrees)
Sg = 2.65 Rock Specific Gravity
g = 32.2 Gravity

COMPUTED DATA

K1 = 0.24 Side slope correction factor
D30 = 32.6 ft
D50 = 39.1 ft

Max D50 = 39.1 ft

METHOD 2 - UDFCD/SPRINGS

SOURCE: *Urban Storm Drainage Criteria Manual, Vol. 2*
Uban Drainage and Flood Control District, Denver, Colorado
Rev. April 2008

City of Colorado Springs/El Paso County Drainage Criteria Manual
12-Oct-94

INPUT DATA

V = 7.894 Mean channel flow velocity (ft/s) 0

Adjust Velocity for Bend (UDFCD EQ. MD-10, pg MD-47). No Adjustment for Rc/T > 8.
Rc = 50 radius of curvature (ft From design pattern min
T = 23.5 Topwidth (ft) Bankfull
Va = 15 Velocity adjusted for bend (ft/s)

S = 0.055 Channel slope (ft/ft) from proposed grading
S_s = 2.65 Rock specific gravity

COMPUTED DATA

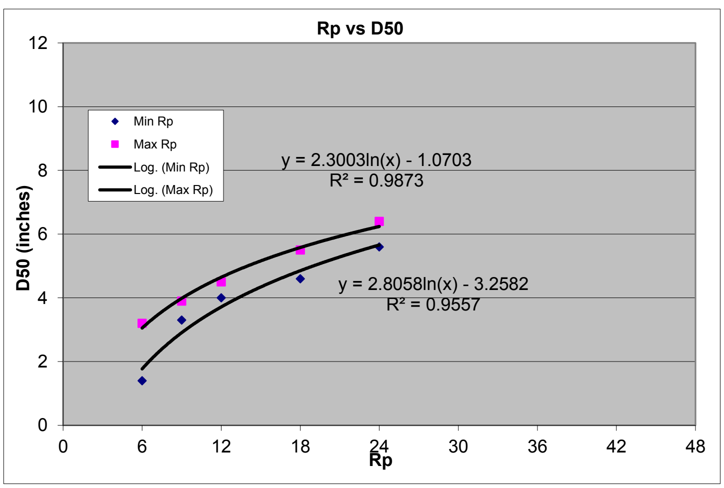
Class/Type
R_p = 6.5
Riprap **D50 (ft) = >2.0!!! !NA!**
Boulder **D50 (ft) = 2.50 B30**

Values in UDFCD Manual

Min Rp	Max Rp	Riprap Type	D50 (inches)
1.4	3.2	VL	6
3.3	3.9	L	9
4	4.5	M	12
4.6	5.5	H	18
5.6	6.4	VH	24
6.3	6.8		30
6.8	7.2		36
7.2	7.5		42
7.6	7.8		48
7.9	8.1		54
8.2	8.3		60

Extrapolated from UDFCD Values (See Curves Below)

Min Rp	Max Rp	Boulder Class	D50 (inches)
4.6	5.5	B18	18
5.6	6.4	B24	24
6.5	7.1	B30	30
7.2	7.8	B36	36
7.9	8.4	B42	42
8.5	9.0	B48	48



Client:	Boulder County	By:	SMA
Project:	Fourmile Canyon Creek Stream Restoration	Date:	31-Dec-15
Description:	**LPSTP Toe Protection for Bankfull Flow in Riffle at Maximum Velocity Upstream of Lion Point**		

METHOD 1 - CORPS OF ENGINEERS

SOURCE: *U.S. Army Corps of Engineers. 1994. Hydraulic Design of Flood Control Channels. EM 1110-2-1601, Change 1. June 30.*
Revetment Method (Recommended for slopes < 2%)

INPUT DATA

y =	1.9	Depth of Flow
Sf =	1.1	Safety Factor
Cs =	0.3	Stability Coefficient (0.3 for angular rock, 0.375 for rounded)
Cv =	1	Velocity Distribution Coeff.
Ct =	4.5	Blanket Thickness Coefficient
Vdes =	8.275	Design Velocity
Theta =	23	Bank Angle in Degrees
Sg =	2.65	Rock Specific Gravity
g =	32.2	Gravity

COMPUTED DATA

K1 =	0.93	Side slope correction factor
D30 =	1.9	ft
D50 =	**2.3**	**ft**

METHOD 2 - UDFCD/SPRINGS

SOURCE: *Urban Storm Drainage Criteria Manual, Vol. 2*
Uban Drainage and Flood Control District, Denver, Colorado
Rev. April 2008

City of Colorado Springs/El Paso County Drainage Criteria Manual
12-Oct-94

INPUT DATA

V =	8.275	Mean channel flow velocity (ft/s)
S =	0.065	Channel slope (ft/ft)
S_s =	2.65	Rock specific gravity

COMPUTED DATA

R_p =	3.7	
D50 =	**0.75**	**ft**

Rp	**Riprap Type**	**D50 (inches)**
1.4 to 3.2	VL	6
3.3 to 3.9	L	9
4.0 to 4.5	M	12
4.6 to 5.5	H	18
5.6 to 6.4	VH	24

Client:	Boulder County	By:	SMA
Project:	Fourmile Canyon Creek Stream Restoration	Date:	31-Dec-15
Description:	**LPSTP Toe Protection for Bankfull Flow in Riffle at Maximum Velocity Downstream of Lion Point**		

METHOD 1 - CORPS OF ENGINEERS

SOURCE: *U.S. Army Corps of Engineers. 1994. Hydraulic Design of Flood Control Channels. EM 1110-2-1601, Change 1. June 30.*
Revetment Method (Recommended for slopes < 2%)

INPUT DATA

y =	1.9	Depth of Flow
Sf =	1.1	Safety Factor
Cs =	0.3	Stability Coefficient (0.3 for angular rock, 0.375 for rounded)
Cv =	1	Velocity Distribution Coeff.
Ct =	4.5	Blanket Thickness Coefficient
Vdes =	8.275	Design Velocity
Theta =	23	Bank Angle in Degrees
Sg =	2.65	Rock Specific Gravity
g =	32.2	Gravity

COMPUTED DATA

K1 =	0.93	Side slope correction factor
D30 =	1.9	ft
D50 =	**2.3**	**ft**

METHOD 2 - UDFCD/SPRINGS

SOURCE: *Urban Storm Drainage Criteria Manual, Vol. 2*
Uban Drainage and Flood Control District, Denver, Colorado
Rev. April 2008

City of Colorado Springs/El Paso County Drainage Criteria Manual
12-Oct-94

INPUT DATA

V =	7.95	Mean channel flow velocity (ft/s)
S =	0.065	Channel slope (ft/ft)
S_s =	2.65	Rock specific gravity

COMPUTED DATA

R_p =	3.6	
D50 =	**0.75**	**ft**

Rp	**Riprap Type**	**D50 (inches)**
1.4 to 3.2	VL	6
3.3 to 3.9	L	9
4.0 to 4.5	M	12
4.6 to 5.5	H	18
5.6 to 6.4	VH	24

MAYNORD METHOD FOR CHANNEL SCOUR AT A BEND

Ref: HEC-23 Page 4.10, method assumes bank is protected and that erosion potential will be directed at invert.

100-yr Flow (subcritical flow condition)

D_{mnc}	1.2	ft	cross section area/topwidth upstream of bend	*Reach 8 Pool*
R_c	45	ft	centerline radius of bend	*From Proposed Alignm*
W	23.5	ft	topwidth in bend	*Reach 8 Pool*
D	2	ft	Flow depth in bend without scour	*Reach 8 Pool*

D_{mxb}	2.2	ft	Water depth at max scour
Ds	0.2	ft	Scour depth (below existing invert)
Ds X 2	0.5	ft	Scour depth (below existing invert) including recommended SF of 2

MAYNORD METHOD FOR CHANNEL SCOUR AT A BEND

Ref: HEC-23 Page 4.10, method assumes bank is protected and that erosion potential will be directed at invert.

100-yr Flow (subcritical flow condition)

D_{mnc}	1.2	ft	cross section area/topwidth upstream of bend	*Reach 8 Pool*
R_c	75	ft	centerline radius of bend	*From Proposed Alignm*
W	23.5	ft	topwidth in bend	*Reach 8 Pool*
D	2	ft	Flow depth in bend without scour	*Reach 8 Pool*

D_{mxb}	2.2	ft	Water depth at max scour
Ds	0.2	ft	Scour depth (below existing invert)
Ds X 2	0.3	ft	Scour depth (below existing invert) including recommended SF of 2

MAYNORD METHOD FOR CHANNEL SCOUR AT A BEND

Ref: HEC-23 Page 4.10, method assumes bank is protected and that erosion potential will be directed at invert.

100-yr Flow (subcritical flow condition)

D_{mnc}	1.4	ft	cross section area/topwidth upstream of bend	*Reach 9 Pool*
R_c	45	ft	centerline radius of bend	*From Proposed Alignm*
W	25	ft	topwidth in bend	*Reach 9 Pool*
D	2.4	ft	Flow depth in bend without scour	*Reach 9 Pool*

D_{mxb}	2.6	ft	Water depth at max scour
Ds	0.2	ft	Scour depth (below existing invert)
Ds X 2	0.3	ft	Scour depth (below existing invert) including recommended SF of 2

MAYNORD METHOD FOR CHANNEL SCOUR AT A BEND

Ref: HEC-23 Page 4.10, method assumes bank is protected and that erosion potential will be directed at invert.

100-yr Flow (subcritical flow condition)

D_{mnc}	1.4	ft	cross section area/topwidth upstream of bend	*Reach 9 Pool*
R_c	75	ft	centerline radius of bend	*From Proposed Alignm*
W	25	ft	topwidth in bend	*Reach 9 Pool*
D	2.4	ft	Flow depth in bend without scour	*Reach 9 Pool*

D_{mxb}	2.5	ft	Water depth at max scour
Ds	0.1	ft	Scour depth (below existing invert)
Ds X 2	0.2	ft	Scour depth (below existing invert) including recommended SF of 2

Sediment Transport Modeling Results

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Fourmile Canyon Creek**	Location:	**Reach - Reach 1**
Date:	Stream Type: **C4**	Valley Type:	**VIII**
Observers:		HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	25.27	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	1.18	d_{bkf} (ft)
Bankfull Riffle WIDTH	21.50	W_{bkf} (ft)	Wetted PERIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	22.14	W_p (ft)
D_{84} at Riffle	90.00	Dia. (mm)	D_{84} (mm) / 304.8	0.30	D_{84} (ft)
Bankfull SLOPE	0.0430	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.14	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	3.86	R / D_{84}
Drainage Area	4.5	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	1.256	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * \text{Log} \{R / D_{84}\}] u^*$	7.74	ft / sec	195.48	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0.04	8.42	ft / sec	212.67	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0.04	8.42	ft / sec	212.67	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2}/n$ $n = 0.39*S^{0.38}*R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for $n =$ 0.116	2.92	ft / sec	73.66	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	8.03	ft / sec	202.97	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Chezy C**	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$ **Return Period for Bankfull Discharge** Q = 0.0 **year**	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Fourmile Canyon Creek**		Location:	**Reach - Reach 2**	
Date:		Stream Type: **B4**	Valley Type:	**VIII**	
Observers:			HUC:		

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	25.27	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	1.18	d_{bkf} (ft)
Bankfull Riffle WIDTH	21.50	W_{bkf} (ft)	Wetted PERIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	22.14	W_p (ft)
D_{84} at Riffle	90.00	Dia. (mm)	D_{84} (mm) / 304.8	0.30	D_{84} (ft)
Bankfull SLOPE	0.0500	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.14	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	3.97	R / D_{84}
Drainage Area	4.5	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	1.355	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * \text{Log}\{R / D_{84}\}] u^*$	8.34	ft / sec	210.79	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2}/n$; $n =$ 0.057	6.37	ft / sec	160.95	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2}/n$; $n =$ 0.057	6.37	ft / sec	160.95	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2}/n$; $n = 0.39*S^{0.38}*R^{-0.16}$; **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for $n =$ 0.122	2.97	ft / sec	75.00	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	8.66	ft / sec	218.87	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Chezy C**	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves **u = Q / A** ; **Return Period for Bankfull Discharge** **Q =** 0.0 **year**	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data **u = Q / A**	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Fourmile Canyon Creek**	Location:	**Reach - Reach 3**
Date:	Stream Type: **B4**	Valley Type:	**VIII**
Observers:		HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**24.93**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**1.25**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**20.00**	W_{bkf} (ft)	Wetted PERIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**21.03**	W_p (ft)
D_{84} at Riffle	**90.00**	Dia. (mm)	D_{84} (mm) / 304.8	**0.30**	D_{84} (ft)
Bankfull SLOPE	**0.0440**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**1.19**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**3.97**	R / D_{84}
Drainage Area	**4.9**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	**1.298**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**8.10**	ft / sec	**201.82**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.057**	**6.13**	ft / sec	**152.75**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.057**	**6.13**	ft / sec	**152.75**	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n = 0.39 * S^{0.38} * R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for $n =$ **0.116**	**3.02**	ft / sec	**75.19**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	**8.55**	ft / sec	**213.25**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Chezy C**	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$ **Return Period for Bankfull Discharge** Q = **0.0** **year**	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$	**0.00**	ft / sec	**0.00**	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Fourmile Canyon Creek**		Location:	**Reach - Reach 4**	
Date:		Stream Type: **B4**	Valley Type:	**VIII**	
Observers:			HUC:		

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**24.93**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**1.25**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**20.00**	W_{bkf} (ft)	Wetted PERIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**21.03**	W_p (ft)
D_{84} at Riffle	**90.00**	Dia. (mm)	D_{84} (mm) / 304.8	**0.30**	D_{84} (ft)
Bankfull SLOPE	**0.0440**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**1.19**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**4.03**	R / D_{84}
Drainage Area	**4.9**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	**1.298**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**8.10**	ft / sec	**201.82**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.057**	**6.13**	ft / sec	**152.75**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.057**	**6.13**	ft / sec	**152.75**	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n = 0.39 * S^{0.38} * R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for $n =$ **0.116**	**3.02**	ft / sec	**75.19**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	**8.55**	ft / sec	**213.25**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Chezy C**	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$ **Return Period for Bankfull Discharge** Q = **0.0** **year**	**0.00**	ft / sec	**0.00**	cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$	**0.00**	ft / sec	**0.00**	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	Fourmile Canyon Creek			Location:	Reach - Reach 5
Date:		Stream Type:	B4	Valley Type:	VIII
Observers:				HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	24.93	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	1.25	d_{bkf} (ft)
Bankfull Riffle WIDTH	20.00	W_{bkf} (ft)	Wetted PERIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	21.03	W_p (ft)
D_{84} at Riffle	90.00	Dia. (mm)	D_{84} (mm) / 304.8	0.30	D_{84} (ft)
Bankfull SLOPE	0.0430	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.19	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	3.97	R / D_{84}
Drainage Area	4.9	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	1.284	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	8.00	ft / sec	199.51	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0.057	6.06	ft / sec	151.00	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2}/n$ $n =$ 0.057	6.06	ft / sec	151.00	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2}/n$ $n = 0.39*S^{0.38}*R^{-0.16}$ Note: This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for $n =$ 0.115	3.01	ft / sec	74.99	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	8.46	ft / sec	210.81	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$ Return Period for Bankfull Discharge Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	Fourmile Canyon Creek	Location:	Reach - Reach 6
Date:		Stream Type: C4	Valley Type: VIII
Observers:		HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	25.27	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	1.18	d_{bkf} (ft)
Bankfull Riffle WIDTH	21.50	W_{bkf} (ft)	Wetted PERIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	22.14	W_p (ft)
D_{84} at Riffle	86.00	Dia. (mm)	D_{84} (mm) / 304.8	0.28	D_{84} (ft)
Bankfull SLOPE	0.0400	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.14	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	4.04	R / D_{84}
Drainage Area	4.9	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	1.212	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * \text{Log}\{R / D_{84}\}] u^*$	7.60	ft / sec	191.96	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49 * R^{2/3} * S^{1/2} / n$ n = 0.04	8.12	ft / sec	205.12	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49 * R^{2/3} * S^{1/2} / n$ n = 0.04	8.12	ft / sec	205.12	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n = 0.39 * S^{0.38} * R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for n = 0.112	2.89	ft / sec	73.01	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	7.89	ft / sec	199.29	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge** Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	Fourmile Canyon Creek	Location:	Reach - Reach 7
Date:		Stream Type: B4	Valley Type: VIII
Observers:		HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	24.93	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	1.25	d_{bkf} (ft)
Bankfull Riffle WIDTH	20.00	W_{bkf} (ft)	Wetted PERIMETER ~ (2 * d_{bkf}) + W_{bkf}	21.03	W_p (ft)
D_{84} at Riffle	90.00	Dia. (mm)	D_{84} (mm) / 304.8	0.30	D_{84} (ft)
Bankfull SLOPE	0.0470	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.19	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	3.97	R / D_{84}
Drainage Area	4.9	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	1.342	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	8.37	ft / sec	208.58	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3} *S^{1/2} / n$ *n* = 0.057	6.33	ft / sec	157.88	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3} *S^{1/2} / n$ *n* = 0.057	6.33	ft / sec	157.88	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3} *S^{1/2} / n$ $n = 0.39*S^{0.38} *R^{-0.16}$ Note: This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for *n* = 0.119	3.04	ft / sec	75.74	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	8.84	ft / sec	220.40	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves u = Q / A Return Period for Bankfull Discharge Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	Fourmile Canyon Creek	Location:	Reach - Reach 8
Date:	Stream Type: B4	Valley Type:	VIII
Observers:		HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	25.27	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	1.18	d_{bkf} (ft)
Bankfull Riffle WIDTH	21.50	W_{bkf} (ft)	Wetted PERIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	22.14	W_p (ft)
D_{84} at Riffle	86.00	Dia. (mm)	D_{84} (mm) / 304.8	0.28	D_{84} (ft)
Bankfull SLOPE	0.0420	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.14	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	4.04	R / D_{84}
Drainage Area	4.9	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	1.242	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	7.78	ft / sec	196.70	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2}/n$ *n* = 0.057	5.84	ft / sec	147.50	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2}/n$ *n* = 0.057	5.84	ft / sec	147.50	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2}/n$ $n = 0.39*S^{0.38}*R^{-0.16}$ Note: This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for *n* = 0.115	2.91	ft / sec	73.44	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	8.08	ft / sec	204.21	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves u = Q / A Return Period for Bankfull Discharge Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	Fourmile Canyon Creek	Location:	Reach - Reach 9
Date:	Stream Type: B4	Valley Type:	VIII
Observers:		HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	26.64	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	1.18	d_{bkf} (ft)
Bankfull Riffle WIDTH	22.50	W_{bkf} (ft)	Wetted PERIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	23.13	W_p (ft)
D_{84} at Riffle	90.00	Dia. (mm)	D_{84} (mm) / 304.8	0.30	D_{84} (ft)
Bankfull SLOPE	0.0430	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.15	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	3.90	R / D_{84}
Drainage Area	7.4	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	1.262	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * \text{Log}\{R / D_{84}\}] u^*$	7.80	ft / sec	207.76	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2} / n$ *n* = 0.057	5.94	ft / sec	158.30	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2} / n$ *n* = 0.057	5.94	ft / sec	158.30	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2} / n$; $n = 0.39*S^{0.38}*R^{-0.16}$ *n* = 0.115. Note: This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for	2.94	ft / sec	78.24	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	8.03	ft / sec	213.97	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves u = Q / A; Return Period for Bankfull Discharge Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrustion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	Fourmile Canyon Creek		Location:	Reach - Reach 10	
Date:		Stream Type: B4	Valley Type:	VIII	
Observers:			HUC:		

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	26.64	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	1.18	d_{bkf} (ft)
Bankfull Riffle WIDTH	22.50	W_{bkf} (ft)	Wetted PERIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	23.13	W_p (ft)
D_{84} at Riffle	86.00	Dia. (mm)	D_{84} (mm) / 304.8	0.28	D_{84} (ft)
Bankfull SLOPE	0.0380	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.15	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	4.08	R / D_{84}
Drainage Area	7.4	DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$	1.186	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	7.46	ft / sec	198.84	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ 0.057	5.59	ft / sec	148.81	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ 0.057	5.59	ft / sec	148.81	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2} / n$ $n = 0.39*S^{0.38}*R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for $n =$ 0.110	2.89	ft / sec	77.10	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	7.69	ft / sec	204.78	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Chezy C	0.00	ft / sec	0.00	cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge** Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrution heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**		Stream Type:	**C 4b**
Location:	**Reach 1**		Valley Type:	**VIII**
Observers:	**Lucas Babbitt**		Date:	**05/11/2015**

Enter Required Information for Existing Condition

41.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.791	D_{max}	Largest particle from bar sample (ft)	**241**	**(mm)**	304.8 mm/ft
0.04300	S	Existing bankfull water surface slope (ft/ft)			
1.18	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
5.88	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Sediment Competence Using Dimensional Shear Stress

3.166		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **259.1**	CO **354.8**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.954**	CO **1.871**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **1.10**	CO **0.70**	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope $\quad d = \frac{\tau}{\gamma S}$
Shields **0.0401**	CO **0.0254**	Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, d = existing depth $\quad S = \frac{\tau}{\gamma d}$

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**D4a**
Location:	**Reach 2**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**05/11/2015**

Enter Required Information for Existing Condition

41.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.791	D_{max}	Largest particle from bar sample (ft)	**241**	**(mm)**	304.8 mm/ft
0.05000	S	Existing bankfull water surface slope (ft/ft)			
1.18	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
5.88	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Sediment Competence Using Dimensional Shear Stress

3.682		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **303.2**	CO **396.5**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.954**	CO **1.871**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **0.95**	CO **0.60**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0401**	CO **0.0254**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**F 4b**
Location:	**Reach 3**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Enter Required Information for Existing Condition

41.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.791	D_{max}	Largest particle from bar sample (ft)	**241**	**(mm)**	304.8 mm/ft
0.04400	S	Existing bankfull water surface slope (ft/ft)			
1.25	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834 \, (D_{50}/\hat{D}_{50})^{-0.872}$
5.88	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384 \, (D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \dfrac{\tau^* (\gamma_s - 1) D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \dfrac{\tau^* (\gamma_s - 1) D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☑ Aggrading ☐ Degrading

Sediment Competence Using Dimensional Shear Stress

3.432		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **281.8**	CO **376.5**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.954**	CO **1.871**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **1.08**	CO **0.68**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \dfrac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0379**	CO **0.0240**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \dfrac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☐ Stable ☑ Aggrading ☐ Degrading

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**		Stream Type: **B 4**		
Location:	**Reach 4**		Valley Type: **XIII**		
Observers:	**Lucas Babbitt**		Date: **08/20/2015**		
Enter Required Information for Existing Condition					
41.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.791	D_{max}	Largest particle from bar sample (ft)	**241**	**(mm)**	304.8 mm/ft
0.04400	S	Existing bankfull water surface slope (ft/ft)			
1.25	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress					
0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1: $\tau^* = 0.0834 \, (D_{50}/\hat{D}_{50})^{-0.872}$		
5.88	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2: $\tau^* = 0.0384 \, (D_{max}/D_{50})^{-0.887}$		
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:		**N/A**
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample					
	d	Required bankfull mean depth (ft) $d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$ (use D_{max} in ft)			
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample					
	S	Required bankfull water surface slope (ft/ft) $S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$ (use D_{max} in ft)			
Check: ☑ Stable ☐ Aggrading ☐ Degrading					

Sediment Competence Using Dimensional Shear Stress		
3.432		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **281.8**	CO **376.5**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.954**	CO **1.871**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **1.08**	CO **0.68**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0379**	CO **0.0240**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth
Check: ☑ Stable ☐ Aggrading ☐ Degrading		

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	
Location:	**Reach 5**	Valley Type:	**VIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Enter Required Information for Existing Condition

41.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.791	D_{max}	Largest particle from bar sample (ft)	**241**	**(mm)**	304.8 mm/ft
0.04300	S	Existing bankfull water surface slope (ft/ft)			
1.25	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$	
5.88	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$	
	τ^*	Bankfull Dimensionless Shear Stress		EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☑ Stable ☐ Aggrading ☐ Degrading

Sediment Competence Using Dimensional Shear Stress

3.354		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **275.1**	CO **370.2**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.954**	CO **1.871**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **1.10**	CO **0.70**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0379**	CO **0.0240**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☑ Stable ☐ Aggrading ☐ Degrading

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**C4**
Location:	**Reach 6**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Enter Required Information for Existing Condition

39.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.764	D_{max}	Largest particle from bar sample (ft)	**233**	**(mm)**	304.8 mm/ft
0.04000	S	Existing bankfull water surface slope (ft/ft)			
1.18	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1: $\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
5.97	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2: $\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED: **N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft) $d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft) $S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☑ Aggrading ☐ Degrading

Sediment Competence Using Dimensional Shear Stress

Shields	CO	
2.945		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft²) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
240.3	**336.5**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
2.86	**1.787**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
1.15	**0.72**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
0.0388	**0.0243**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☐ Stable ☑ Aggrading ☐ Degrading

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**F 4b**
Location:	**Reach 7**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Enter Required Information for Existing Condition

41.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.791	D_{max}	Largest particle from bar sample (ft)	**241**	**(mm)**	304.8 mm/ft
0.04700	S	Existing bankfull water surface slope (ft/ft)			
1.23	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
5.88	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \frac{\tau^* (\gamma_s - 1) D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^* (\gamma_s - 1) D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Sediment Competence Using Dimensional Shear Stress

3.607		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **296.8**	CO **390.6**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.954**	CO **1.871**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **1.01**	CO **0.64**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0385**	CO **0.0244**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**		Stream Type: **C 4b**		
Location:	**Reach 8**		Valley Type: **XIII**		
Observers:	**Lucas Babbitt**		Date: **08/20/2015**		
Enter Required Information for Existing Condition					
39.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.764	D_{max}	Largest particle from bar sample (ft)	**233**	**(mm)**	304.8 mm/ft
0.04200	S	Existing bankfull water surface slope (ft/ft)			
1.18	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress				
0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1: $\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$	
5.97	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2: $\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$	
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample			
	d	Required bankfull mean depth (ft) $d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample			
	S	Required bankfull water surface slope (ft/ft) $S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)
Check: ☐ Stable ☐ Aggrading ☑ Degrading			

Sediment Competence Using Dimensional Shear Stress		
3.093		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope
Shields **252.8**	CO **348.8**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**
Shields **2.86**	CO **1.787**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**
Shields **1.09**	CO **0.68**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0388**	CO **0.0243**	Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth
Check: ☐ Stable ☐ Aggrading ☑ Degrading		

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**			Stream Type:	**E 4b**
Location:	**Reach 9**			Valley Type:	**XIII**
Observers:	**Lucas Babbitt**			Date:	**08/20/2015**
Enter Required Information for Existing Condition					
41.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.791	D_{max}	Largest particle from bar sample (ft)	**241**	**(mm)**	304.8 mm/ft
0.04300	S	Existing bankfull water surface slope (ft/ft)			
1.18	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress				
0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
5.88	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample				
	d	Required bankfull mean depth (ft)	$d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)
Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample				
	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)
Check: ☐ Stable ☐ Aggrading ☑ Degrading				

Sediment Competence Using Dimensional Shear Stress			
3.166		Bankfull shear stress $\tau = \gamma d S$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope	
Shields **259.1**	CO **354.8**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**	
Shields **2.954**	CO **1.871**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**	
Shields **1.10**	CO **0.70**	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope	$d = \frac{\tau}{\gamma S}$
Shields **0.0401**	CO **0.0254**	Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, d = existing depth	$S = \frac{\tau}{\gamma d}$
Check: ☐ Stable ☐ Aggrading ☑ Degrading			

Worksheet 3-14. Sediment competence calculation form to assess bed stability.

Stream:	**Fourmile Canyon Creek**	Stream Type:	**B 4**
Location:	**Reach 10**	Valley Type:	**XIII**
Observers:	**Lucas Babbitt**	Date:	**08/20/2015**

Enter Required Information for Existing Condition

39.0	D_{50}	Median particle size of riffle bed material (mm)			
0.0	$\hat{D}_{50}$	Median particle size of bar or sub-pavement sample (mm)			
0.764	D_{max}	Largest particle from bar sample (ft)	**233**	**(mm)**	304.8 mm/ft
0.03800	S	Existing bankfull water surface slope (ft/ft)			
1.18	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - \gamma / \gamma$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.00	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
5.97	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**N/A**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample

	d	Required bankfull mean depth (ft)	$d = \frac{\tau^*(\gamma_s - 1)D_{max}}{S}$	(use D_{max} in ft)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample

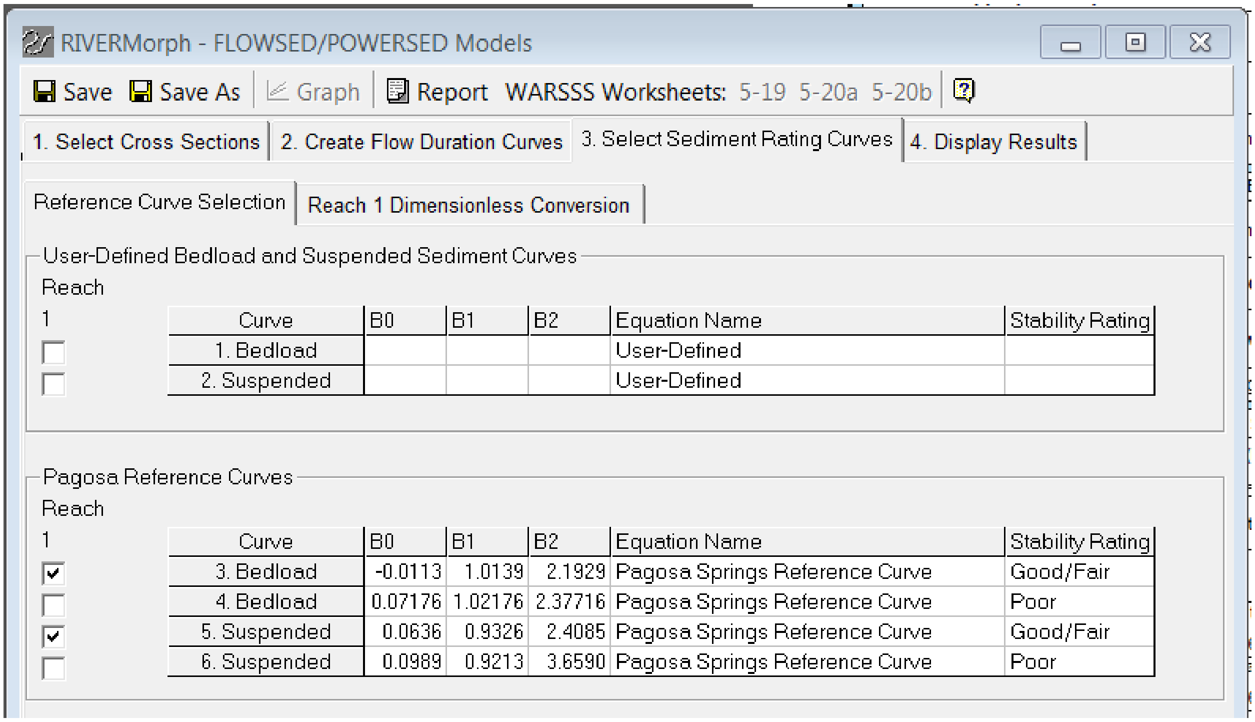
	S	Required bankfull water surface slope (ft/ft)	$S = \frac{\tau^*(\gamma_s - 1)D_{max}}{d}$	(use D_{max} in ft)

Check: ☐ Stable ☐ Aggrading ☑ Degrading

Sediment Competence Using Dimensional Shear Stress

2.798		Bankfull shear stress $\tau = \gamma dS$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d) γ = 62.4, d = existing depth, S = existing slope	
Shields **227.8**	CO **324**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 3-11)**	
Shields **2.86**	CO **1.787**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 3-11)**	
Shields **1.21**	CO **0.75**	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope	$d = \frac{\tau}{\gamma S}$
Shields **0.0388**	CO **0.0243**	Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, d = existing depth	$S = \frac{\tau}{\gamma d}$

Check: ☐ Stable ☐ Aggrading ☑ Degrading


RIVERMorph - FLOWSED/POWERSED Models
Save
Save As
Graph
Report
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Reference Curve Selection
Reach 1 Dimensionless Conversion
User-Defined Bedload and Suspended Sediment Curves
Reach
1
Curve | B0 | B1 | B2 | Equation Name | Stability Rating
1. Bedload | | | | User-Defined |
2. Suspended | | | | User-Defined |
Pagosa Reference Curves
Reach
1
Curve | B0 | B1 | B2 | Equation Name | Stability Rating
3. Bedload | -0.0113 | 1.0139 | 2.1929 | Pagosa Springs Reference Curve | Good/Fair
4. Bedload | 0.07176 | 1.02176 | 2.37716 | Pagosa Springs Reference Curve | Poor
5. Suspended | 0.0636 | 0.9326 | 2.4085 | Pagosa Springs Reference Curve | Good/Fair
6. Suspended | 0.0989 | 0.9213 | 3.6590 | Pagosa Springs Reference Curve | Poor

RIVERMorph - FLOWSED/POWERSED Models

Save | Save As | Graph | Report | WARSSS Worksheets: 5-19 5-20a 5-20b

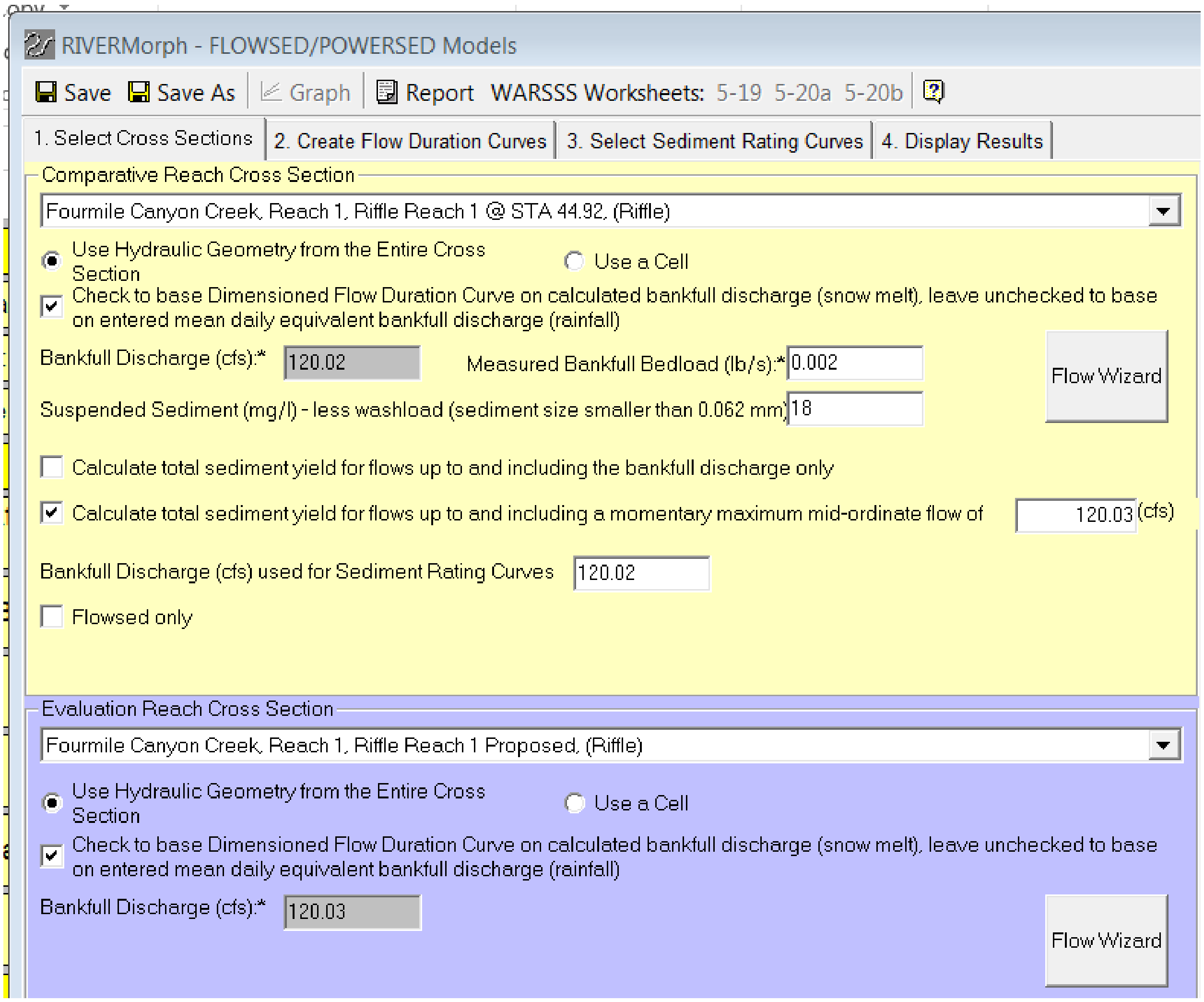
1. Select Cross Sections | 2. Create Flow Duration Curves | 3. Select Sediment Rating Curves | 4. Display Results

Gage Name: NORTH ST. VRAIN CREEK NEAR ALLENS PARK, CO.

Base Flow Duration Curve On: (•) Gage Daily Data ( ) Gage Incremental Data Curve ( ) User Defined Curve

Qbkf (cfs): 275 Mean Daily Equivalent Qbkf (cfs): 275

Date	Mean Daily Flow (cfs)	Rank	Probability	Dimension-less Flow	Comparative Predicted Flow (cfs)	Evaluation Predicted Flow (cfs)
1930-02-18	4	1826	1	0.015	1.8	1.8
1930-02-06	4	1825	0.99945	0.015	1.8	1.8
1930-02-12	4	1824	0.9989	0.015	1.8	1.8
1930-02-11	4	1823	0.99836	0.015	1.8	1.8
1930-02-13	4	1822	0.99781	0.015	1.8	1.8
1930-02-10	4	1821	0.99726	0.015	1.8	1.8
1930-02-09	4	1820	0.99671	0.015	1.8	1.8
1930-02-08	4	1819	0.99617	0.015	1.8	1.8
1930-02-19	4	1818	0.99562	0.015	1.8	1.8
1930-02-28	4	1817	0.99507	0.015	1.8	1.8
1930-02-26	4	1816	0.99452	0.015	1.8	1.8
1930-02-27	4	1815	0.99398	0.015	1.8	1.8
1930-02-17	4	1814	0.99343	0.015	1.8	1.8
1930-02-16	4	1813	0.99288	0.015	1.8	1.8
1930-02-15	4	1812	0.99233	0.015	1.8	1.8
1930-02-14	4	1811	0.99179	0.015	1.8	1.8
1930-02-01	4	1810	0.99124	0.015	1.8	1.8
1930-02-02	4	1809	0.99069	0.015	1.8	1.8
1930-02-03	4	1808	0.99014	0.015	1.8	1.8
1930-02-04	4	1807	0.98959	0.015	1.8	1.8
1930-02-05	4	1806	0.98905	0.015	1.8	1.8
1930-02-07	4	1805	0.9885	0.015	1.8	1.8
1930-03-06	4	1804	0.98795	0.015	1.8	1.8
1930-02-21	4	1803	0.9874	0.015	1.8	1.8
1930-02-22	4	1802	0.98686	0.015	1.8	1.8
1930-02-23	4	1801	0.98631	0.015	1.8	1.8
1930-02-24	4	1800	0.98576	0.015	1.8	1.8
1930-02-25	4	1799	0.98521	0.015	1.8	1.8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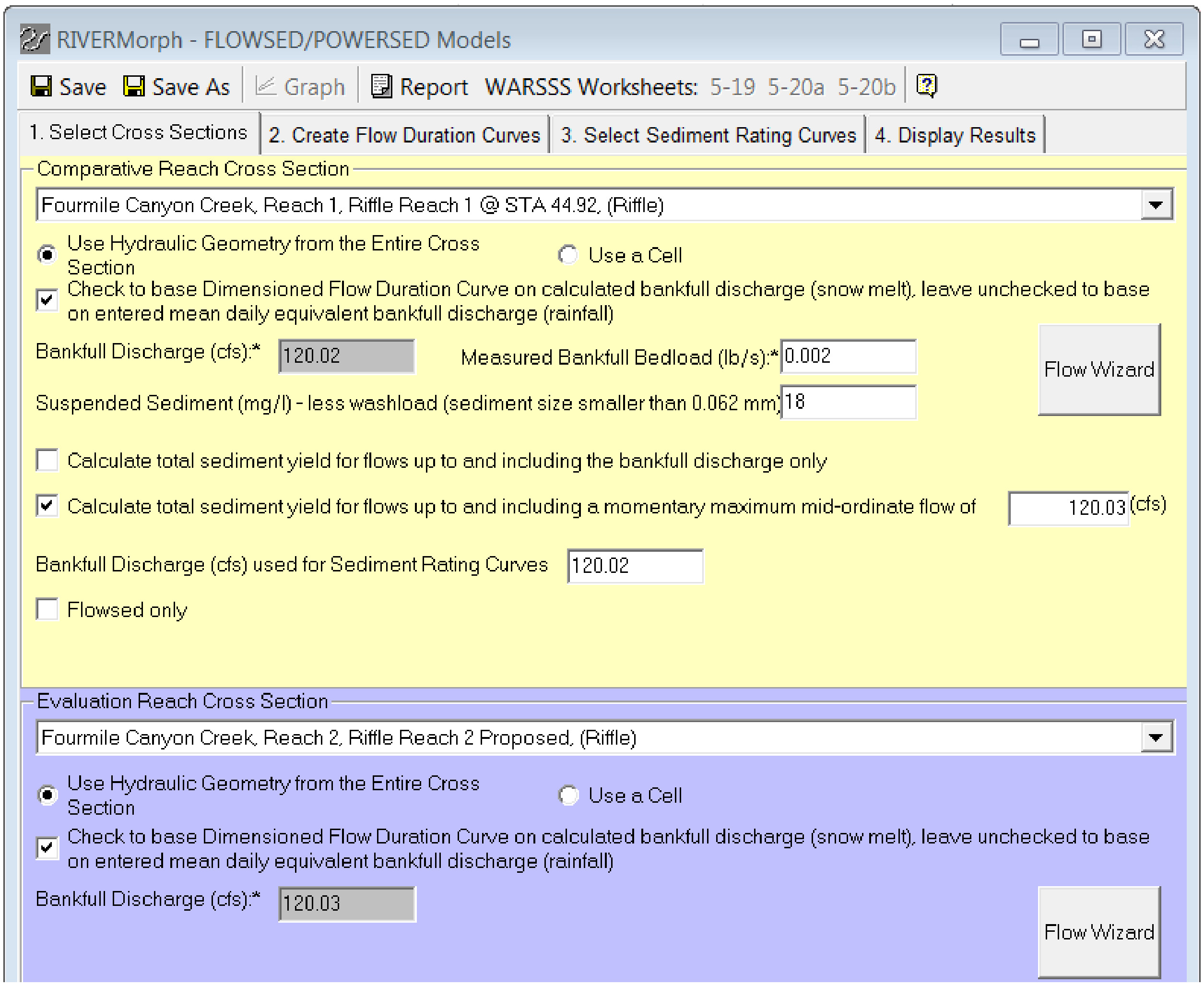
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 1, Riffle Reach 1 @ STA 44.92, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):* 120.02
Measured Bankfull Bedload (lb/s):* 0.002
Flow Wizard
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm) 18
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of 120.03 (cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves 120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 1, Riffle Reach 1 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):* 120.03
Flow Wizard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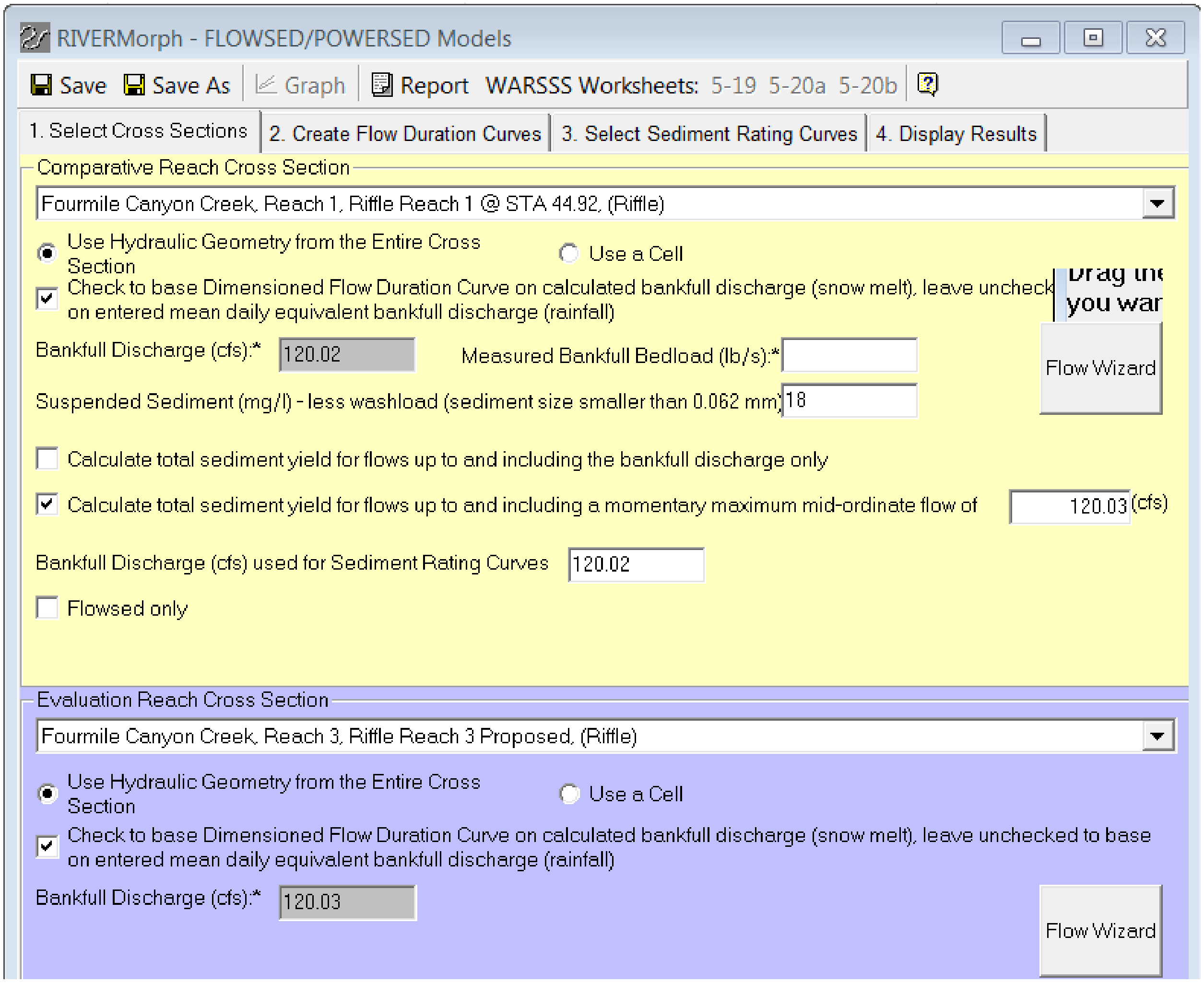
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 1, Riffle Reach 1 @ STA 44.92, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Measured Bankfull Bedload (lb/s):*
0.002
Flow Wizard
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm)
18
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of
120.03
(cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves
120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 2, Riffle Reach 2 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.03
Flow Wizard


RIVERMorph - FLOWSED/POWERSED Models
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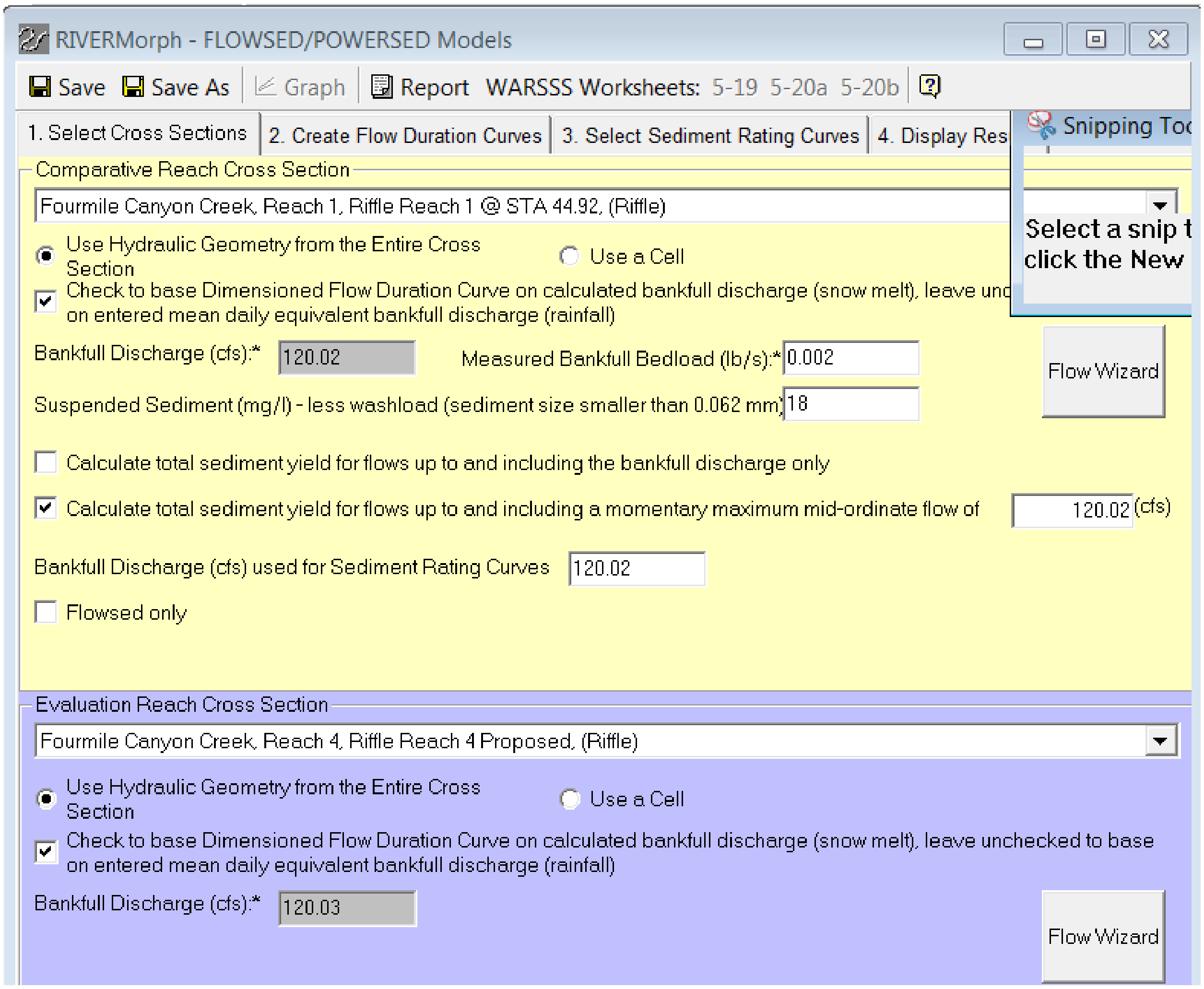
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 1, Riffle Reach 1 @ STA 44.92, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave uncheck on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Measured Bankfull Bedload (lb/s):*
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm)
18
Flow Wizard
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of
120.03
(cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves
120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 3, Riffle Reach 3 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.03
Flow Wizard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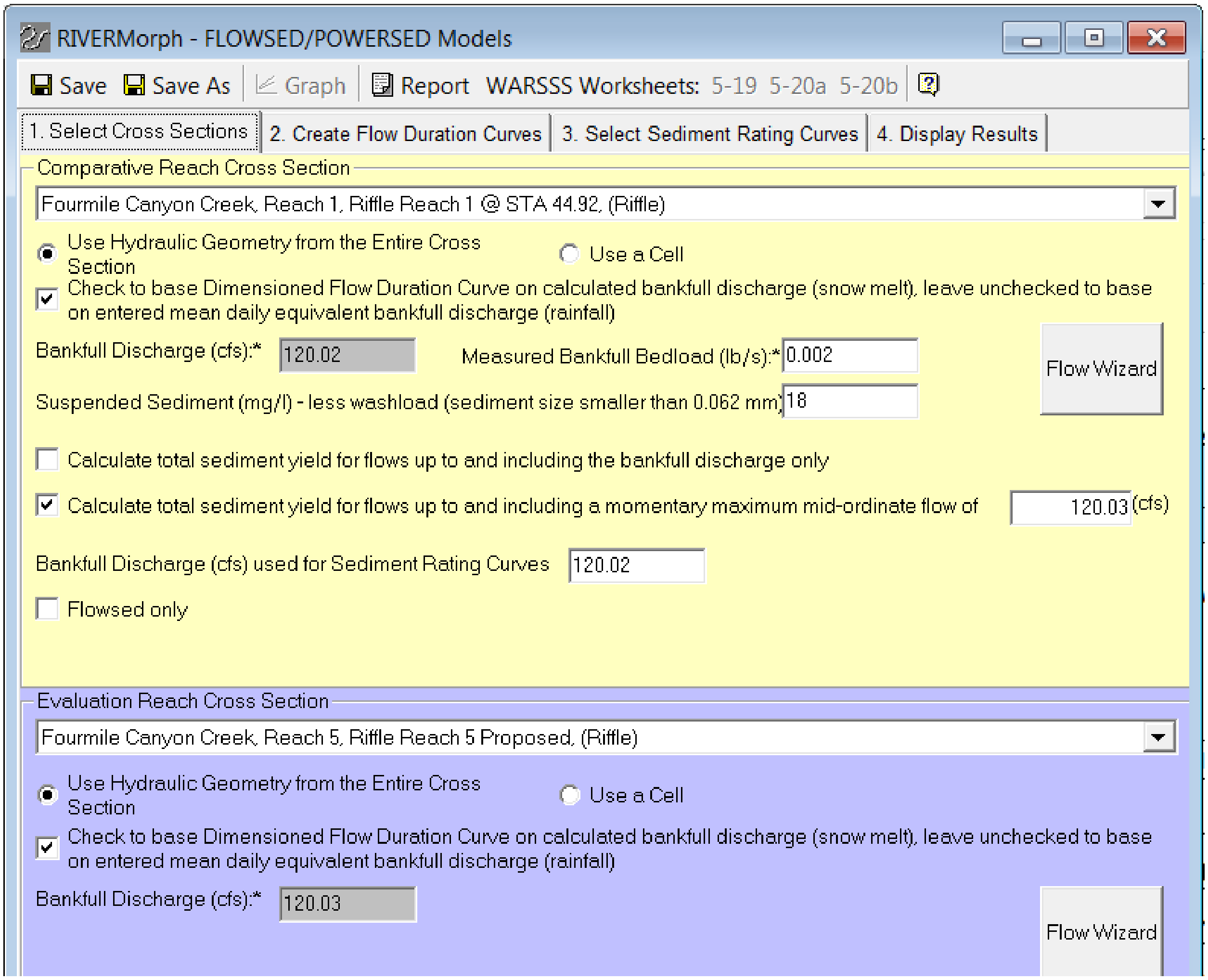
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Res
Snipping Too
Select a snip t
click the New
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 1, Riffle Reach 1 @ STA 44.92, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unc
on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Measured Bankfull Bedload (lb/s):*
0.002
Flow Wizard
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm)
18
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of
120.02
(cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves
120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 4, Riffle Reach 4 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.03
Flow Wizard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Save As
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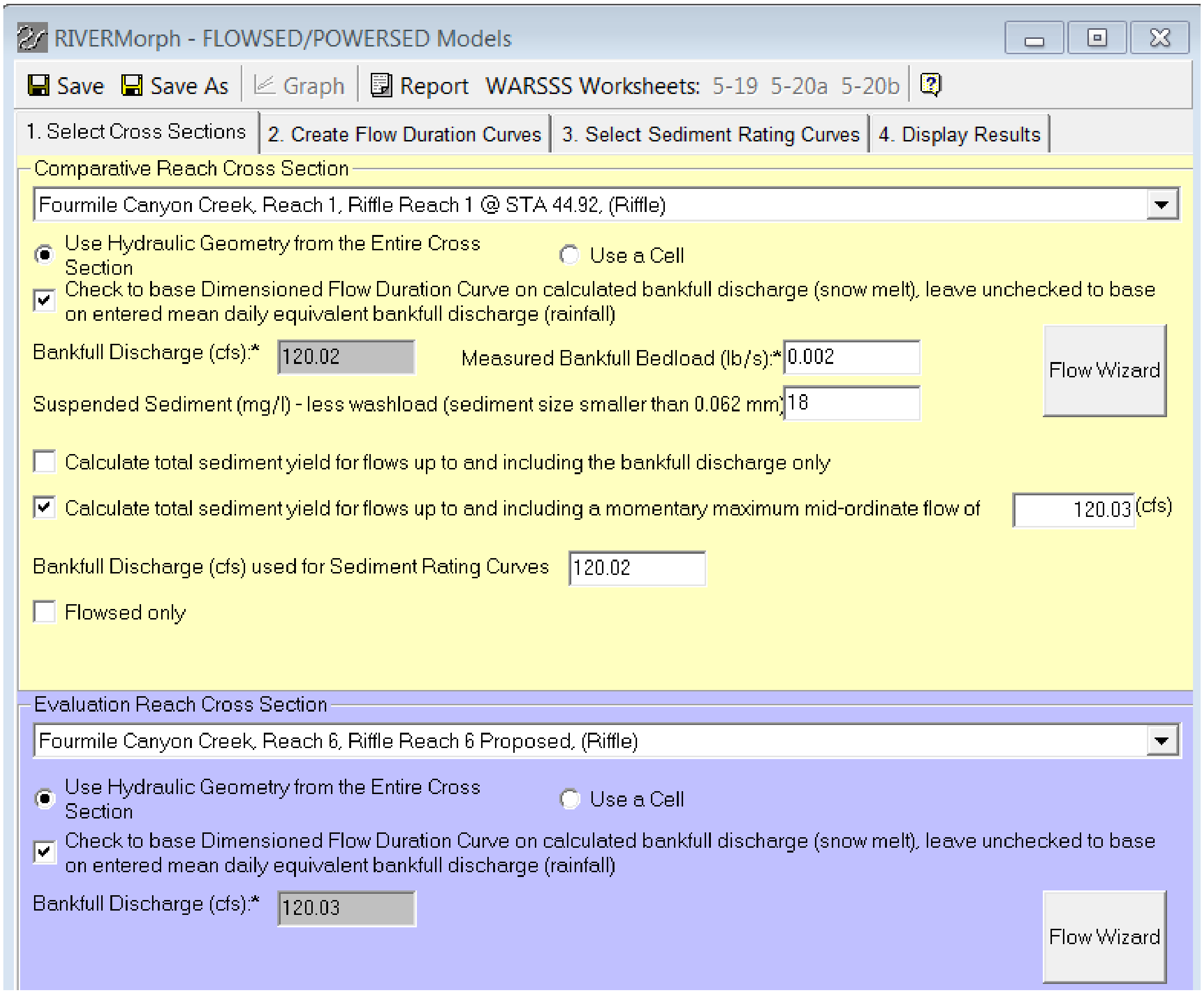
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 1, Riffle Reach 1 @ STA 44.92, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Measured Bankfull Bedload (lb/s):*
0.002
Flow Wizard
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm)
18
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of
120.03
(cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves
120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 5, Riffle Reach 5 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.03
Flow Wizard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Save As
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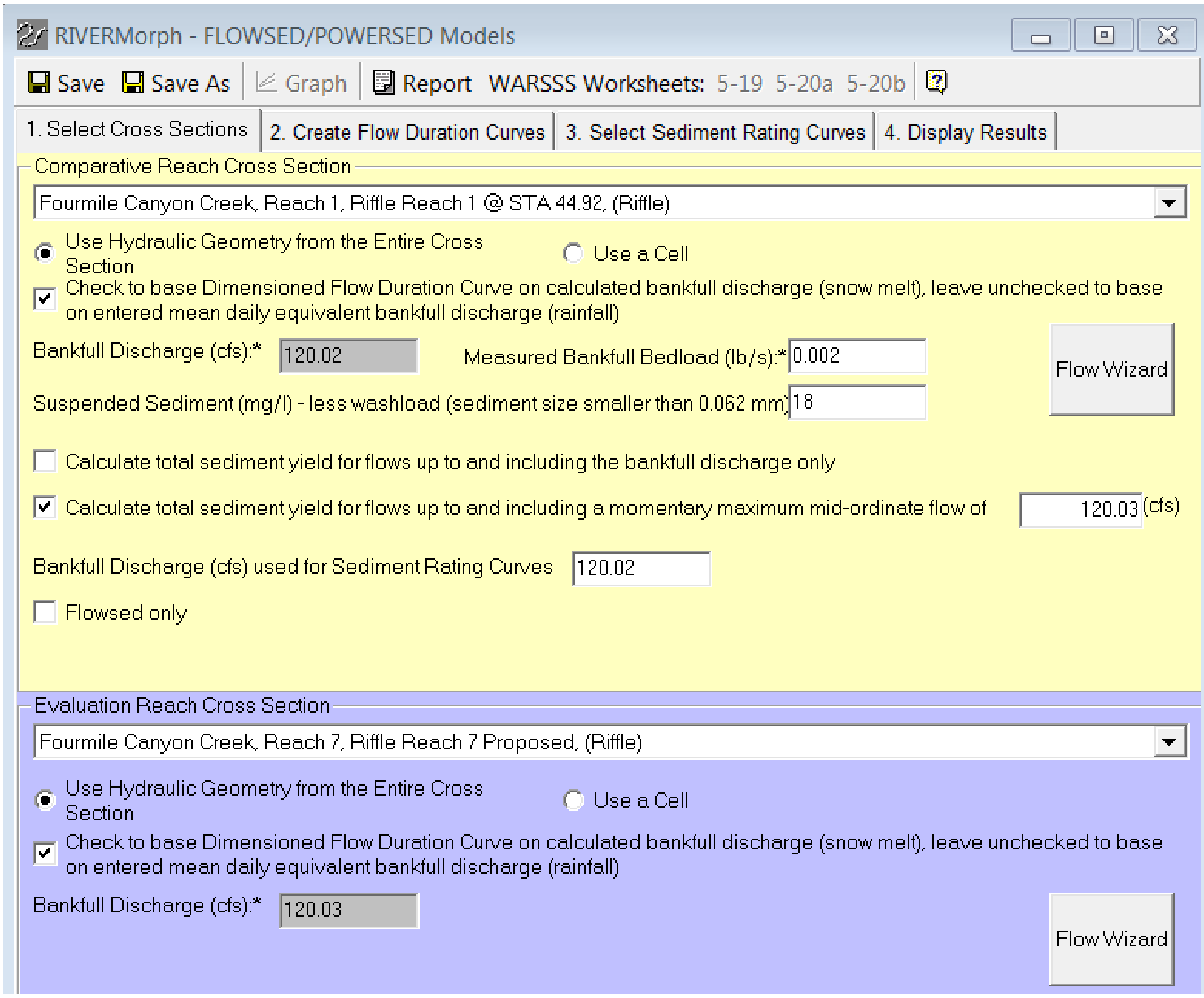
Report
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 1, Riffle Reach 1 @ STA 44.92, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Measured Bankfull Bedload (lb/s):*
0.002
Flow Wizard
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm)
18
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of
120.03
(cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves
120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 6, Riffle Reach 6 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.03
Flow Wizard


RIVERMorph - FLOWSED/POWERSED Models
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Save As
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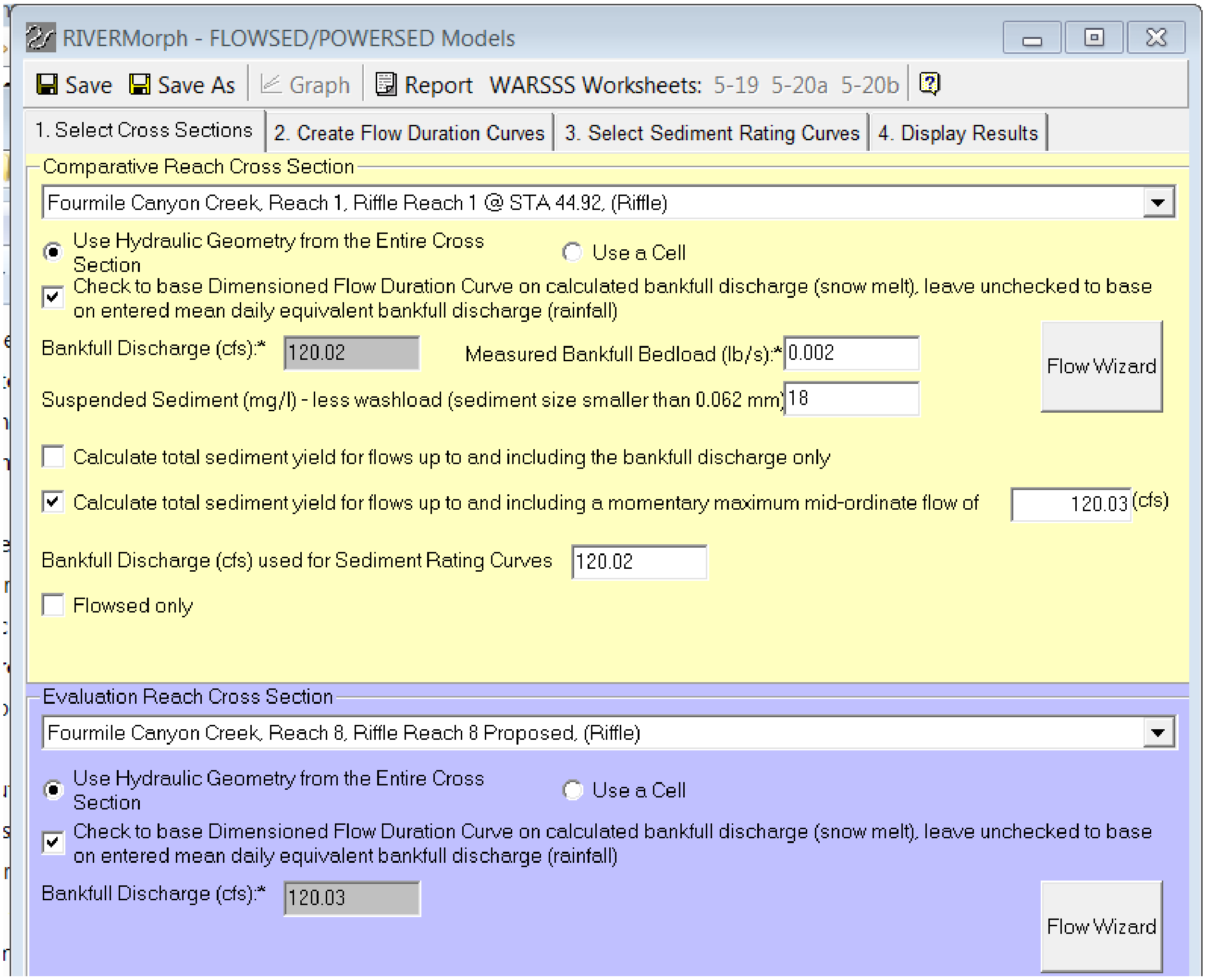
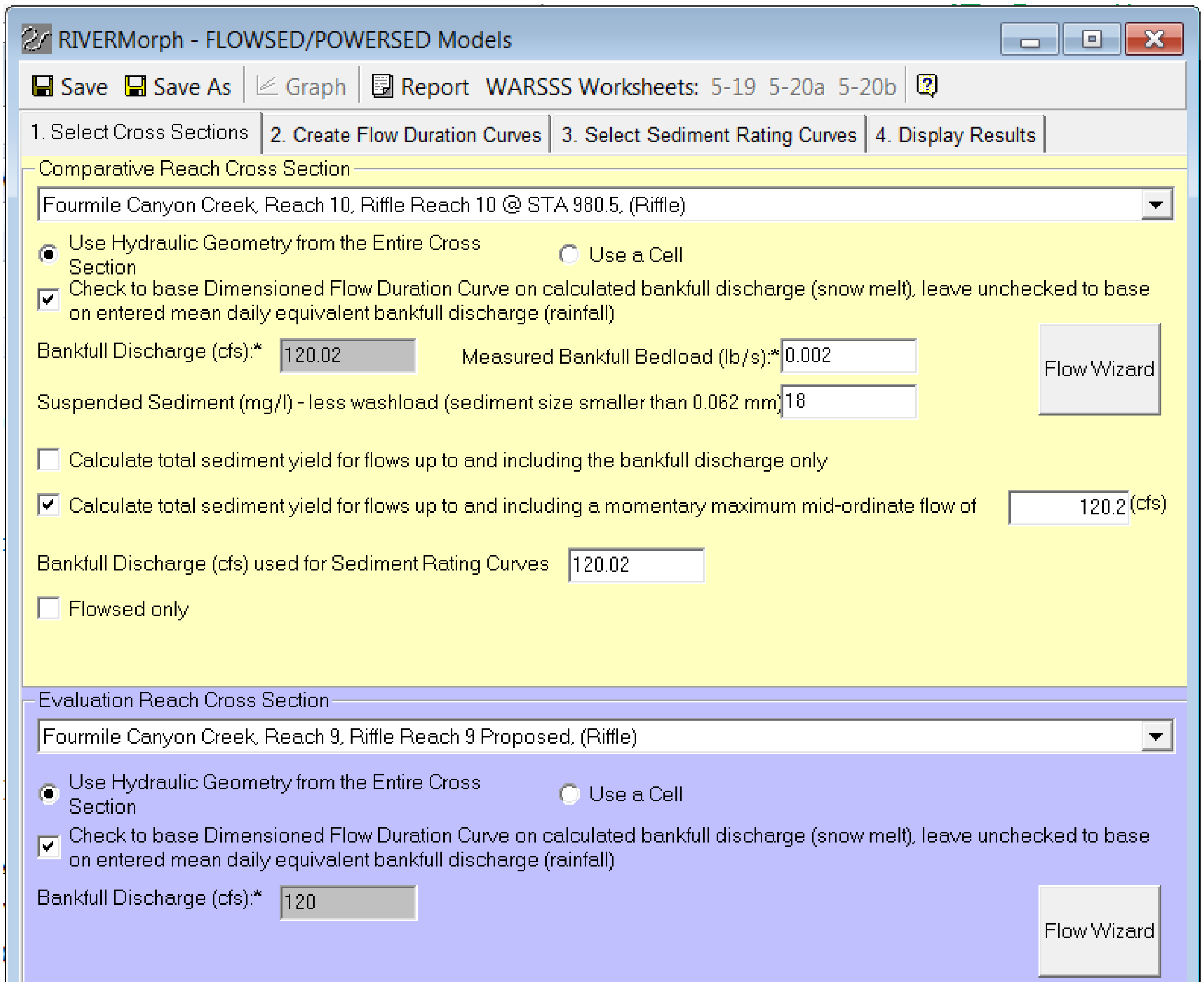
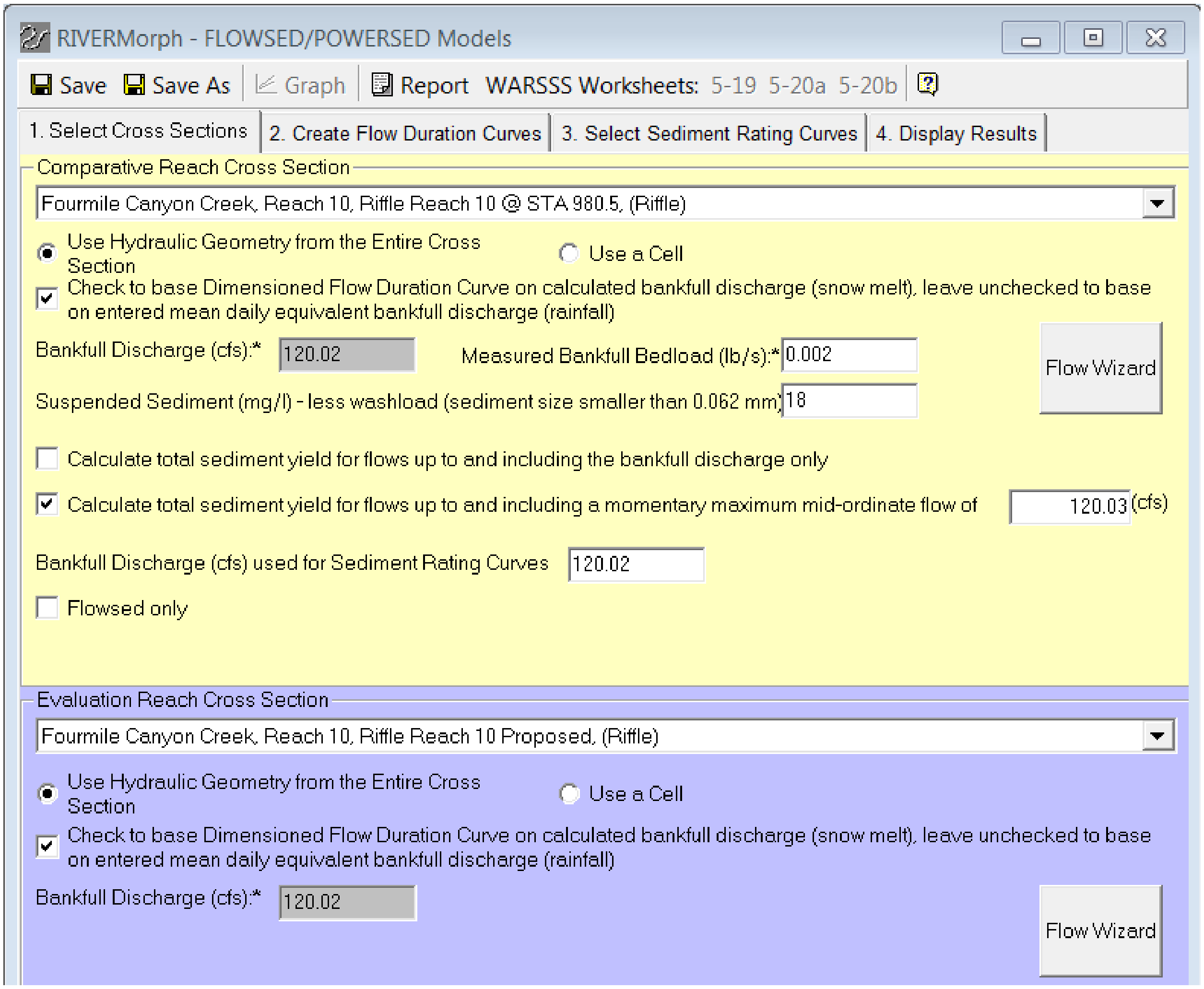
Report
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 1, Riffle Reach 1 @ STA 44.92, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Measured Bankfull Bedload (lb/s):*
0.002
Flow Wizard
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm)
18
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of
120.03
(cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves
120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 7, Riffle Reach 7 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.03
Flow Wizard


RIVERMorph - FLOWSED/POWERSED Models
Save
Save As
Graph
Report
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 1, Riffle Reach 1 @ STA 44.92, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Measured Bankfull Bedload (lb/s):*
0.002
Flow Wizard
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm)
18
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of
120.03
(cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves
120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 8, Riffle Reach 8 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.03
Flow Wizard



RIVERMorph - FLOWSED/POWERSED Models
Save
Save As
Graph
Report
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 10, Riffle Reach 10 @ STA 980.5, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Measured Bankfull Bedload (lb/s):*
0.002
Flow Wizard
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm)
18
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of
120.2
(cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves
120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 9, Riffle Reach 9 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120
Flow Wizard


RIVERMorph - FLOWSED/POWERSED Models
Save
Save As
Graph
Report
WARSSS Worksheets: 5-19 5-20a 5-20b
1. Select Cross Sections
2. Create Flow Duration Curves
3. Select Sediment Rating Curves
4. Display Results
Comparative Reach Cross Section
Fourmile Canyon Creek, Reach 10, Riffle Reach 10 @ STA 980.5, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Measured Bankfull Bedload (lb/s):*
0.002
Flow Wizard
Suspended Sediment (mg/l) - less washload (sediment size smaller than 0.062 mm)
18
Calculate total sediment yield for flows up to and including the bankfull discharge only
Calculate total sediment yield for flows up to and including a momentary maximum mid-ordinate flow of
120.03
(cfs)
Bankfull Discharge (cfs) used for Sediment Rating Curves
120.02
Flowsed only
Evaluation Reach Cross Section
Fourmile Canyon Creek, Reach 10, Riffle Reach 10 Proposed, (Riffle)
Use Hydraulic Geometry from the Entire Cross Section
Use a Cell
Check to base Dimensioned Flow Duration Curve on calculated bankfull discharge (snow melt), leave unchecked to base on entered mean daily equivalent bankfull discharge (rainfall)
Bankfull Discharge (cfs):*
120.02
Flow Wizard

Worksheet 5-19. FLOWSED calculation of total annual sediment yield.

Stream: **Fourmile Canyon Creek** Location: **Reach 1** Date: **05/11/2015**

Observers: **Lucas Babbitt** Gage Station #: **06721500** Stream Type: **C 4b** Valley Type: **VIII**

Equation type	Intercept	Coefficient	Exponent	Form (e.g., linear, non-linear, etc.)	Equation name	Bankfull discharge (cfs)	Bankfull bedload (kg/s)	Bankfull suspended (mg/l)
1. Bedload (dimensionless)	-0.0113	1.0139	2.1929	Non-Linear	Pagosa Springs Reference Curve	120.02	0.0009	18
2. Suspended sediment (dimensionless)	0.0636	0.9326	2.4085	Non-Linear	Pagosa Springs Reference Curve			
3. User-defined relations (bedload)						Notes:		
4. User-defined relations (suspended sediment)								

From dimensioned flow-duration curve							From sediment rating curves				Calculate	Calculate sediment yield		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Flow exceedence	Daily mean discharge	Mid-ordinate	Time increment (percent)	Time increment (days)	Mid-ordinate streamflow	Dimension-less streamflow	Dimension-less suspended sediment discharge	Suspended sediment discharge	Dimension-less bedload discharge	Bedload	Time adjusted streamflow	Suspended sediment [(5)×(9)]	Bedload sediment [(5)×(11)]	Suspended + bedload [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
100.000	1.8													
90.000	2.8	95.00	10.00	36.50	2.3	0.02	0.0637	0.0	0.0000	0.00	22.80	0.36	0.00	0.36
80.000	3.5	85.00	10.00	36.50	3.1	0.03	0.0637	0.0	0.0000	0.00	31.20	0.36	0.00	0.36
70.000	4.0	75.00	10.00	36.50	3.7	0.03	0.0638	0.0	0.0000	0.00	37.20	0.36	0.00	0.36
60.000	5.3	65.00	10.00	36.50	4.6	0.04	0.0640	0.0	0.0000	0.00	46.20	0.36	0.00	0.36
50.000	8.8	55.00	10.00	36.50	7.0	0.06	0.0646	0.0	0.0000	0.00	70.20	0.73	0.00	0.73
40.000	13.9	45.00	10.00	36.50	11.3	0.09	0.0668	0.0	0.0000	0.00	113.40	1.46	0.00	1.46
30.000	26.2	35.00	10.00	36.50	20.0	0.17	0.0761	0.1	0.0087	0.00	200.40	2.56	0.00	2.56
20.000	51.0	25.00	10.00	36.50	38.6	0.32	0.1243	0.2	0.0729	0.00	385.90	8.39	0.00	8.39
10.000	87.9	15.00	10.00	36.50	69.5	0.58	0.3135	1.1	0.2944	0.04	694.70	38.69	1.46	40.15
5.000	108.6	7.50	5.00	18.25	98.3	0.82	0.6399	3.1	0.6428	0.04	491.40	55.84	0.73	56.57
4.000	116.1	4.50	1.00	3.65	112.3	0.94	0.8589	4.7	0.8657	0.09	112.34	17.12	0.33	17.45
3.000	124.0	3.50	1.00	3.65	120.0	1.00	0.9962	5.8	1.0026	0.09	120.02	21.21	0.33	21.54
2.000	131.4	2.50			127.7	1.06	1.1456		1.1495		0.00	0.00	0.00	0.00
1.500	138.4	1.75			134.9	1.12	1.2987		1.2982		0.00	0.00	0.00	0.00
1.000	152.2	1.25			145.3	1.21	1.5410		1.5300		0.00	0.00	0.00	0.00
0.900	152.8	0.95			152.5	1.27	1.7235		1.7025		0.00	0.00	0.00	0.00
0.800	154.1	0.85			153.4	1.28	1.7488		1.7263		0.00	0.00	0.00	0.00
0.700	156.3	0.75			155.2	1.29	1.7954		1.7700		0.00	0.00	0.00	0.00
0.600	158.6	0.65			157.4	1.31	1.8565		1.8272		0.00	0.00	0.00	0.00
0.500	165.1	0.55			161.9	1.35	1.9802		1.9422		0.00	0.00	0.00	0.00
0.250	177.2	0.38			171.1	1.43	2.2553		2.1960		0.00	0.00	0.00	0.00
0.100	188.3	0.18			182.7	1.52	2.6293		2.5365		0.00	0.00	0.00	0.00
0.050	189.0	0.08			188.6	1.57	2.8349		2.7217		0.00	0.00	0.00	0.00
0.010	189.0	0.03			189.0	1.57	2.8487		2.7341		0.00	0.00	0.00	0.00
0.005	189.0	0.01			189.0	1.57	2.8487		2.7341		0.00	0.00	0.00	0.00
0.001	189.0	0.00			189.0	1.57	2.8487		2.7341		0.00	0.00	0.00	0.00
										Annual totals:		147.4 (tons/yr)	2.9 (tons/yr)	150.3 (tons/yr)

Worksheet 5-20a. Bedload and suspended sand bed-material load transport prediction for the upstream reach, using the POWERSED model.

Stream: **Fourmile Canyon Creek, Reach 1, Riffle Reach 1 @** Location: Date: **05/11/15**

Observers: **Lucas Babbitt** Stream Type: **C 4b** Valley Type: **VIII** Gage Station #: **06721500**

Flow-duration curve		**Calculate**	**Hydraulic geometry**				**Measure**	**Calculate**									
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport **[(13)×(14)]**	Time adjusted suspended sand transport **[(13)×(15)]**	Time adjusted total transport **[(16)+(17)]**
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	**1.80**									**0.00**					**0.00**	**0.00**	**0.00**
90.000	**2.76**	**2.28**	**1.01**	**5.78**	**0.17**	**2.24**	**0.0370**	**0.39**	**5.26**	**0.91**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
80.000	**3.48**	**3.12**	**1.25**	**6.18**	**0.20**	**2.43**	**0.0370**	**0.45**	**7.20**	**1.17**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
70.000	**3.96**	**3.72**	**1.42**	**6.47**	**0.22**	**2.57**	**0.0370**	**0.49**	**8.59**	**1.33**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
60.000	**5.28**	**4.62**	**1.66**	**6.84**	**0.24**	**2.77**	**0.0370**	**0.54**	**10.67**	**1.56**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.000	**8.76**	**7.02**	**2.17**	**7.17**	**0.30**	**3.20**	**0.0370**	**0.67**	**16.21**	**2.26**	**10.000**	**36.50**	**0.00**	**0.02**	**0.00**	**0.73**	**0.73**
40.000	**13.92**	**11.34**	**3.00**	**7.75**	**0.39**	**3.77**	**0.0370**	**0.86**	**26.18**	**3.38**	**10.000**	**36.50**	**0.00**	**0.04**	**0.00**	**1.46**	**1.46**
30.000	**26.16**	**20.04**	**4.34**	**8.27**	**0.52**	**4.59**	**0.0370**	**1.15**	**46.27**	**5.59**	**10.000**	**36.50**	**0.00**	**0.07**	**0.00**	**2.56**	**2.56**
20.000	**51.01**	**38.59**	**7.14**	**10.69**	**0.67**	**5.39**	**0.0370**	**1.47**	**89.10**	**8.33**	**10.000**	**36.50**	**0.00**	**0.23**	**0.00**	**8.39**	**8.39**
10.000	**87.93**	**69.47**	**10.69**	**12.05**	**0.89**	**6.49**	**0.0370**	**1.93**	**160.39**	**13.31**	**10.000**	**36.50**	**0.04**	**0.72**	**1.46**	**26.28**	**27.74**
5.000	**108.62**	**98.28**	**14.29**	**14.72**	**0.97**	**6.87**	**0.0370**	**2.10**	**226.91**	**15.42**	**5.000**	**18.25**	**0.04**	**1.19**	**0.73**	**21.72**	**22.45**
4.000	**116.06**	**112.34**	**18.14**	**22.14**	**0.82**	**6.21**	**0.0370**	**1.80**	**259.37**	**11.71**	**1.000**	**3.65**	**0.04**	**1.38**	**0.15**	**5.04**	**5.19**
3.000	**123.98**	**120.02**	**19.91**	**25.34**	**0.79**	**6.03**	**0.0370**	**1.73**	**277.10**	**10.94**	**1.000**	**3.65**	**0.04**	**1.3**	**0.15**	**4.75**	**4.90**
2.000	**131.35**	**127.66**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
1.500	**138.38**	**134.87**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
1.000	**152.18**	**145.28**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.900	**152.78**	**152.48**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.800	**154.11**	**153.44**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.700	**156.27**	**155.19**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.600	**158.60**	**157.44**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.500	**165.11**	**161.86**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.250	**177.16**	**171.13**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.100	**188.25**	**182.70**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.050	**189.03**	**188.64**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.010	**189.03**	**189.03**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.005	**189.03**	**189.03**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
0.001	**189.03**	**189.03**					**0.0370**			**0.00**					**0.00**	**0.00**	**0.00**
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**2.4**	**72.6**	**75.0**

Worksheet 5-20b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Fourmile Canyon Creek, Reach 1, Riffle Reach 1 Pr** Location: Date: **05/11/15**

Observers: **Lucas Babbitt** Stream Type: **C 4b** Valley Type: **VIII** Gage Station #: **06721500**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport **[(13)×(14)]**	Time adjusted suspended sand transport **[(13)×(15)]**	Time adjusted total transport **[(16)+(17)]**
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	**1.80**								**0.00**						**0.00**	**0.00**	**0.00**
90.000	**2.76**	**2.28**	**1.55**	**7.85**	**0.20**	**1.46**	**0.0430**	**0.53**	**6.12**	**0.78**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
80.000	**3.48**	**3.12**	**1.87**	**7.98**	**0.23**	**1.63**	**0.0430**	**0.62**	**8.37**	**1.05**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
70.000	**3.96**	**3.72**	**2.09**	**8.07**	**0.26**	**1.74**	**0.0430**	**0.69**	**9.98**	**1.24**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
60.000	**5.28**	**4.62**	**2.41**	**8.21**	**0.29**	**1.90**	**0.0430**	**0.78**	**12.40**	**1.51**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.000	**8.76**	**7.02**	**3.16**	**8.51**	**0.37**	**2.22**	**0.0430**	**0.98**	**18.84**	**2.21**	**10.000**	**36.50**	**0.00**	**0.02**	**0.00**	**0.73**	**0.73**
40.000	**13.92**	**11.34**	**4.31**	**8.94**	**0.48**	**2.62**	**0.0430**	**1.26**	**30.43**	**3.40**	**10.000**	**36.50**	**0.00**	**0.04**	**0.00**	**1.46**	**1.46**
30.000	**26.17**	**20.05**	**7.46**	**15.07**	**0.50**	**2.68**	**0.0430**	**1.30**	**53.80**	**3.57**	**10.000**	**36.50**	**0.00**	**0.07**	**0.00**	**2.56**	**2.56**
20.000	**51.01**	**38.59**	**11.56**	**16.77**	**0.69**	**3.33**	**0.0430**	**1.80**	**103.54**	**6.17**	**10.000**	**36.50**	**0.00**	**0.16**	**0.00**	**5.84**	**5.84**
10.000	**87.93**	**69.47**	**17.27**	**18.88**	**0.91**	**4.02**	**0.0430**	**2.39**	**186.40**	**9.87**	**10.000**	**36.50**	**0.00**	**0.62**	**0.00**	**22.63**	**22.63**
5.000	**108.63**	**98.28**	**21.96**	**20.46**	**1.07**	**4.47**	**0.0430**	**2.80**	**263.70**	**12.89**	**5.000**	**18.25**	**0.04**	**1.42**	**0.73**	**25.91**	**26.64**
4.000	**116.07**	**112.35**	**24.12**	**21.14**	**1.14**	**4.66**	**0.0430**	**2.97**	**301.46**	**14.26**	**1.000**	**3.65**	**0.04**	**1.91**	**0.15**	**6.97**	**7.12**
3.000	**123.99**	**120.03**	**25.27**	**21.50**	**1.18**	**4.75**	**0.0430**	**3.06**	**322.06**	**14.98**	**1.000**	**3.65**	**0.04**	**2.2**	**0.15**	**8.03**	**8.18**
2.000	**131.36**	**127.68**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
1.500	**138.39**	**134.88**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
1.000	**152.20**	**145.29**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.900	**152.80**	**152.50**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.800	**154.12**	**153.46**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.700	**156.28**	**155.20**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.600	**158.62**	**157.45**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.500	**165.13**	**161.88**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.250	**177.17**	**171.15**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.100	**188.26**	**182.71**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.050	**189.05**	**188.66**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.010	**189.05**	**189.05**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.005	**189.05**	**189.05**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**
0.001	**189.05**	**189.05**					**0.0430**		**0.00**						**0.00**	**0.00**	**0.00**

Notes:

	(16)	(17)	(18)
Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**0.9**	**75.7**	**76.7**
Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):	**2.5**	**72.4**	**74.9**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-1.6**	**3.3**	**1.8**
Stability evaluation: Aggradation, Degradation or Stable:			

Worksheet 5-20b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Fourmile Canyon Creek, Reach 2, Riffle Reach 2 Pr** Location: Date: **05/11/15**

Observers: **Lucas Babbitt** Stream Type: **C 4b** Valley Type: **VIII** Gage Station #: **06721500**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport **[(13)×(14)]**	Time adjusted suspended sand transport **[(13)×(15)]**	Time adjusted total transport **[(16)+(17)]**
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	**1.80**								**0.00**						**0.00**	**0.00**	**0.00**
90.000	**2.76**	**2.28**	**1.55**	**7.85**	**0.20**	**1.46**	**0.0500**	**0.61**	**7.11**	**0.91**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
80.000	**3.48**	**3.12**	**1.87**	**7.98**	**0.23**	**1.63**	**0.0500**	**0.72**	**9.73**	**1.22**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
70.000	**3.96**	**3.72**	**2.09**	**8.07**	**0.26**	**1.74**	**0.0500**	**0.80**	**11.61**	**1.44**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
60.000	**5.28**	**4.62**	**2.41**	**8.21**	**0.29**	**1.90**	**0.0500**	**0.90**	**14.41**	**1.76**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.000	**8.76**	**7.02**	**3.16**	**8.51**	**0.37**	**2.22**	**0.0500**	**1.14**	**21.90**	**2.57**	**10.000**	**36.50**	**0.00**	**0.02**	**0.00**	**0.73**	**0.73**
40.000	**13.92**	**11.34**	**4.31**	**8.94**	**0.48**	**2.62**	**0.0500**	**1.46**	**35.38**	**3.96**	**10.000**	**36.50**	**0.00**	**0.04**	**0.00**	**1.46**	**1.46**
30.000	**26.17**	**20.05**	**7.46**	**15.07**	**0.50**	**2.68**	**0.0500**	**1.51**	**62.56**	**4.15**	**10.000**	**36.50**	**0.00**	**0.07**	**0.00**	**2.56**	**2.56**
20.000	**51.01**	**38.59**	**11.56**	**16.77**	**0.69**	**3.33**	**0.0500**	**2.10**	**120.40**	**7.18**	**10.000**	**36.50**	**0.00**	**0.19**	**0.00**	**6.94**	**6.94**
10.000	**87.93**	**69.47**	**17.27**	**18.88**	**0.91**	**4.02**	**0.0500**	**2.78**	**216.75**	**11.48**	**10.000**	**36.50**	**0.04**	**0.82**	**1.46**	**29.93**	**31.39**
5.000	**108.63**	**98.28**	**21.96**	**20.46**	**1.07**	**4.47**	**0.0500**	**3.25**	**306.63**	**14.99**	**5.000**	**18.25**	**0.04**	**1.80**	**0.73**	**32.85**	**33.58**
4.000	**116.07**	**112.35**	**24.11**	**21.14**	**1.14**	**4.66**	**0.0500**	**3.46**	**350.53**	**16.58**	**1.000**	**3.65**	**0.04**	**2.39**	**0.15**	**8.72**	**8.87**
3.000	**123.99**	**120.03**	**25.27**	**21.50**	**1.18**	**4.75**	**0.0500**	**3.56**	**374.49**	**17.42**	**1.000**	**3.65**	**0.00**	**2.74**	**0.00**	**10.00**	**10.00**
2.000	**131.36**	**127.68**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
1.500	**138.39**	**134.88**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
1.000	**152.20**	**145.29**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.900	**152.80**	**152.50**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.800	**154.12**	**153.46**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.700	**156.28**	**155.20**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.600	**158.62**	**157.45**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.500	**165.13**	**161.88**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.250	**177.17**	**171.15**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.100	**188.26**	**182.71**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.050	**189.05**	**188.66**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.010	**189.05**	**189.05**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.005	**189.05**	**189.05**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**
0.001	**189.05**	**189.05**					**0.0500**		**0.00**						**0.00**	**0.00**	**0.00**

Notes:

	(16)	(17)	(18)
Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**2.3**	**94.8**	**97.2**
Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):	**2.5**	**72.4**	**74.9**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-0.2**	**22.4**	**22.3**
Stability evaluation: Aggradation, Degradation or Stable:			

Worksheet 5-20b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Fourmile Canyon Creek, Reach 3, Riffle Reach 3 Pr** Location: Date: **05/11/15**

Observers: **Lucas Babbitt** Stream Type: **C 4b** Valley Type: **VIII** Gage Station #: **06721500**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport [(13)×(14)]	Time adjusted suspended sand transport [(13)×(15)]	Time adjusted total transport [(16)+(17)]
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	**1.80**								**0.00**						**0.00**	**0.00**	**0.00**
90.000	**2.76**	**2.28**	**1.55**	**7.85**	**0.20**	**1.46**	**0.0440**	**0.54**	**6.26**	**0.80**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
80.000	**3.48**	**3.12**	**1.87**	**7.98**	**0.23**	**1.63**	**0.0440**	**0.64**	**8.57**	**1.07**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
70.000	**3.96**	**3.72**	**2.09**	**8.07**	**0.26**	**1.74**	**0.0440**	**0.70**	**10.21**	**1.27**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
60.000	**5.28**	**4.62**	**2.41**	**8.21**	**0.29**	**1.90**	**0.0440**	**0.79**	**12.68**	**1.54**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.000	**8.76**	**7.02**	**3.16**	**8.51**	**0.37**	**2.22**	**0.0440**	**1.00**	**19.27**	**2.26**	**10.000**	**36.50**	**0.00**	**0.02**	**0.00**	**0.73**	**0.73**
40.000	**13.92**	**11.34**	**4.31**	**8.94**	**0.48**	**2.62**	**0.0440**	**1.29**	**31.14**	**3.48**	**10.000**	**36.50**	**0.00**	**0.04**	**0.00**	**1.46**	**1.46**
30.000	**26.17**	**20.05**	**7.46**	**15.07**	**0.50**	**2.68**	**0.0440**	**1.33**	**55.05**	**3.65**	**10.000**	**36.50**	**0.00**	**0.07**	**0.00**	**2.56**	**2.56**
20.000	**51.01**	**38.59**	**11.56**	**16.77**	**0.69**	**3.33**	**0.0440**	**1.85**	**105.95**	**6.32**	**10.000**	**36.50**	**0.00**	**0.17**	**0.00**	**6.21**	**6.21**
10.000	**87.93**	**69.47**	**17.27**	**18.88**	**0.91**	**4.02**	**0.0440**	**2.44**	**190.74**	**10.10**	**10.000**	**36.50**	**0.00**	**0.65**	**0.00**	**23.73**	**23.73**
5.000	**108.63**	**98.28**	**21.96**	**20.46**	**1.07**	**4.47**	**0.0440**	**2.86**	**269.84**	**13.19**	**5.000**	**18.25**	**0.04**	**1.48**	**0.73**	**27.01**	**27.74**
4.000	**116.07**	**112.35**	**24.12**	**21.14**	**1.14**	**4.66**	**0.0440**	**3.04**	**308.47**	**14.59**	**1.000**	**3.65**	**0.04**	**1.97**	**0.15**	**7.19**	**7.34**
3.000	**123.99**	**120.03**	**25.27**	**21.50**	**1.18**	**4.75**	**0.0440**	**3.13**	**329.55**	**15.33**	**1.000**	**3.65**	**0.04**	**2.28**	**0.15**	**8.32**	**8.47**
2.000	**131.36**	**127.68**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
1.500	**138.39**	**134.88**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
1.000	**152.20**	**145.29**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.900	**152.80**	**152.50**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.800	**154.12**	**153.46**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.700	**156.28**	**155.20**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.600	**158.62**	**157.45**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.500	**165.13**	**161.88**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.250	**177.17**	**171.15**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.100	**188.26**	**182.71**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.050	**189.05**	**188.66**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.010	**189.05**	**189.05**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.005	**189.05**	**189.05**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.001	**189.05**	**189.05**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**

Notes:

	(16)	(17)	(18)
Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**0.9**	**78.8**	**79.8**
Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):	**2.5**	**72.4**	**74.9**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-1.6**	**6.4**	**4.9**
Stability evaluation: Aggradation, Degradation or Stable:			

Worksheet 5-20b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Fourmile Canyon Creek, Reach 4, Riffle Reach 4 Pr** Location: Date: **05/11/15**

Observers: **Lucas Babbitt** Stream Type: **C 4b** Valley Type: **VIII** Gage Station #: **06721500**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport **[(13)×(14)]**	Time adjusted suspended sand transport **[(13)×(15)]**	Time adjusted total transport **[(16)+(17)]**
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	**1.80**								**0.00**						**0.00**	**0.00**	**0.00**
90.000	**2.76**	**2.28**	**1.55**	**7.85**	**0.20**	**1.46**	**0.0440**	**0.54**	**6.26**	**0.80**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
80.000	**3.48**	**3.12**	**1.87**	**7.98**	**0.23**	**1.63**	**0.0440**	**0.64**	**8.57**	**1.07**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
70.000	**3.96**	**3.72**	**2.09**	**8.07**	**0.26**	**1.74**	**0.0440**	**0.70**	**10.21**	**1.27**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
60.000	**5.28**	**4.62**	**2.41**	**8.21**	**0.29**	**1.90**	**0.0440**	**0.79**	**12.68**	**1.54**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.000	**8.76**	**7.02**	**3.16**	**8.51**	**0.37**	**2.22**	**0.0440**	**1.00**	**19.27**	**2.26**	**10.000**	**36.50**	**0.00**	**0.02**	**0.00**	**0.73**	**0.73**
40.000	**13.92**	**11.34**	**4.31**	**8.94**	**0.48**	**2.62**	**0.0440**	**1.29**	**31.14**	**3.48**	**10.000**	**36.50**	**0.00**	**0.04**	**0.00**	**1.46**	**1.46**
30.000	**26.17**	**20.05**	**7.46**	**15.07**	**0.50**	**2.68**	**0.0440**	**1.33**	**55.05**	**3.65**	**10.000**	**36.50**	**0.00**	**0.07**	**0.00**	**2.56**	**2.56**
20.000	**51.01**	**38.59**	**11.56**	**16.77**	**0.69**	**3.33**	**0.0440**	**1.85**	**105.95**	**6.32**	**10.000**	**36.50**	**0.00**	**0.17**	**0.00**	**6.21**	**6.21**
10.000	**87.93**	**69.47**	**17.27**	**18.88**	**0.91**	**4.02**	**0.0440**	**2.44**	**190.74**	**10.10**	**10.000**	**36.50**	**0.00**	**0.65**	**0.00**	**23.73**	**23.73**
5.000	**108.63**	**98.28**	**21.96**	**20.46**	**1.07**	**4.47**	**0.0440**	**2.86**	**269.84**	**13.19**	**5.000**	**18.25**	**0.04**	**1.48**	**0.73**	**27.01**	**27.74**
4.000	**116.07**	**112.35**	**24.12**	**21.14**	**1.14**	**4.66**	**0.0440**	**3.04**	**308.47**	**14.59**	**1.000**	**3.65**	**0.04**	**1.97**	**0.15**	**7.19**	**7.34**
3.000	**123.99**	**120.03**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
2.000	**131.36**	**127.68**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
1.500	**138.39**	**134.88**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
1.000	**152.20**	**145.29**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.900	**152.80**	**152.50**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.800	**154.12**	**153.46**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.700	**156.28**	**155.20**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.600	**158.62**	**157.45**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.500	**165.13**	**161.88**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.250	**177.17**	**171.15**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.100	**188.26**	**182.71**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.050	**189.05**	**188.66**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.010	**189.05**	**189.05**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.005	**189.05**	**189.05**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**
0.001	**189.05**	**189.05**					**0.0440**		**0.00**						**0.00**	**0.00**	**0.00**

Notes:

	(16)	(17)	(18)
Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**0.8**	**70.5**	**71.3**
Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):	**2.5**	**72.4**	**74.9**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-1.7**	**-1.9**	**-3.6**
Stability evaluation: Aggradation, Degradation or Stable:			

Worksheet 5-20b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Fourmile Canyon Creek, Reach 5, Riffle Reach 5 Pr** Location: Date: **05/11/15**

Observers: **Lucas Babbitt** Stream Type: **C 4b** Valley Type: **VIII** Gage Station #: **06721500**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport [(13)×(14)]	Time adjusted suspended sand transport [(13)×(15)]	Time adjusted total transport [(16)+(17)]
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	1.80								0.00						0.00	0.00	0.00
90.000	2.76	2.28	1.55	7.85	0.20	1.46	0.0430	0.53	6.12	0.78	10.000	36.50	0.00	0.01	0.00	0.36	0.36
80.000	3.48	3.12	1.87	7.98	0.23	1.63	0.0430	0.62	8.37	1.05	10.000	36.50	0.00	0.01	0.00	0.36	0.36
70.000	3.96	3.72	2.09	8.07	0.26	1.74	0.0430	0.69	9.98	1.24	10.000	36.50	0.00	0.01	0.00	0.36	0.36
60.000	5.28	4.62	2.41	8.21	0.29	1.90	0.0430	0.78	12.40	1.51	10.000	36.50	0.00	0.01	0.00	0.36	0.36
50.000	8.76	7.02	3.16	8.51	0.37	2.22	0.0430	0.98	18.84	2.21	10.000	36.50	0.00	0.02	0.00	0.73	0.73
40.000	13.92	11.34	4.31	8.94	0.48	2.62	0.0430	1.26	30.43	3.40	10.000	36.50	0.00	0.04	0.00	1.46	1.46
30.000	26.17	20.05	7.46	15.07	0.50	2.68	0.0430	1.30	53.80	3.57	10.000	36.50	0.00	0.07	0.00	2.56	2.56
20.000	51.01	38.59	11.56	16.77	0.69	3.33	0.0430	1.80	103.54	6.17	10.000	36.50	0.00	0.16	0.00	5.84	5.84
10.000	87.93	69.47	17.27	18.88	0.91	4.02	0.0430	2.39	186.40	9.87	10.000	36.50	0.00	0.62	0.00	22.63	22.63
5.000	108.63	98.28	21.96	20.46	1.07	4.47	0.0430	2.80	263.70	12.89	5.000	18.25	0.04	1.42	0.73	25.91	26.64
4.000	116.07	112.35	24.12	21.14	1.14	4.66	0.0430	2.97	301.46	14.26	1.000	3.65	0.04	1.91	0.15	6.97	7.12
3.000	123.99	120.03	25.27	21.50	1.18	4.75	0.0430	3.06	322.06	14.98	1.000	3.65	0.04	2.2	0.15	8.03	8.18
2.000	131.36	127.68					0.0430		0.00						0.00	0.00	0.00
1.500	138.39	134.88					0.0430		0.00						0.00	0.00	0.00
1.000	152.20	145.29					0.0430		0.00						0.00	0.00	0.00
0.900	152.80	152.50					0.0430		0.00						0.00	0.00	0.00
0.800	154.12	153.46					0.0430		0.00						0.00	0.00	0.00
0.700	156.28	155.20					0.0430		0.00						0.00	0.00	0.00
0.600	158.62	157.45					0.0430		0.00						0.00	0.00	0.00
0.500	165.13	161.88					0.0430		0.00						0.00	0.00	0.00
0.250	177.17	171.15					0.0430		0.00						0.00	0.00	0.00
0.100	188.26	182.71					0.0430		0.00						0.00	0.00	0.00
0.050	189.05	188.66					0.0430		0.00						0.00	0.00	0.00
0.010	189.05	189.05					0.0430		0.00						0.00	0.00	0.00
0.005	189.05	189.05					0.0430		0.00						0.00	0.00	0.00
0.001	189.05	189.05					0.0430		0.00						0.00	0.00	0.00

Notes:

	(16)	(17)	(18)
Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	0.9	75.7	76.7
Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):	2.5	72.4	74.9
Difference in sediment transport capacity (tons/yr) (+ or -):	-1.6	3.3	1.8
Stability evaluation: Aggradation, Degradation or Stable:			

Worksheet 5-20b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Fourmile Canyon Creek, Reach 6, Riffle Reach 6 Pr** Location: Date: **05/11/15**

Observers: **Lucas Babbitt** Stream Type: **C 4b** Valley Type: **VIII** Gage Station #: **06721500**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport **[(13)×(14)]**	Time adjusted suspended sand transport **[(13)×(15)]**	Time adjusted total transport **[(16)+(17)]**
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	**1.80**								**0.00**						**0.00**	**0.00**	**0.00**
90.000	**2.76**	**2.28**	**1.55**	**7.85**	**0.20**	**1.46**	**0.0400**	**0.49**	**5.69**	**0.72**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
80.000	**3.48**	**3.12**	**1.87**	**7.98**	**0.23**	**1.63**	**0.0400**	**0.58**	**7.79**	**0.98**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
70.000	**3.96**	**3.72**	**2.09**	**8.07**	**0.26**	**1.74**	**0.0400**	**0.64**	**9.29**	**1.15**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
60.000	**5.28**	**4.62**	**2.41**	**8.21**	**0.29**	**1.90**	**0.0400**	**0.72**	**11.53**	**1.40**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.000	**8.76**	**7.02**	**3.16**	**8.51**	**0.37**	**2.22**	**0.0400**	**0.91**	**17.52**	**2.06**	**10.000**	**36.50**	**0.00**	**0.02**	**0.00**	**0.73**	**0.73**
40.000	**13.92**	**11.34**	**4.31**	**8.94**	**0.48**	**2.62**	**0.0400**	**1.17**	**28.30**	**3.17**	**10.000**	**36.50**	**0.00**	**0.04**	**0.00**	**1.46**	**1.46**
30.000	**26.17**	**20.05**	**7.46**	**15.07**	**0.50**	**2.68**	**0.0400**	**1.21**	**50.04**	**3.32**	**10.000**	**36.50**	**0.00**	**0.07**	**0.00**	**2.56**	**2.56**
20.000	**51.01**	**38.59**	**11.56**	**16.77**	**0.69**	**3.33**	**0.0400**	**1.68**	**96.32**	**5.74**	**10.000**	**36.50**	**0.00**	**0.15**	**0.00**	**5.47**	**5.47**
10.000	**87.93**	**69.47**	**17.27**	**18.88**	**0.91**	**4.02**	**0.0400**	**2.22**	**173.40**	**9.18**	**10.000**	**36.50**	**0.00**	**0.53**	**0.00**	**19.35**	**19.35**
5.000	**108.63**	**98.28**	**21.96**	**20.46**	**1.07**	**4.47**	**0.0400**	**2.60**	**245.31**	**11.99**	**5.000**	**18.25**	**0.04**	**1.26**	**0.73**	**23.00**	**23.73**
4.000	**116.07**	**112.35**	**24.11**	**21.14**	**1.14**	**4.66**	**0.0400**	**2.76**	**280.43**	**13.27**	**1.000**	**3.65**	**0.04**	**1.70**	**0.15**	**6.21**	**6.36**
3.000	**123.99**	**120.03**	**25.27**	**21.50**	**1.18**	**4.75**	**0.0400**	**2.85**	**299.59**	**13.93**	**1.000**	**3.65**	**0.04**	**1.96**	**0.15**	**7.15**	**7.30**
2.000	**131.36**	**127.68**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
1.500	**138.39**	**134.88**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
1.000	**152.20**	**145.29**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.900	**152.80**	**152.50**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.800	**154.12**	**153.46**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.700	**156.28**	**155.20**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.600	**158.62**	**157.45**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.500	**165.13**	**161.88**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.250	**177.17**	**171.15**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.100	**188.26**	**182.71**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.050	**189.05**	**188.66**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.010	**189.05**	**189.05**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.005	**189.05**	**189.05**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**
0.001	**189.05**	**189.05**					**0.0400**		**0.00**						**0.00**	**0.00**	**0.00**

Notes:

	(16)	(17)	(18)
Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**0.9**	**67.7**	**68.7**
Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):	**2.5**	**72.4**	**74.9**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-1.6**	**-4.7**	**-6.2**
Stability evaluation: Aggradation, Degradation or Stable:			

Worksheet 5-20b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Fourmile Canyon Creek, Reach 7, Riffle Reach 7 Pr** Location: Date: **05/11/15**

Observers: **Lucas Babbitt** Stream Type: **C 4b** Valley Type: **VIII** Gage Station #: **06721500**

Flow-duration curve		**Calculate**	**Hydraulic geometry**				**Measure**	**Calculate**									
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport **[(13)×(14)]**	Time adjusted suspended sand transport **[(13)×(15)]**	Time adjusted total transport **[(16)+(17)]**
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	**1.80**								**0.00**						**0.00**	**0.00**	**0.00**
90.000	**2.76**	**2.28**	**1.55**	**7.85**	**0.20**	**1.46**	**0.0470**	**0.57**	**6.69**	**0.85**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
80.000	**3.48**	**3.12**	**1.87**	**7.98**	**0.23**	**1.63**	**0.0470**	**0.68**	**9.15**	**1.15**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
70.000	**3.96**	**3.72**	**2.09**	**8.07**	**0.26**	**1.74**	**0.0470**	**0.75**	**10.91**	**1.35**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
60.000	**5.28**	**4.62**	**2.41**	**8.21**	**0.29**	**1.90**	**0.0470**	**0.85**	**13.55**	**1.65**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.000	**8.76**	**7.02**	**3.16**	**8.51**	**0.37**	**2.22**	**0.0470**	**1.07**	**20.59**	**2.42**	**10.000**	**36.50**	**0.00**	**0.02**	**0.00**	**0.73**	**0.73**
40.000	**13.92**	**11.34**	**4.31**	**8.94**	**0.48**	**2.62**	**0.0470**	**1.38**	**33.26**	**3.72**	**10.000**	**36.50**	**0.00**	**0.04**	**0.00**	**1.46**	**1.46**
30.000	**26.17**	**20.05**	**7.46**	**15.07**	**0.50**	**2.68**	**0.0470**	**1.42**	**58.80**	**3.90**	**10.000**	**36.50**	**0.00**	**0.07**	**0.00**	**2.56**	**2.56**
20.000	**51.01**	**38.59**	**11.56**	**16.77**	**0.69**	**3.33**	**0.0470**	**1.97**	**113.18**	**6.75**	**10.000**	**36.50**	**0.00**	**0.18**	**0.00**	**6.57**	**6.57**
10.000	**87.93**	**69.47**	**17.27**	**18.88**	**0.91**	**4.02**	**0.0470**	**2.61**	**203.74**	**10.79**	**10.000**	**36.50**	**0.00**	**0.74**	**0.00**	**27.01**	**27.01**
5.000	**108.63**	**98.28**	**21.96**	**20.46**	**1.07**	**4.47**	**0.0470**	**3.06**	**288.24**	**14.09**	**5.000**	**18.25**	**0.04**	**1.64**	**0.73**	**29.93**	**30.66**
4.000	**116.07**	**112.35**	**24.11**	**21.14**	**1.14**	**4.66**	**0.0470**	**3.25**	**329.50**	**15.59**	**1.000**	**3.65**	**0.04**	**2.18**	**0.15**	**7.96**	**8.11**
3.000	**123.99**	**120.03**	**25.27**	**21.50**	**1.18**	**4.75**	**0.0470**	**3.35**	**352.02**	**16.37**	**1.000**	**3.65**	**0.04**	**2.51**	**0.15**	**9.16**	**9.31**
2.000	**131.36**	**127.68**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
1.500	**138.39**	**134.88**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
1.000	**152.20**	**145.29**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.900	**152.80**	**152.50**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.800	**154.12**	**153.46**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.700	**156.28**	**155.20**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.600	**158.62**	**157.45**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.500	**165.13**	**161.88**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.250	**177.17**	**171.15**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.100	**188.26**	**182.71**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.050	**189.05**	**188.66**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.010	**189.05**	**189.05**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.005	**189.05**	**189.05**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**
0.001	**189.05**	**189.05**					**0.0470**		**0.00**						**0.00**	**0.00**	**0.00**

Notes:

	(16)	(17)	(18)
Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**0.9**	**87.1**	**88.1**
Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):	**2.5**	**72.4**	**74.9**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-1.6**	**14.7**	**13.2**
Stability evaluation: Aggradation, Degradation or Stable:			

Worksheet 5-20b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Fourmile Canyon Creek, Reach 8, Riffle Reach 8 Pr** Location: Date: **05/11/15**

Observers: **Lucas Babbitt** Stream Type: **C 4b** Valley Type: **VIII** Gage Station #: **06721500**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport **[(13)×(14)]**	Time adjusted suspended sand transport **[(13)×(15)]**	Time adjusted total transport **[(16)+(17)]**
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	**1.80**								**0.00**						**0.00**	**0.00**	**0.00**
90.000	**2.76**	**2.28**	**1.55**	**7.85**	**0.20**	**1.46**	**0.0420**	**0.51**	**5.98**	**0.76**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
80.000	**3.48**	**3.12**	**1.87**	**7.98**	**0.23**	**1.63**	**0.0420**	**0.61**	**8.18**	**1.03**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
70.000	**3.96**	**3.72**	**2.09**	**8.07**	**0.26**	**1.74**	**0.0420**	**0.67**	**9.75**	**1.21**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
60.000	**5.28**	**4.62**	**2.41**	**8.21**	**0.29**	**1.90**	**0.0420**	**0.76**	**12.11**	**1.48**	**10.000**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.000	**8.76**	**7.02**	**3.16**	**8.51**	**0.37**	**2.22**	**0.0420**	**0.95**	**18.40**	**2.16**	**10.000**	**36.50**	**0.00**	**0.02**	**0.00**	**0.73**	**0.73**
40.000	**13.92**	**11.34**	**4.31**	**8.94**	**0.48**	**2.62**	**0.0420**	**1.23**	**29.72**	**3.32**	**10.000**	**36.50**	**0.00**	**0.04**	**0.00**	**1.46**	**1.46**
30.000	**26.17**	**20.05**	**7.46**	**15.07**	**0.50**	**2.68**	**0.0420**	**1.27**	**52.55**	**3.49**	**10.000**	**36.50**	**0.00**	**0.07**	**0.00**	**2.56**	**2.56**
20.000	**51.01**	**38.59**	**11.56**	**16.77**	**0.69**	**3.33**	**0.0420**	**1.76**	**101.14**	**6.03**	**10.000**	**36.50**	**0.00**	**0.16**	**0.00**	**5.84**	**5.84**
10.000	**87.93**	**69.47**	**17.27**	**18.88**	**0.91**	**4.02**	**0.0420**	**2.33**	**182.07**	**9.64**	**10.000**	**36.50**	**0.00**	**0.59**	**0.00**	**21.54**	**21.54**
5.000	**108.63**	**98.28**	**21.96**	**20.46**	**1.07**	**4.47**	**0.0420**	**2.73**	**257.57**	**12.59**	**5.000**	**18.25**	**0.04**	**1.37**	**0.73**	**25.00**	**25.73**
4.000	**116.07**	**112.35**	**24.11**	**21.14**	**1.14**	**4.66**	**0.0420**	**2.90**	**294.45**	**13.93**	**1.000**	**3.65**	**0.04**	**1.84**	**0.15**	**6.72**	**6.87**
3.000	**123.99**	**120.03**	**25.27**	**21.50**	**1.18**	**4.75**	**0.0420**	**2.99**	**314.57**	**14.63**	**1.000**	**3.65**	**0.04**	**2.12**	**0.15**	**7.74**	**7.89**
2.000	**131.36**	**127.68**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
1.500	**138.39**	**134.88**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
1.000	**152.20**	**145.29**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.900	**152.80**	**152.50**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.800	**154.12**	**153.46**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.700	**156.28**	**155.20**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.600	**158.62**	**157.45**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.500	**165.13**	**161.88**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.250	**177.17**	**171.15**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.100	**188.26**	**182.71**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.050	**189.05**	**188.66**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.010	**189.05**	**189.05**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.005	**189.05**	**189.05**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**
0.001	**189.05**	**189.05**					**0.0420**		**0.00**						**0.00**	**0.00**	**0.00**

Notes:

	(16)	(17)	(18)
Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**0.9**	**73.1**	**74.2**
Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):	**2.5**	**72.4**	**74.9**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-1.6**	**0.7**	**-0.7**
Stability evaluation: Aggradation, Degradation or Stable:			

	Sed Analysis				Competence				Velocity Discharge		
	n	Q	tons	Str. Type	D50	Dmax	Dcomp	Shear	D84	Q	V
Reach 1	0.07087	120.03	76.6	C4	41	241	354.8	3.1662	90	212.67	8.42
Reach 2	0.07642	120.03	96.9	B4	41	241	396.5	3.682	90	160.95	6.37
Reach 3	0.07169	120.03	79.7	B4	41	241	376.5	3.432	90	152.75	6.13
Reach 4	0.07169	120.03	79.7	B4	41	241	376.5	3.432	90	152.75	6.13
Reach 5	0.07087	120.03	76.6	B4	41	241	370.2	3.352	90	151	6.06
Reach 6	0.06835	120.03	68.4	C4	39	233	336.5	2.945	86	205.12	8.12
Reach 7	0.07409	120.03	87.8	B4	41	241	390.6	3.607	90	157.88	6.33
Reach 8	0.07004	120.03	74.0	B4	39	233	348.8	3.093	86	147.5	5.84
Reach 9	0.07520	120.00	93.8	B4	41	241	354.8	3.166	90	158.3	5.94
Reach 10	0.07068	120.02	75.5	B4	39	233	324	2.798	86	148.81	5.59
Comparitive R1:	0.03911	120.02	74.9								

Reach Prioritization

Fourmile Canyon Creek Reach Prioritization

Reach	Reach Condition Rating	Ongoing Erosion to Impact VAR	Required for Road Reconstruction	Accessibility/Ease of Construction	Amount of Private Property Coordination	Total	Rank
1	2	2	1	3	3	11	5
2	3	2	1	3	2	11	5
3	2	3	2	3	3	13	1
4	1	2	2	3	3	11	4
5	3	3	2	3	1	12	2
6	2	2	2	3	1	10	3
7	3	1	1	1	2	8	3
8	3	1	1	1	2	8	3
9	2	2	3	3	2	12	2
10	3	3	3	3	1	13	1

Notes:

Scoring: 1=worst, 3=best

Fourmile Canyon Creek DSR Field Walk

Reach	Existing Erosion Problem	Future Flooding Concern		Values At Risk if Channel Isn't Repaired			Proposed Improvements					Estimated Cost
		Concern?	Why?	Property	Homes	Infrastructure	Natural Channel Restoration	Revegetation	Channel Bank Stabilization	Channel Grade Stabilization	Road Crossing Enhancement	
1	Moderate	Yes	Homes in floodplain	x	x		x	x	x			
2	Extreme	Yes	Homes in floodplain	x	x		x	x	x	x		
3	Moderate	Yes	Homes in floodplain, road overtopping	x	x	x	x	x	x		x	
4	Major	Yes	Road flooding	x		x	x	x	x	x		
5	Major	Yes	Homes in floodplain, road overtopping	x	x	x	x	x	x		x	
6	Moderate	Yes	Homes in floodplain	x	x		x	x	x			
7	Major	Yes	Road flooding	x			x	x	x	x		
8	Major	Yes	Road flooding	x			x	x	x	x		
9	Moderate	Yes	Road flooding	x		x	x	x	x	x	x	
10	Extreme	Yes	Homes in floodplain, road overtopping, road flooding	x	x	x	x	x	x	x	x	